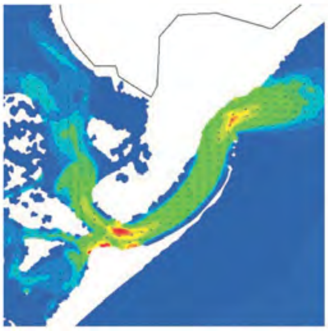
Solent Forum

Beneficial Use of Dredge Sediment in the Solent (BUDS)

Phase 1 Project Scoping and Partnership Building

March 2018




Innovative Thinking - Sustainable Solutions

ABP mer

Page intentionally left blank

Beneficial Use of Dredge Sediment in the Solent (BUDS)

Phase 1 Project Scoping and Partnership Building

March 2018



Document Information

Document History and Authorisation	
Title	Beneficial Use of Dredge Sediment in the Solent (BUDS)
	Phase 1 Project Scoping and Partnership Building
Commissioned by	Solent Forum
Issue date	March 2018
Document ref	R.2845
Project no	R/4540/1

Date	Version	Revision Details
23 March 2018	1	Issued for Client Comment

Prepared (PM)	Approved (QM)	Authorised (PD)
Colin Scott	Susanne Armstrong	Stephen Hull

Suggested Citation

ABPmer (2018). Beneficial Use of Dredge Sediment in the Solent (BUDS), Phase 1 Project Scoping and Partnership Building, ABPmer Report No. R.2845. A report produced by ABPmer for Solent Forum, March 2018.

Acknowledgements

We would like to thank the many people and organisations that were consulted and provided information during this study. This includes members of the technical group that is overseeing the BUDS project as well as a wide range of interested parties and industry specialists who provided input during the consultation process and the BUDS workshop.

ABPmer
Quayside Suite, Medina Chambers, Town Quay, Southampton, Hampshire SO14 2AQ
T: +44 (0) 2380 711844 W: http://www.abpmer.co.uk/

Executive Summary

Project background

This report reviews the work undertaken for Phase 1 of the Solent Forum's 'Beneficial Use of Dredge Sediment in the Solent' (BUDS) project. The BUDS project was initiated by the Solent Forum partnership because its members are keen to see more of the region's dredged sediment used to restore its intertidal habitats[1]. To consider this issue further, this first phase of the project involved a high-level review of the locations where dredge arisings (silts mainly) could be used in the Solent to 'recharge' coastal habitat. It has also been undertaken to help identify collaborative partnerships that might be willing to support one or more intertidal recharge initiatives, especially at a large scale.

Methods

At the start of this study, a short literature review was conducted to provide a context for the project. In advance of this review it was recognised that many of the concepts and issues relating to the beneficial use of fine sediment have been reviewed often enough in the past. Similarly, the reasons why such work is only seldom carried out have also been well rehearsed. Care was taken, therefore, not to repeat too much of this previous analysis but instead to clarify many of the contemporary issues, initiatives and case example evidence.

As an additional task, alongside this brief literature review, a more specific study was also carried out by ABPmer into the costs and benefits of using sediment to restore habitats. This was conducted because the main reason why such projects are difficult to implement is that they incur increased cost; and yet, there is a lack of any clear consensus as to the value of these initiatives or clarity about who benefits. It was important, therefore, to carry out this review to inform future discussions about the objectives and funding streams for any future projects.

Following these initial review stages, a set of criteria were developed to inform the selection of potential beneficial use sites. These were expressed as a set of 11 questions designed to help identify locations where there is a demonstrable need for beneficial use measures (e.g. providing coastal protection and habitat restoration) as well as areas where such work would be technically achievable.

Once these selection criteria were agreed (with the BUDS Technical Group), a GIS mapping exercise was carried out to assemble the spatial information needed to help select, or eliminate, locations where projects might be undertaken on the basis of these criteria. Data was collated from various sources to describe aspects such as: the coastal habitat types, the standard of coastal defences, and the location of appropriate sources of dredged sediment. This mapping is available online.

In tandem with this mapping work, a consultation process was undertaken in which many interested parties throughout the Solent were asked for additional information as well as their views and advice. Through this consultation, details were obtained about extant and proposed dredging projects as well as other relevant information including the future plans for coastal defence works in the Solent. Finally, to complete the review, a BUDS workshop was held on 6 December 2017 to discuss any possible or proposed future beneficial use project sites with key stakeholders and industry experts.

[1] This Phase 1 study has included a review of the existing situation and shown that over 1 million m^3 of fine sediment is typically excavated through maintenance dredging in the Solent each year. However, no more than around 0.02% of this (at the most) is used beneficially to protect and restore the deteriorating marshes and coast of the Solent.

Findings and recommendations

Following this review it was concluded that there is one 'stand out' area where a major large scale project should be carried out. This is along the 'Hurst Spit to Lymington' frontage in the western Solent. This is an area where the marshes play a key role in coastal protection and where there would be many social, economic and environmental benefits. This review furthermore identified opportunities for carrying out other large-scale projects to restore marsh islands within Portsmouth Harbour and / or the habitats fronting Farlington Marshes in Langstone Harbour. This study has also separately noted some opportunities for smaller-scale initiatives within individual estuaries or the East Solent harbours.

Based on the findings, it is recommended that the following is undertaken for the next stage of the BUDS project:

- Develop a large-scale project for the Keyhaven to Lymington frontage where there are clear benefits for nature conservation and coastal protection;
- Develop (a) large-scale project(s) in the East Solent (e.g. Farlington and/or Portsmouth Harbour Islands) where there are clear benefits, particularly for nature conservation;
- Work with regulatory bodies to develop regional guidance to assist with both large-scale and small-scale initiatives in the future;
- Continue to maintain and populate the BUDS map so that it can remain a useful resource for ongoing decisions making; and
- Consider the case for a small-scale project at Eling Marshes (Southampton Water) because there is a distinct economic case for recharge work at this site.

In summary, therefore, it is recommended that the next project phases involve actively progressing one or more of the large-scale projects while also helping to develop guidance and providing oversight (e.g. through maintaining the BUDS mapping product). This oversight would help both large-scale projects and smaller-scale schemes that individual operators and harbour authorities would like to progress.

In moving to the next stage, it will be important to build partnerships around the large-scale initiatives. A key objective should be to create regionally strategic intertidal disposal sites that can be used by a range of parties; as appropriate and as conditions allow. This approach is expected to be vital for ensuring that more dredged sediment can be used beneficially in the Solent. Particular care should be taken though to ensure that an extra undue cost burden for this is not put on individual parties (especially dredging operators and harbour authorities) who are not, typically, the beneficiaries.

The implementation and funding of these projects will also be facilitated by elevating the importance of delivering natural capital gain. Increasing the degree to which enhancing natural capital is seen as a core project objective (linked to a greater recognition of the ecosystem services provided by coastal habitats) would greatly help to see these projects become realised. Adopting such a natural capital approach would also be fully in keeping with the ambitions of the Defra 25 year environment plan.

Finally, it is also recognised that pursuing the larger-scale projects that are proposed here would represent relatively novel and pioneering projects in both a national and European context. This is because most precedents for work have been at relatively modest scales so far. However, there is a demonstrable economic case for such work in the Solent and an opportunity for this region to provide a leading example in the strategic beneficial use of dredge sediment, and in the placing of a natural capital approach at the heart of coastal management and flood protection decision making.

Contents

Appendices

Tables

Images

1 Introduction

1.1 Report background

This report reviews the work undertaken for Phase 1 of the Solent Forum's 'Beneficial Use of Dredge Sediment in the Solent' (BUDS) project. The BUDS project was initiated by the Solent Forum partnership because its members are keen to see more of the region's dredged sediment used to restore its intertidal habitats. The Solent Forum fully recognises, that several barriers exist with respect to implementing such projects (nationally as well as in the Solent), but it would like to find a way of overcoming these so that a new project, or set of projects, might be undertaken in the near future.

In response, the Solent Forum commissioned ABPmer to conduct this initial Phase 1 review. This first phase of the BUDS initiative was undertaken to identify, at a high-level, possible locations in the Solent where dredge arisings (silts especially) could be used to 'recharge' coastal habitat. It has also been carried out to help identify collaborative partnerships that might be willing to support one or more initiatives to recharge intertidal marshes, especially at a large scale. It is hoped that the information provided within this first stage review will act as a springboard for the implementation of more frequent, and more ambitious, beneficial use projects in the Solent.

To achieve these goals though, and overcome the barriers to implementation, it will be important to find restoration sites that would be of interest to, and benefit for, several regional partners/stakeholders so that they can work together to mutual benefit. An appropriate project will therefore need to be relatively large in scale and provide demonstrable benefits such as: achieving flood and coastal risk management objectives, improving coastal habitats and/or providing more efficient consenting, licencing and sediment disposal processes (whether over the short or long term).

1.2 Project approach

To progress this initial Phase 1 site-selection study, the following tasks were undertaken:

- Outline Literature Review (Section 2). This was conducted to provide a brief overview of the subject and particularly to clarify contemporary issues, initiatives and case example evidence that are pertinent to the use of dredge sediments for intertidal restoration;
- Criteria Mapping and Consultation Exercise (Section 3). To inform the site selection process, a set of selection criteria were developed to help identify locations where there is a demonstrable need for beneficial use, as well as areas where such work would be technically achievable. Once these criteria had been agreed, a GIS mapping exercise was carried out to assemble the information needed to help select, or eliminate, locations on the basis of these criteria. In tandem with this work, a consultation process and BUDS workshop event were also undertaken to obtain additional information and comment from many interested parties throughout the Solent;
- Site Selection Review (Section 4). Based on the information collated, a site review was then undertaken to identify potential beneficial use sites and consider other key issues that might influence future project implementation; and
- Summary of Findings and Recommendations (Section 5). As a final element of this review a set of summary findings, key considerations and final recommendations are made for progressing the next phase of the BUDS work.

To further inform this study, selected additional individual reviews and data collation exercises were conducted to provide relevant contextual information. The results of these processes are included as appendices to this report as follows:

- Review of Project Costs and Benefits (Appendix A). To underpin this Phase 1 BUDS study, ABPmer carried out a stand-alone review of the technical approaches and the costs and benefits associated with beneficially using dredged sediment to restore intertidal habitats. This was conducted because the main reasons why such projects are difficult to implement are the increased cost they can incur, as well as the lack of any clear consensus as to their value. It was important, therefore, to carry out this review to help inform the debate on future project funding. It is hoped that improving understanding about this subject will assist with future project implementation in the Solent;
- Review of Solent Dredging Campaigns (Appendix B). To inform the site selection work and identify the areas where dredge sediment is currently being excavated (and will be excavated in the future), publicly available Marine Management Organisation (MMO) Marine licences and Maintenance Dredge Protocols were reviewed;
- Summary of data used for the GIS mapping (Appendix C). To summarise the information collected for the criteria mapping exercise, a metadata table was prepared; and
- Summary of the BUDS workshop (Appendix D). To inform the review, a BUDS stakeholder workshop was held on 6 December 2017; the key points arising from this event are outlined.

In addition to this report and its supporting appendices, an online GIS mapping product was produced (see Section 3.3). It is hoped that this will be used to inform future decisions in the Solent and will be updated during future phases of the BUDS project as more information is collated.

2 Outline Literature Review

This section provides a brief background to the subject of beneficial using sediments for habitat restoration while also identifying some of contemporary issues, initiatives and case example evidence. It also reviews past initiatives in the Solent. A further, and more general, review of this subject is also included in the introductory chapter of the cost and benefit review in Appendix A.

2.1 National use of the existing dredge resource

In the Solent, and across the rest of the UK, large quantities of sediments are dredged on a regular basis to maintain navigable access to economically valuable ports, harbours and marinas. The majority of the excavated sediment is then deposited at licenced coastal or offshore disposal sites. The locations of these disposal sites, and the volume of material deposited at them on an annual basis, are well understood. These values are nationally audited by the MMO's Marine Information System[2] and in Defra's Disposal At Sea (DAS) Database.

Although these national audits are available, there is a lack of clarity about the details associated with the country's dredging and disposal processes. For example, there is limited accessible information about aspects such as: sediment types, excavation methods, individual sediment sources (i.e. dredge locations), and frequency/regularity of disposal from individual sources. Also, there is no formal auditing of the considerations that have been given to beneficial use alternatives.

Some information on such details is contained within individual marine licence applications and maintenance dredge protocol documents; however, there are no accessible audits of this information that might be used to readily inform decision making and planning for beneficial use projects. Part of the challenge in this respect is that the amount of dredging and the volumes excavated varies temporally and spatially (especially due to the intermittent nature of larger capital excavations). However, what is missing, and is needed for reviews such as this, is a way to understand the key dredge locations and excavation volumes from regular maintenance dredging activities. This would then help to understand the distribution and availability of the reliable maintenance dredge resources at either national or regional scales[3].

Although there is this uncertainty about the details of dredging activities and the availability of the dredge sediment resource, a few reviews are available which have sought to clarify some of these aspects and to understand the distinction between the amount of sediment that is available and the amount that is used, or could be used, beneficially. For example, Bolam and Whomersley (2005) (quoting Bolam *et al.*, 2003) estimated that around 40-50 million m^{-3} $year^{-1}$ of sediment was available and deposited at sea (at the time of that review), of which less than 1% was used for intertidal restoration nationally.

Further analysis of the DAS database has also been carried out during this BUDS study (see Appendix B). This indicates that around 727 million tonnes of maintenance dredge sediment was deposited at licenced disposal sites in England between 1986 and 2012 (or 27 million tonnes $year^{-1}$ over this period). Over the five years from 2006 to 2012, the average volume of maintenance dredge excavations was 24 million tonnes $year^{-1}$. Of this annual average, around 40% was 'sustainably

2 http://defra.maps.arcgis.com/apps/webappviewer/index.html?id=3dc94e81a22e41a6ace0bd327af4f346

3 For regional analyses such as this Solent BUDS study, it is therefore necessary to collate this detail from the range of available documents and through consultations with dredging operators and harbour authorities. This has been done for this Phase 1 BUDS review, as described in Section 3.3.9 and Appendix D.

relocated/deposited[4], in estuaries like the Humber, Wash and Severn or in harbours such as Chichester and Poole.

While sustainable relocation is better from an environmental perspective than offshore disposal, it does not directly address the deterioration of intertidal habitats, or help to hold on to (or enhance) the habitats' resources (or the 'Natural Capital') and all the functions they provide. It is evident from a number of studies that only a small fraction of 1% of the maintenance dredge arisings is actually used directly for habitat restoration in a way that delivers such direct biodiversity gain (ABPmer, 2017; MMO, 2014a; Paipai, 2003). Only a limited number of beneficial use projects have been undertaken to protect and enhance intertidal habitat in the UK (and indeed this applies across the rest of Europe) despite the large amounts of fine sediment that is available each year. The previous reviews describe how this fraction varies between 0.05% and 0.8% (see also Section 1.2.3 of the review in Appendix A). It is typically at the lower level of this range, but reaches the higher level in years when notable projects are undertaken. As described in Section 2.5, in the Solent, the proportion is no more than 0.02% at most. The reasons for this are now well known.

2.2 Reasons why there is limited beneficial use

This ongoing situation, in which there is limited beneficial re-use of dredge arisings for direct habitat restoration, occurs despite the fact that there has been a long-term desire to see dredge arisings used beneficially for environmental and/or socio-economical activities, at a national and international level. For example, the need to seek beneficial use opportunities was identified within the 1996 International Maritime Organisation (IMO) London Protocol and other dredge management reviews and guidance (OSPAR, 2014; HELCOM, 2015).

Consideration of the beneficial use opportunities is also a requirement of the marine licensing process under the 2009 Marine and Coastal Access Act (as it was under the preceding FEPA/CPA[5] consenting arrangements). A policy (Ref S-DD-2) has also been recently included within the draft south marine plans (MMO, 2016) which states that '*proposals must identify where use of dredge disposal sites can be minimised by pursuing re-use opportunities through matching of spoil to suitable sites*'. The Waste regulations also request reasonable measures to apply the waste hierarchy process in which re-use and recycling are preferential over disposal.

Many organisations/studies over many years have described this situation (RSPB, 2018; Ausden *et al.*, 2016; ABPmer, 2014; Foster, 2014, MMO, 2014a; CEDA, 2010; IADC, 2009; PIANC, 2009; Murray, 2008; Paipai, 2003). These studies have often sought to understand how this waste of a resource could be rectified and have often identified the many reasons why dredge material is very rarely used beneficially to restore eroding and deteriorating intertidal habitats. These barriers were also reviewed within some of the presentations at the ABPmer conference on this topic that was held in November 2016 (ABPmer, 2016a).

The reasons why there is limited beneficial use are therefore well-rehearsed (and they are also set out in Section 1.2.4 of Appendix A). In summary however it is because of:

- Technical difficulties of achieving projects and the resulting extra costs incurred;
- Extra tasks that are required to progress through consenting processes;
- Lack of bespoke legislation or single government body/department to champion this subject;

4 Sustainable relocation involves depositing sediment within the estuary or coastal sediment cell to ensure that the material is not lost from the system (see also Section 2.3).

5 FEPA -Food And Environmental Protection Act 1985; CPA - Coast Protection Act 1949

- Absence of any transparent mechanism for identifying sediment sources and linking these locations with sites that have a need for sediment; and
- Concerns regarding the environmental effects that could arise from the beneficial use activity.

In essence these factors mean that it is almost always easier to maintain long-established 'business as usual' practices and place sediment at an established disposal site rather than go through a new and lengthy process to undertake a beneficial use project. Of all these issues, the fundamental ones really are that it typically costs more money and also that those who incur the costs (the dredging operators, marina owners and harbour authorities) are not those that benefit and so there is a fundamental disincentive for beneficial use measures to be pursued[6].

There are also limited funding mechanisms for habitat restoration and improvement work and the limited adoption of approaches which quantify ecosystem service benefits[7] and, hence, seek to deliver environmental gains in tandem with flood protection objectives. Application of the Environment Agency's Flood and Coastal Erosion Risk Management (FCERM) process does not end up placing the required level of emphasis on delivering natural capital gain to facilitate beneficial use projects. It is recognised, however, that the Government's new 25-year environment Plan (Defra, 2018) places an emphasis on the adoption of a natural capital approach with the objective of reversing loss of marine biodiversity and where practicable restoring it. This offers an opportunity to attach greater weight to natural capital benefits in FCERM decision-making.

To place this issue of funding and cost in context, it is notable that coarser sands and gravels do get beneficially used in large quantities for beach nourishment projects. This is because there is often a much clearer coastal protection rationale and because there are often economies of scale associated with using large volumes of sand and shingle in this manner.

Alongside the issue of cost, further key constraints are the nature, duration and uncertainties associated with the consenting process. These factors mean that, even where a potential beneficial use initiative has been identified, the process of realising a project can still be protracted and can hamper implementation.

A spotlight has been thrown on the combined challenges of costs and consenting by the recent failure of a project at Holes Bay in Poole Harbour to be progressed. This project had the potential to deliver multiple benefits for a number of supportive partners. However, it is not now being pursued by Poole Borough Council (PBC) because there was not enough consistency and clarity in the consenting processes. The uncertainties associated with costs for the consenting has meant that PBC are unable to budget for this project (Justine Hawkes, PBC, pers. comm.). PBC has concluded that there needs to be clearer guidance and a change of mind site on this subject if projects are to be implemented in the future (ABPmer, 2016a).

2.3 Available techniques for beneficial use

Although there are clear issues and challenges associated with beneficially using fine dredged sediment, several projects and trials have been undertaken in the UK over the last quarter of a century. These have used a wide range of techniques to place sediment directly onto intertidal marsh habitat. Therefore our understanding about the techniques that are available, and about what works, and what does not, is well advanced.

6 It is because cost is such a key issue that the additional review of project costs and benefits has been undertaken (see Appendix A).

7 These are numerous, and include coastal protections, carbon sequestration, provision of roosting and nesting areas etc.). See Section 3.1 of Appendix A for more detail.

A case-example-based review of four key approaches is included in Section 2 of the ABPmer White Paper in Appendix A. To this list it is worth also adding the 'bottom dumping approach that has recently been trialled and recently consented at Lymington (see Section 2.5 for further details). In simple terms, therefore, the following five approaches (with previous case examples of their use in brackets) represent the main ways in which dredged sediment could be placed directly on intertidal habitat within the Solent:

- Back-hoe extraction translocated for back-hoe placement (e.g. Maldon Hythe Quay);
- Back-hoe extraction translocated for pumped placement (e.g. Lymington Boiler Marsh Recharge by Wightlink Ltd.);
- Back-hoe extraction translocated for intertidal bottom dumping (e.g. recent and on-going recharge work at Lymington by the Lymington Harbour Commissioners (LHC);
- Suction dredge with direct pumped placement (e.g. Levington Marina and Lymington Yacht Haven Marina); and
- Suction dredge translocated for pump/rainbow release (e.g. Horsey Island, Shotley).

In addition to these approaches however, it is noted that the following two options are also available which could be considered for any beneficial use projects in the Solent although they will not directly recharge existing intertidal habitats (especially not at a large-scale):

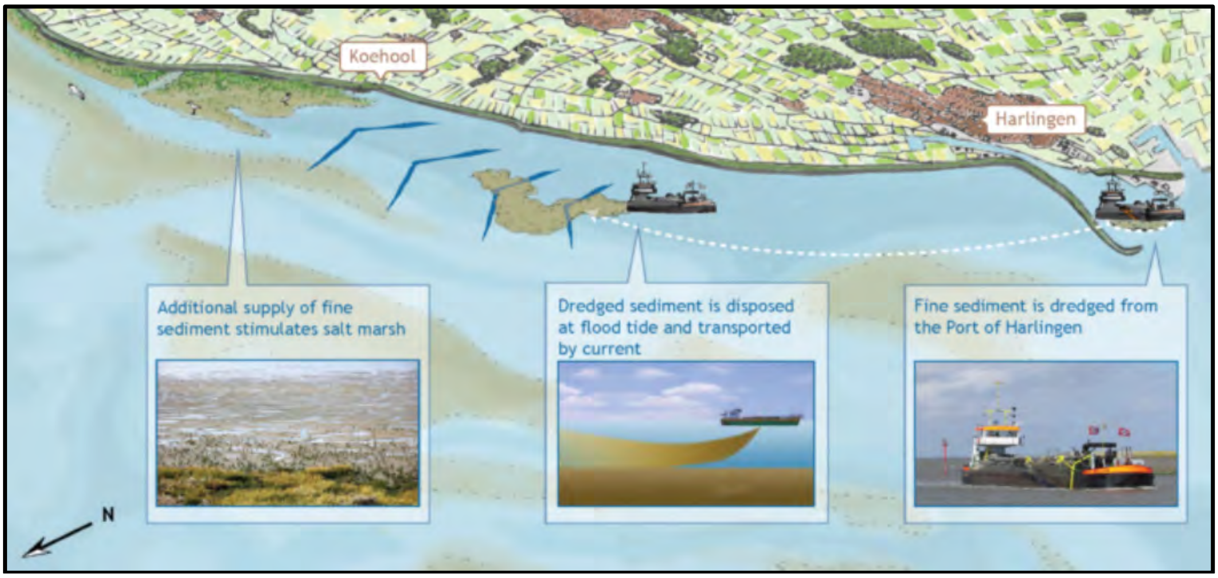
- Nearshore subtidal bottom placement of dredged materials (e.g. Treloar Hole, and Harlingen (as summarised below)); and
- Pumping of dredged materials into hinterland areas that will later be subject to managed realignment (e.g. Allfleet's Marsh).

The first of these techniques involves placing sediment subtidally within an estuary / harbour or sediment cell. Often, this is done to ensure that the sediment is not removed from the system or, better still, that a proportion of the deposited sediment feeds back onto intertidal areas. This 'sustainable relocation'[8] approach is for example adopted at Treloar Hole at the mouth of Chichester Harbour.

At Treloar Hole, a maximum of 10,000 tonnes of maintenance dredged sediment can be deposited each year (on a flooding tide to ensure that the sediment is carried back into the harbour). The trials and modelling work that was undertaken to inform the use of the Treloar Hole site indicate that large proportions of sediment remain in the harbour and principally in the marginal areas of the main channels (HR Wallingford, 2004). This site is only intermittently used, which is understood to be due to the costs associated with carrying out the required diver-based monitoring work.

A larger scale variation of this 'sustainable relocation' approach has recently been undertaken near Harlingen (Friesland, northern Netherlands). The Port of Harlingen dredges around 1.3 million m^3 of sediment each year (roughly the same as the total annual maintenance dredge sediment resource for the whole of the Solent) and has historically deposited close to the harbour entrance. Much of the sediment would then wash back towards the port. Recently, an alternative shallow subtidal deposit ground was identified further north along the coast. Modelling work and tracer trials indicated that most of the deposited sediment will be carried north along the shorelines and towards an area of mudflat and vestigial marsh in front of Koehoal (see Image 1).

[8] As noted in Section 2.1 this 'sustainable relocation' approach is also adopted in large estuaries such as the Humber and the Severn.



Source: www.ecoshape.org/en/projects/mud-motor

Image 1. Schematic description of the Harlingen 'Building with Nature' approach

The first phase of these works was conducted between September 2016 and April 2017, when 300,000 m^3 of maintenance dredge sediment was deposited subtidally from a 600 m^3 hoper barge on a flood tide (van Eekelen *et al*., 2017; Vroom *et al*. 2017). Preliminary results from what is called a 'Mud Motor' approach indicate that the intertidal accreted by 10 cm over the first two months.

This accretion over the marshes shows the potential value of this approach. However, in this case the sediment did not accrete enough or stay long enough for saltmarsh plants to grow and help stabilise the environment and the sediments. This work will continue from late 2017 onwards with additional disposals and further monitoring to understand the effectiveness and value of this approach.

The other approach (of the two bullets above) involves using dredged sediments to recharge hinterland areas in advance of a managed realignment. This approach has been pursued in locations where the existing land elevations within a future managed realignment are low and need to be raised to a higher elevation to specifically create saltmarsh habitat quickly[9]. This 'land raising' approach was adopted, for example, at Allfleet's Marsh (Wallasea Island) in Essex, where 550,000 m^3 of maintenance dredge arisings were used to raise land elevations by around 1 to 2 m along a 40 m-wide 4 km- long strip in front of a new sea wall (Dixon *et al*., 2008) (see Image 2).

In the Solent, there are several potential managed realignment sites which are low lying and where recharge could be done to create marsh quickly. However, if this approach were to be adopted in the Solent it would be necessary in the first instance to be assured that marsh habitat needs to be created at speed for the extra cost. This is because most sites that are opened up to the tide are likely to accrete naturally over time without the need to prior recharge.

[9] This approach of recharging a realignment site with sediment has also been used at Trimley but in this case it was undertaken mainly to facilitate benthic invertebrate colonisation of mudflat habitat. http://www.ecrr.org/Portals/27/Trimley,%20Suffolk.pdf

Source: ABPmer taken in 2005

Image 2. Sediment recharge at the Allfleet's Marsh Managed Realignment site

2.4 Recent beneficial use projects and initiatives

Over recent years, a number of different small-scale beneficial use projects have been carried out using silt/clay sediments to enhance intertidal habitat. Some examples of these include the following (see Appendix A for some further details):

- At Northey Island in the Blackwater Estuary, new dredge deposits are being placed to enhance marshes (following the approach also adopted at the nearby Maldon Hythe Quay Marsh);
- At Loder's Cut, near Woodbridge in the Deben Estuary new deposits were placed to build a small island marsh in 2015 and 2017;
- At the Lymington Marshes in the Solent, sediment is being regularly 'bottom dumped' in front of an eroding marsh edge (see next section); and
- At Levington Marina on the Orwell, there are annual initiatives (working with the Suffolk Wildlife Trust) involving the pumping sediment onto adjacent marshes.

In addition to these practical examples of ongoing work, there are several organisations that are actively exploring the subject of beneficial use, and seeking ways in which such projects can implemented in the future. The RSPB has been conducting a SEABUDS (Sea-change in the Beneficial Use of Dredgings) project to help create a new precedent whereby dredged materials are routinely used to re-charge eroding islands, saltmarshes, mudflats and other areas of the coast, and through this provide multiple benefits (for priority species/habitats, flood defence and fisheries). Through this project a Beneficial Use Working Group has been set up that will meet every 6 months to promote and review progress on this subject. This value of beneficially using sediment was also recognised within the RSPB's recent Sustainable Shores Project (RSPB, 2018).

The Central Dredging Association (CEDA) has also set up a Working Group on Beneficial Use of Sediment (under the CEDA Environment Commission) to review the socio-economic benefits and approaches to beneficial use. This group will follow up and expand on the recommendations and guidance given in the PIANC (2009) publication on 'Dredged Material as a Resource', drawing on the lessons learned over the past 10 years. CEDA UK has also set up a Committee Liaison Group on the beneficial use of dredged material that is exploring the commercial aspects of this issue.

Following advice from the Natural Capital Committee, the Government has also set up four Pioneer projects to help identify good practice and develop innovative solutions as part of its work to develop a long-term strategy for the environment. Two of these Pioneer projects cover the marine environment, of which the 'Suffolk Marine Natural Capital Pioneer' (Eftec/ABPmer, 2017) has given specific consideration to the opportunities for beneficially using dredge arisings to restore coastal habitats and increasing the benefits they provide. The beneficial use elements of this study were, in turn, informed by a preceding review carried out by The Environment Bank (2015) which had considered the economic and investment case for saltmarsh restoration in the Deben Estuary specifically (on behalf of the Deben Estuary Partnership).

In addition to these programmes of work, as noted in Section 2.2, ABPmer hosted a conference on this specific topic in November 2016. Based on the feedback at that conference, and all the other initiatives that are underway, there does appear to be an increasing desire to see such projects implemented. This may well have been fuelled by some positive findings from completed projects in the UK and abroad.

2.5 Beneficial use in the Solent

In the Solent, there is essentially only one extant beneficial use location involving the use of silt/clay for recharging marine habitat[10]. This is at Lymington, where the Harbour Commissioners have very recently obtained a new 'saltmarsh recharge' MMO marine licence. This will allow them to bottom dump around 25% of their dredged sediment (10,000 wet tonnes) in front of the eroding Boiler Marsh until 2024[11]. The rest of their annual dredge volumes will continue to go to the Hurst Fort Disposal Site (W1080). It is hoped this recharge work will help to delay the loss of marsh and defer future breakwater construction (LHC, 2016).

This consent followed on from three successful trials that were undertaken between 2014 and 2017. These trials showed that the deposited material had shown a good degree of persistence. Material deposit at the end of 2016 was still largely there in mid-summer 2017 (Black and Veatch, 2017). The implications of this work on the water quality conditions and the changes for benthic invertebrate assemblages were also monitored. Over time, these materials will, of course, winnow away (in the same way that marsh itself is being eroded), but these deposits will act as a valuable 'sacrificial bund' that will help to shield a vulnerable part of the deteriorating marsh edge.

Two previous projects have also been progressed relatively recently at Lymington (in 2012 and 2013). These involved directly pumping sediment onto the marsh from the Yacht Haven Marina to the western marshes (LHC project) or double handling back hoed sediment and then pumping it onto Boiler Marsh (Wightlink Ltd project). These projects have been motivated by the need to slow the rate of saltmarsh erosion at Lymington, either as specific mitigation for potential developmental effects or as a more appropriate disposal option (than taking the material to the Hurst disposal site). Image 3 shows some photographs of these two projects.

In many ways, these projects have been useful 'trials', and their associated monitoring programmes (Black and Veatch, 2017 and 2012; ABPmer, 2015; and Lowe, 2012) have provided valuable lessons about the effectiveness of the techniques adopted (e.g. sediment delivery and retention), the

10 There are also occasional Treloar Hole subtidal depositions (see Section 2.3) at the mouth of Chichester Harbour but this is not direct deposition onto intertidal habitat.

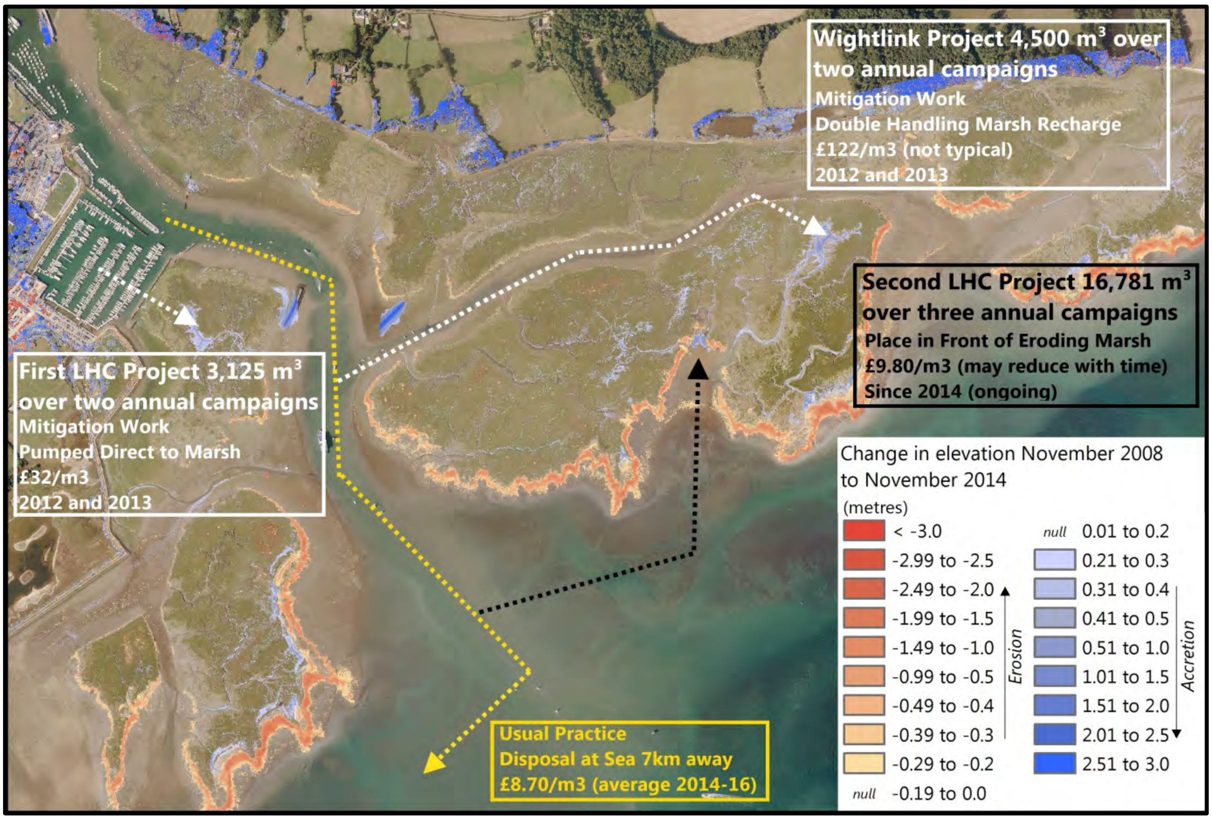
11 This is about 25% of their annual dredge commitments. The rest will go to Hurst Fort Disposal Site (W1080).

ecological effects and responses (e.g. plant growth and benthic invertebrate changes) and the, generally benign, water quality implications.

Sources: ABPmer (left & centre Wightlink project (2012)) and LHC (right 1st LHC project (2013))

Image 3. Photographs from the Lymington projects

It has been especially valuable, in both a regional and national context, that several very different techniques have now been employed at this single location. This is because it enables direct comparisons to be made between approaches. In particular, useful information with regard to the comparative costs of such techniques have been garnered, which will help inform future projects, and those insights have been captured in Appendix A. Image 4 compares the disposal routes and costs incurred for all three projects.



Source ABPmer (2017) using Environment Agency LiDAR data from 1999 and 2015

Image 4. Summary of disposal projects undertaken at Lymington over last few years

Away from Lymington, there have also has also been a recent feasibility review in the Hamble by the River Hamble Harbour Authority (Ahti & Marine Space Ltd., 2016). Out of this review a number beneficial use sites are being considered that may be taken forward in the near future.

There has also been a more broad-scale review of this subject across the south coast which was undertaken as part of the South Marine Plan Review (MMO, 2014a). On behalf of the MMO, ABPmer reviewed the beneficial use opportunities in the south marine plan area. This involved reviewing potential beneficial use sites that would require sand or silt (i.e. beach nourishments as well as habitat restoration) and included consulting with specialists in the south marine plan area. This recorded two other small beneficial silt re-use projects outside of the Solent in Poole Harbour as well as presenting a number of strategic recommendations for implementing beneficial use projects in the region.

A few years ago (in 2010), Southampton University also reviewed possible beneficial use sites in the Solent. This study was prompted by discussions with Hampshire County Council and The Environment Agency (Southampton University, 2010). It included a literature review of the topic, with specific consideration then being given to the viability of carrying out beneficial use at nine marshes that were owned by Hampshire County Council and a further eleven managed realignment sites that were considered within the Solent Dynamic Coast Project (SDCP) (Cope *et al*., 2008).

This Southampton University review used a Multi-Criteria Analysis (MCA) mechanism to examine and compare these sites. Eight selection criteria were used, which reflected the likely physical and ecological success of the scheme. These criteria included factors such as the presence of existing marshes, the habitat elevation (as an indication of the volume of sediment needed) and the spoil grain size. This study distinguished between areas of existing intertidal marshland that could be restored and areas of mudflat in possible managed realignments[12] that could be converted to marsh. On this basis, they identified three marsh locations (Gutner Point, Keyhaven and Calshot) where a trial might be undertaken, as well as three realignment locations (West Northey, Farlington and Pagham South). The ultimate recommendation of the Southampton University study was that these sites should be examined further and robust experimental trials pursued[13].

It is noted also that a sediment release trial was carried out in 2000 on the Hythe Foreshore (Southampton Water). This was a very small scale exploratory test (at the request of conservation bodies and land owners to limit anticipated effects) in which relatively small volumes of quite fluid sediment (1,000 m^3 in a series of small barge loads) were bottom dumped into the water column. Although some sediment settled out on the bed, it was mainly transported away in suspension. Ultimately, it was found that the material amount and the technique adopted was not sufficient to cause detectable environmental or physical impacts in terms of bathymetry, benthic community, chemical or particle size composition within the study area (ABP Research & Consultancy Ltd, 2001). Given the approach adopted, there was limited chance of it being successful as an intertidal recharge initiative but it did provide some lessons about sediment transport.

2.5.1 Solent Regional Habitat Compensation Project target

In considering the most appropriate locations and designs for any beneficial use project in the Solent, it is important to recognise the region's nature conservation priorities. The key indicators of these priorities are the targets within the Regional Habitat Compensation Project (RHCP). These targets

[12] The approach of placing dredge sediment in a managed realignment has not been considered specifically within this report because it is not clear whether it is really be appropriate in the Solent (see Section 2.3). This specific approach remains a possibility though see Section 2.3).

[13] Although such trials were not progressed at these particular locations, other projects have been conducted in the Solent (as described above) which can now be considered as appropriate and completed 'experimental trials'.

have has recently been reviewed and updated by the Environment Agency and the East Solent Coastal Partnership (Hilary Crane and Gavin Holder, East Solent Coastal Partnership (ESCP), pers. comm.).

The key revised objective is for the creation of 435 ha of saltmarsh over the next 100 years. The major change from past projections is that this new target recognises that, as existing saltmarshes are eroded, the extent of mudflat will increase. The projection is that there will be a surplus of mudflat of 43 ha in 100 years' time. It is worth noting that such marsh retreat and increase in the extent of mudflat also has implications for birds. It means that waterbirds (waders especially) should have sufficient feeding grounds and resources into the future, but they will increasingly struggle to finds safe high-water roosting and nesting locations.

Therefore, the primary future focus for the RHCP will be on creating saltmarsh habitat. This is important because it means that future beneficial use projects should be able to make a positive contribution to these targets, where they restore lost marshes or decrease the decline of existing marshes. It would also be especially helpful to these targets and the general functionality of the Solent coastline if such a beneficial use projects can create high-elevation marshes (even above the high water mark) that are available for roosting birds. It would be still more valuable if it were possible to restore declining marsh islands that are relatively inaccessible to predatory species to enhance the potential value of the habitats for roosting and/or nesting birds.

2.6 A description of scale

As things currently stand in the UK and Europe, no genuinely large-scale intertidal beneficial use projects have yet been carried out. Instead projects have mainly been undertaken as trials at a relatively small scale or in some rarer cases perhaps at what might be considered a medium scale. To better understand this however, there is a need to be clear about what can be said to constitute either a small or a large scale initiative.

To some degree the question of scale will be a site-specific one, but the simplest and best indicator is the volume of sediment used. To help answer this question, therefore, Image 5 shows the volumes of sediment that have been used in a range of recharge schemes. These include intertidal habitat restoration projects that have used silt as well as beach nourishment projects that have used sand.

This plot shows how individual intertidal recharge projects have used in the region of just few hundred to a few thousand cubic meters. It also shows (noting the logarithmic y axis) how these volumes are very small compared to beach nourishment works or, indeed, to the total amount of sediment that is deposited annually offshore in the Solent alone (around 1.2 million m^3). The largest individual projects were carried out in Suffolk and Essex using dredge sediment derived form from Harwich and Felixstowe. Here there have been one-off recharge projects (at Horsey Island, Trimley and Shotley) which have used between 15,000 and 94,000 m^3 of silt.

A number of projects though have involved repeated recharge initiatives at individual locations which then build up larger cumulative volumes over time. However in most cases these types of projects cannot really be seen as large scale either. For example, the small annual projects in the Blackwater (near Maldon) have probably used only a few 10s of thousands m^3 cumulatively over 30 years. In the Solent, the different projects that have been done at Lymington over the last few years have only re-used around 30,000 m^3 in total.

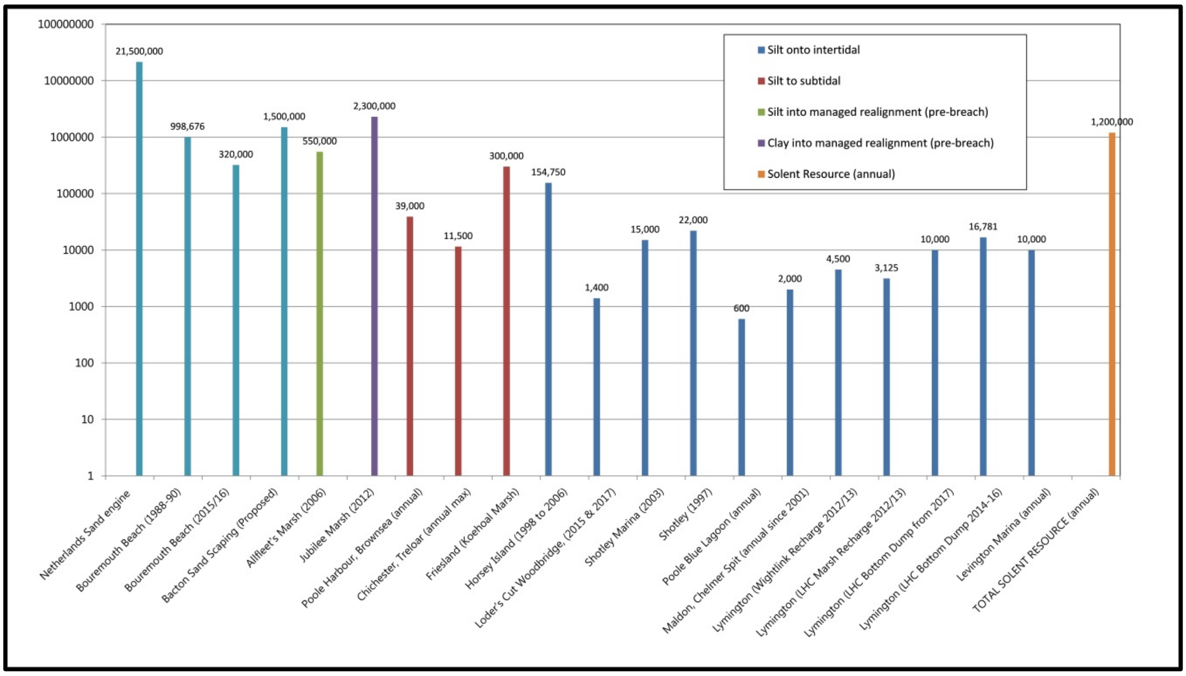


Image 5. **Volumes (m^3) of silt, clay or sand used in several recharge schemes**

The largest UK project is at Horsey Island where there were three separate placements which totalled around 150,000 m^3 of silt (and more shingle) over around 16 years to restore around 3 hectares of habitat (see Image 6). This cumulative project has been successful in delivering persistent intertidal habitat (ABPmer, 2016a). However, it remains small by comparison with the volumes that are used for beach nourishment, or the amount of materials that is deposited offshore, or the kind of volumes that have been used in the US for recharge projects. For example, in order to rebuild Poplar Island in Chesapeake Bay, 138 million m^3 of dredged materials are being utilised (Maryland Environmental Service, 2017).

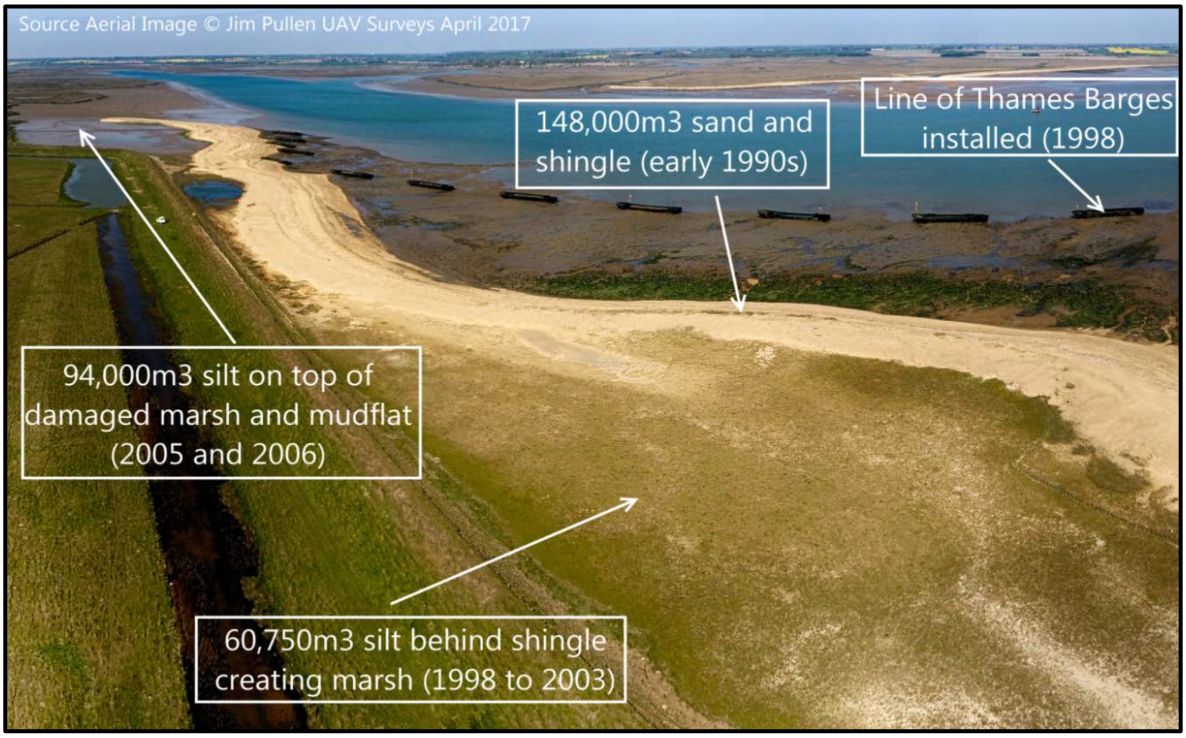


Image 6. **Aerial view of Horsey Recharge (April 2017) showing volumes in each campaign**

3 Selection Criteria and Mapping

3.1 Introduction

To help identify locations where dredge sediment might be used beneficially in the Solent, a four-phase approach was taken.

1. Firstly, a set of **selection criteria were identified** by ABPmer.
2. Then, a **data collation and mapping exercise** was carried out to assemble the spatial information necessary to evaluate locations on the basis of these criteria.
3. As a third stage in the process, a **consultation exercise** was conducted with a wide range of local specialists and interested parties. This was carried out to obtain extra site-specific information for the data collation mapping process but also to obtain views from these interested parties about the beneficial use options in the light of their local and specialist knowledge.
4. As the final task, and a key part of the consultation process, a **workshop** was held on 6 December 2017. At this workshop, 24 stakeholders met and reviewed maps of the Solent and prioritised sites for future consideration.

Further details about the methods adopted for each of these project stages are presented within the following four sections.

3.2 Criteria for site selection

It is evident from the introductory literature review, that if more beneficial use projects are to be achieved, especially at a large scale, it will be necessary to identify locations where such initiatives will provide clear benefits and have a distinct socio-economic justification. Otherwise, it is unlikely that the established challenges to implementation can be overcome and the necessary project funding secured. Indeed, the most viable and successful beneficial use projects are likely to be the ones that achieve multiple benefits such as enhancing coastal defences while also reducing/reversing habitat erosion. Ensuring that a project has clearly defined benefits is therefore seen as the primary consideration in the site selection process.

As a second consideration, a project must also be technically achievable and, here again, cost is a key consideration. In many ways there is nothing that cannot be achieved technically; however, a balance needs to be struck between how much a project will cost and what gains it can attain (and for how long it can achieve them). In general, larger-scale and more technically complex projects can create more extensive and persistent marshes with greater benefits over longer timeframes, but they also incur higher fees. By contrast lower costs solutions generally will have more modest costs, but much shorter-term benefits.

Recognising the importance of these two key considerations, a set of site-selection criteria were developed under the following two headings:

- **Objectives and Benefits**: A set of criteria which help identify recharge locations where there will be clear benefits and beneficiaries. This includes locations where there are vulnerable habitats, coastal defences or low-lying hinterland areas; and
- **Issues and Challenges**: A set of criteria which help to identify potential issues and possible constraints including the nature conservation values, the shoreline morphology and the practicalities of undertaking projects and the availability of a sediment source.

Under these two headings as set of 11 site-evaluation criteria were identified. These are each expressed as questions as follows.

- **Objectives and Benefits**
  1. Would the habitats benefit because they are in poor condition or eroding?
  2. Are the habitats fronting vulnerable sea defences that would benefit?
  3. Is the area behind the sea walls low lying or of high value?

- **Issues and Challenges**
  1. Is the area of nature conservation value?
  2. Is the area important for fisheries?
  3. Is the area shallow enough for low intertidal or subtidal placement?
  4. Can features or structures be introduced to retain sediment?
  5. Is the area used for recreational boating?
  6. Is the site close to a source of sediment?
  7. Can the site be accessed by appropriate vessels?
  8. Are there any sites which have been identified before?

These criteria were presented and agreed at the first meeting of the Technical Group (held on 27 September 2017) which oversees this BUDS project. The mapping work undertaken to evaluate sites on the basis of these 11 criteria is described in the following section.

3.3 Criteria mapping

To provide a mechanism by which these criteria can be evaluated to identify beneficial use locations, a WebGIS system was created and selected data maps were uploaded onto it. To set up this mapping product, relevant data was obtained and stored within an ArcGIS Geodatabase. This was then imported into ArcGIS Pro and, where necessary, it was clipped to exclude data across the rest of the UK outside the Solent region (although the map has been extended west to include Poole Harbour because this is an area of interest for past, present and possible future beneficial use initiatives). This clipping was undertaken to reduce processing times and storage space, which then also helps to ensure that the mapping product can be relatively quickly interrogated.

The spatial data was then organised and assigned suitable nomenclature and symbology, before being uploaded to the ArcGIS Online Platform and customised for use within a 'WebApp'. Within this online "Solent BUDS Criteria Map", all relevant data is visible to the public in the form of separate layers. The key data sources and layers are described in the following sections and metadata is also summarised in Appendix C. The final product of this process is a publicly-accessible WebGIS system which can be interrogated online[14].

The following sections review the issues and the mapping data that has been collated/created, whether that is to evaluate sites based on the potential 'objectives and benefits' (Sections 3.3.1 to 3.3.3), or describe the 'issues and challenges' (Sections 3.3.4 to 3.3.11) that will be pertinent for any future project.

3.3.1 Would the habitats benefit because they are in poor condition or eroding?

The largest gains from beneficial use will arise where (large) expanses of deteriorating marshes can be restored. The best and most cost-effective way to achieve this will be over shallow intertidal and

[14] Available at www.abpmer.maps.arcgis.com/apps/webappviewer/index.html?id=84f75915f4d64d3f84d82e7b8923e9ba

subtidal platforms. To identify these areas, and describe the location and extent of coastal habitats, as well as highlighting those habitats which are vulnerable and would benefit from a recharge project, the following data sources were obtained and uploaded to the BUDS WebApp:

- **Layer 1a) Marsh Habitat Extent (Environment Agency):** The national Environment Agency Saltmarsh Extents layer (from 2009) was obtained to provide a background illustration of marsh extents throughout the Solent (see Image 7).
- **Layer 1b) Mud Habitat Extent (EMODnet):** The EMODnet mudflat layer, which indicates the coverage of this habitat was extracted from the EMODnet seabed habitat dataset (see Image 7).
- **Layer 1c) Marsh Habitat Condition (MMO/ABPmer)**: A layer created for the MMO in 2014 (MMO, 2014a), depicting intertidal SSSI-designated areas which are deemed to be in a poor condition due to erosion and the effects of coastal squeeze.

The first of these datalayers describes the extent of saltmarsh (as of 2009, so potential deterioration of marsh since this date needs to be recognised) and is important, in the first instance, for simply showing where there is marsh habitat that could be recharged. As many of these marshes are eroding and being converted to mudflat, comparing these marsh extents with the second datalayer (of mudflat extent) then also provides quite a good indication of where this marsh erosion is happening and to what degree.

Image 7. Indicative extent of mud and marsh habitat (Layers 1a and 1b)

The third datalayer also indicates where marshes and mudflats are vulnerable to erosion and coastal squeeze based on the SSSI site condition assessments and/or outputs from the Solent Dynamic Coast Project (SDCP). It shows that the majority of the intertidal habitats in the Solent are facing these pressures. In addition to this datalayer, the SDCP report (Cope *et al.*, 2008) provides a valuable and quantitative description of the locations and rates of this marsh retreat (see, for example, Image 8).

It is noted that the available reviews of individual SSSI unit condition assessments do not provide a complete and up-to-date understanding about marsh condition throughout the whole Solent. For example it does not always identify areas where there is qualitative (ecological) deterioration. Natural

England is, however, conducting a more formal condition assessment for marsh features within the SAC and SPA areas (Sandra Unterhollenberg, Natural England, pers. comm.) that could be used in the future.

For the purposes of this study, however, it has been agreed with the Technical Group that it is appropriate to assume that there are few marshes in the Solent which are in a favourable condition and that almost all would benefit to some degree from sediment recharge.

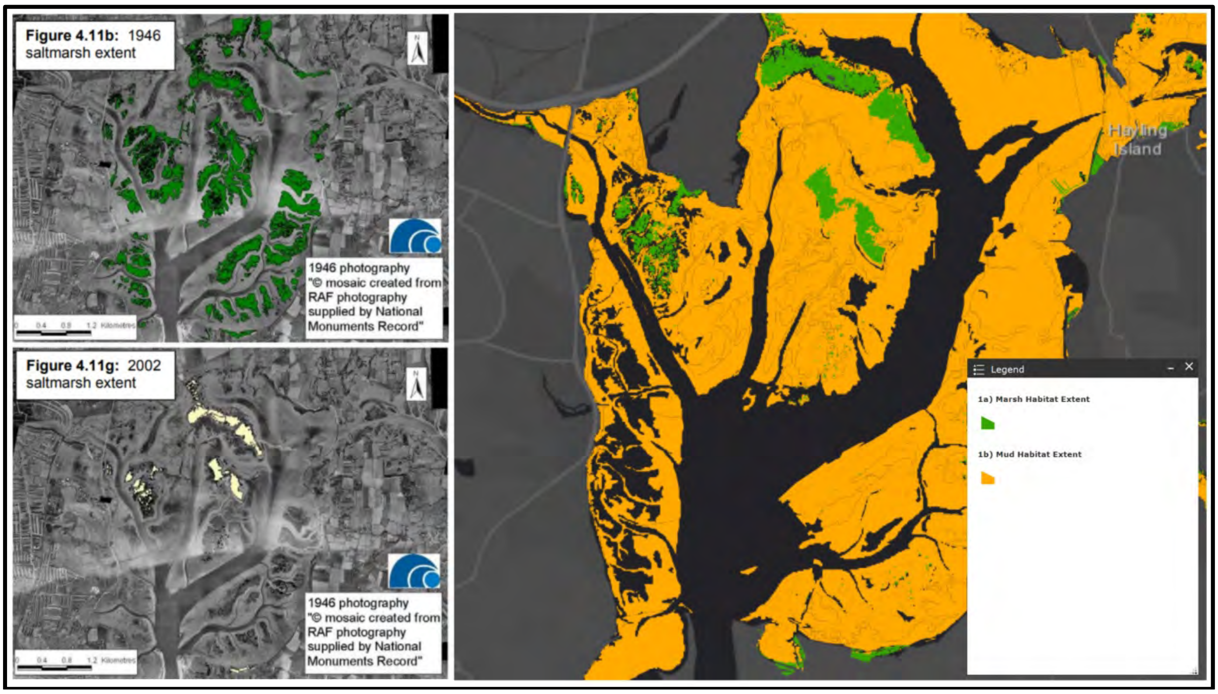


Image 8. Langstone Harbour SDCP marsh erosion plots (left) and BUDS map (right)

3.3.2 Are the habitats fronting vulnerable sea defences that would benefit?

In terms of the coastal protection benefits that could arise from a potential project, the clearest gains will arise in locations where the sea defences are currently in a poor conditions and are in need of repair and investment. It will also be valuable to show that any recharge initiative is in keeping with the established Shoreline Management Plan (SMP) policy for that section of coast.

To therefore, identify the shoreline polices and the areas where coastal defences are in a relatively poor condition, the following data sources were obtained and uploaded to the BUDS Map:

- **Layer 2a) SMP Defence Policy (Environment Agency)**: This layers describes the SMP Policy (i.e. hold the line, managed realignment of no active intervention) for the next 20 years.
- **Layer 2b) Defence Type (Environment Agency):** This layer presents an Environmental Agency dataset which describes the type of coastal defences (e.g. embankment, barrier breach, promenade etc.) throughout the Solent.
- **Layer 2c) Defence Type (CCO):** This layer also describes the nature of the coastal defences throughout the Solent using the CCO defence type layer.
- **Layer 2d) Defence Condition (ESCP):** This layer contains the ESCP Asset Review dataset for the eastern Solent showing the defence conditions as their anticipated lifespan (expressed either as more than 10 years, 1 to 10 years and < 1 year) (see Image 9).

- **Layer 2e) Defence Condition (Environment Agency):** This layer contains the Environment Agency defence condition information, but now covering the whole Solent rather than just the eastern side. Here the defences are rated from 0 (good condition) to 5 (poor condition).

It is noted that a SMP review is underway which may change some of the shoreline policy allocations. Also, the ESCP coastal asset dataset is currently under review (Hilary Crane, ESCP, pers. comm.). Once this is completed, it could be added to the BUDS mapping product. Further details about the coastal defence works that are currently being undertaken or are proposed for coming years can also be obtained from the ESCP web site, amongst others.

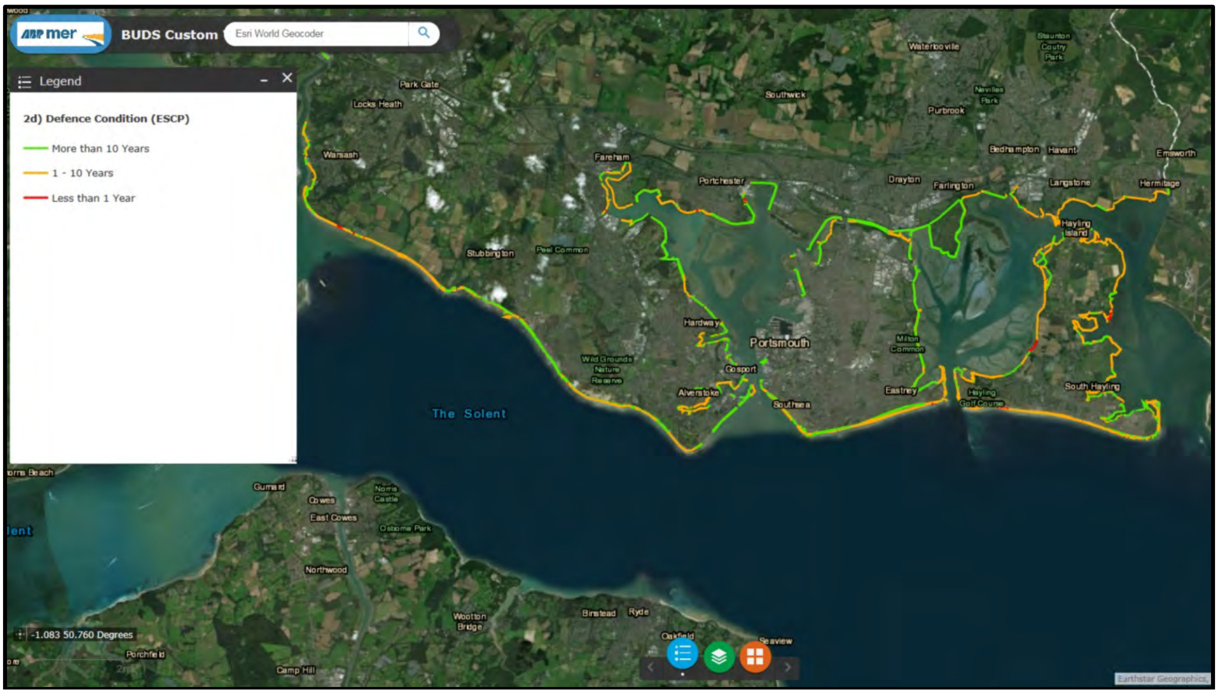


Image 9. ESCP asset map showing defence condition as anticipated lifespan (Layer 2d)

3.3.3 Is the area behind the sea walls low lying or of high value?

Another factor that will influence the extent to which a beneficial use project can provide a coastal defence is the vulnerability of the hinterland. The economic justification will be more obvious, and a funding application will be easier to make, if it will help to protect areas of the coast that are low lying or have a high value.

To help describe this potential benefit, the following data sources were obtained and uploaded to the BUDS Map:

- **Layer 3a) Hinterland Vulnerability (FZ3) (Environment Agency):** This layer describes the Environment Agency Flood Zone 3 dataset which describes the extent of the hinterland that is at risk from flooding with a 1 in 100 or greater annual probability of flooding from the sea (>0.5%) in any year.
- **Layer 3b) Hinterland Vulnerability (FZ2) (Environment Agency):** This layer describes the Environment Agency Flood Zone 2 dataset which describes the extent of the hinterland that is at risk from flooding with between a 1 in 200 and a 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.

These layers (see Image 10) can then be compared against datasets which show the extent of hinterland infrastructure and indicate the potential value of 'at risk' in the flood plain behind the sea walls. Such datasets include Ordnance Survey MasterMap layers, which, due to licencing restrictions, could not be included on the BUDS Map.

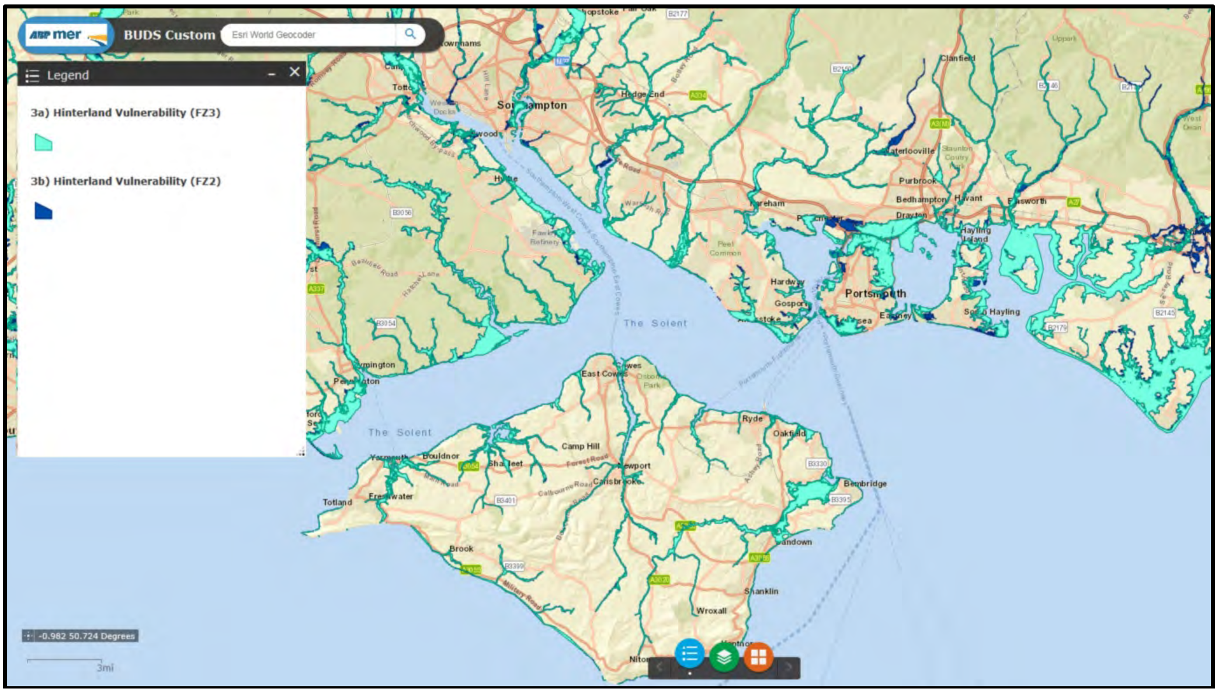


Image 10. Environment Agency maps showing hinterland flood risk (Layers 3a and 3b)

3.3.4 Is the area of nature conservation value?

To describe the areas of nature conservation value, the following data layers were obtained and uploaded to the BUDS Map:

- **Layer 4a) Nature Conservation Areas (SAC) (Natural England):** This layer describes the extent of designated Special Areas of Conservation (SACs) across the Solent (see Image 11).
- **Layer 4c) Nature Conservation Areas (Ramsar Wetland Site) (Natural England):** This layer describes the extent of designated Ramsar Wetlands across the Solent.
- **Layer 4d) Nature Conservation Areas (MCZ) (Natural England):** This layer describes the location of designated Marine Conservation Zones (MCZs) in the Solent.
- **Layer 4d) Nature Conservation Areas (Special Protection Areas) (Natural England):** This layer describes the extent of designated Special Protection Areas (SPAs) across the Solent.

As the majority of the Solent's intertidal habitats are internationally designated, almost all possible beneficial use projects sites will have an effect on, or benefit for, one or more of these protected areas. It will therefore be necessary to recognise the direct and the indirect effects of the proposed project(s) on relevant interest features of the local designated site(s) and to acknowledge that, while there is a lot of useful evidence from past case examples, there will invariably be some degree of uncertainty inherent in seeking to achieve potentially major habitat changes. To assist with these considerations, additional habitat maps may need to be consulted in order to understand the surrounding habitats and features that may lie within a zone of influence from a proposed project. This could, for example, include seagrass beds.

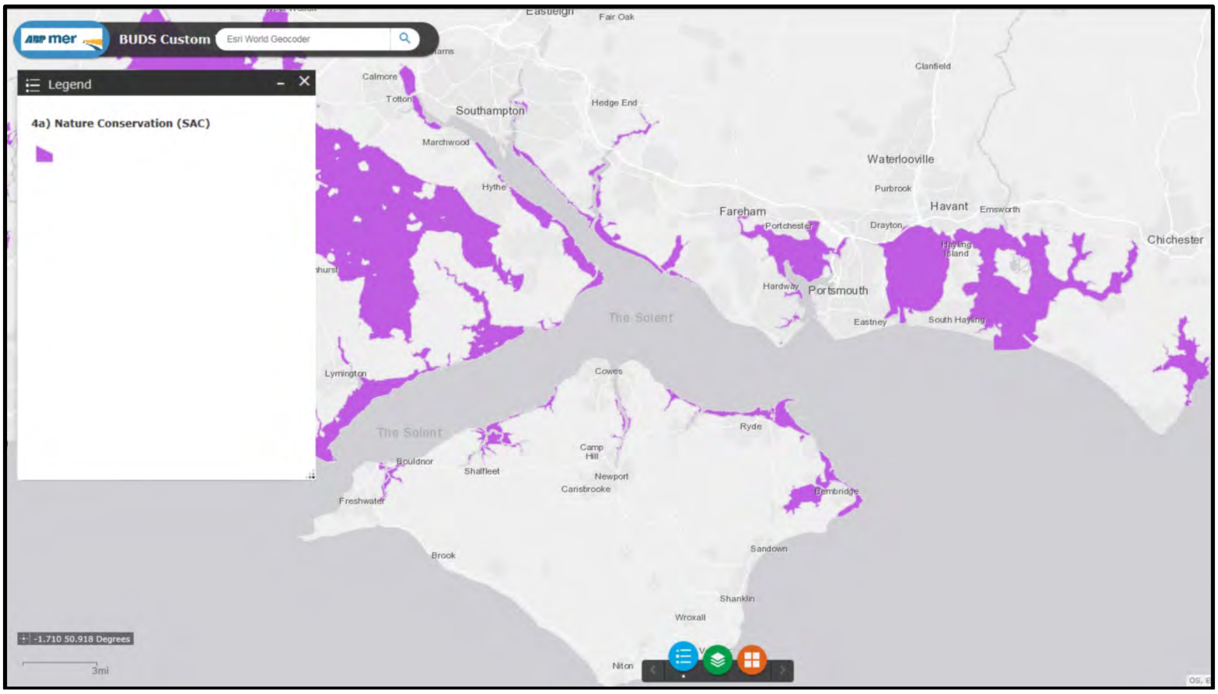


Image 11. Extent of designated Special Area of Conservation (Layer 4b)

3.3.5 Is the area important for fisheries?

To generally describe areas which are of fisheries (and water quality) value, a layer of Shellfish Waters in the Solent was obtained and uploaded to the BUDS Map (**Layer 5a (Natural England)**, see Image 12). Within the Solent and Southampton Water there are several such areas covering most of the region. The Water Framework Directive requires all protected shellfish areas to comply with standards including for dissolved oxygen, suspended solids, metals and other contaminants.

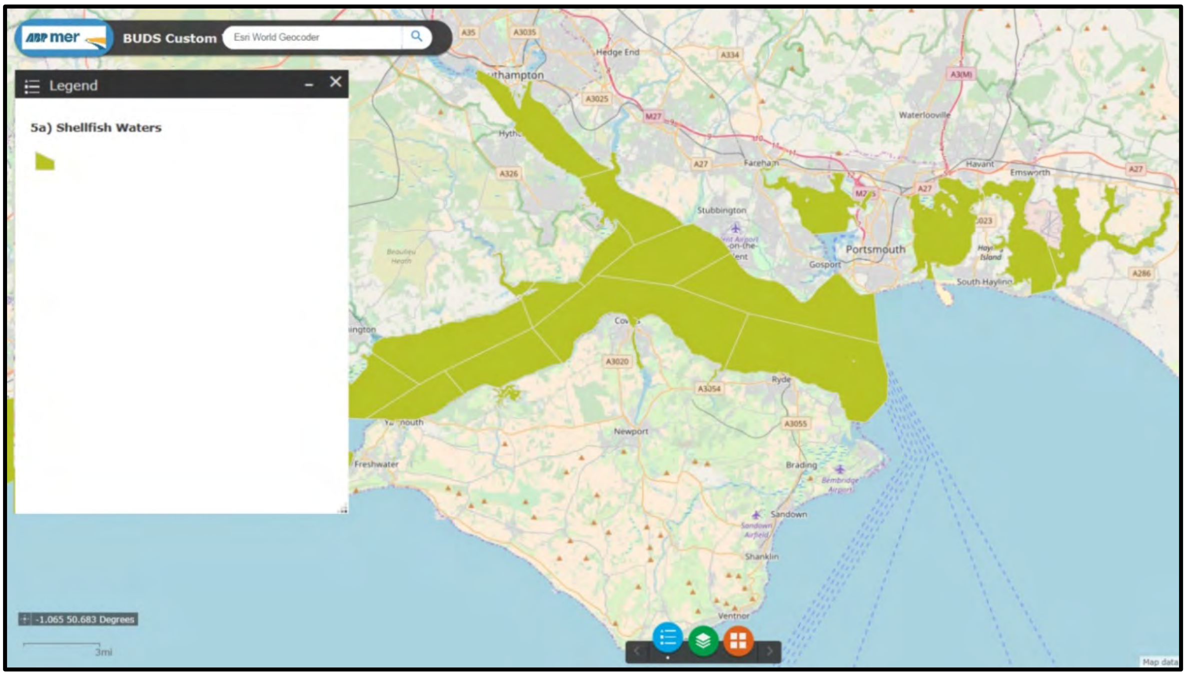


Image 12. Ares designated as Shellfish Waters (Layer 5a)

Almost all areas of the Solent will have some direct or indirect value to fish and fishing and therefore it is difficult to exclude, or select out, sites on the basis of this issue alone. However, it is important that this aspect is noted during site selection as well as during project design and implementation. Also, there will be other layers that might also be added to the maps at a future time (e.g. the location of oyster beds, oyster restoration sites).

3.3.6 Is the area shallow enough for low intertidal or subtidal placement?

In order for any beneficial use project to be efficient and effective, it will be important for there to be a shallow water 'platform' on which the dredged sediment can be placed (as noted in Section 3.3.1). As the aim is to create and restore intertidal habitat, both money and time would be wasted if sediments were placed at too great a depth. Conversely, smaller volumes of sediment can be used to create and restore comparatively large expanses of habitat if they are placed in intertidal areas, or subtidal areas at a shallow depth.

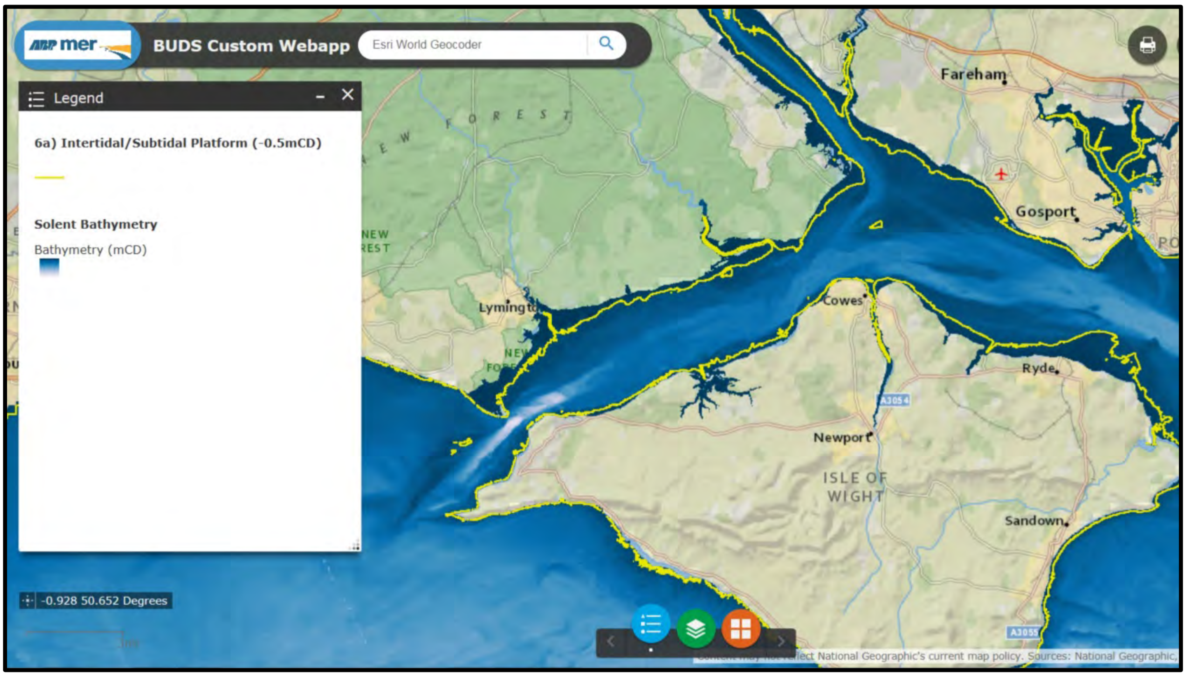


Image 13. Solent bathymetry with 0.5 m below CD contour describing shoreline platform

In the Solent, given that most of the marshes have been retreating and converting to mudflats over the last few decades, most of the marshes (especially the larger expanses) already have a suitable intertidal platform in front of them. The extents of fronting intertidal platforms are therefore indicated to a large degree by the extent of the mudflats which front the remaining marshes (see Layer 1b) Habitat Extent (Mud)').

However, to also illustrate the broader opportunities and the wider extent of the shallow subtidal platform, the following two layers have been uploaded into the BUDS Map.

- **Base Layer Solent Bathymetry (ABPmer Digital Terrain Model (DTM)):** This layer presents an integrated Digital Terrain Model (DTM) of the Solent which was assembled from various bathymetric sources and used for ABPmer's English Channel Model Bathymetry (ABPmer, 2016b). This is presented in Chart Datum (CD) and can be selected to appear at the bottom of the online mapping layers (as it would otherwise overlap all the other layered information).

- **Layer 6a) Shallow subtidal platform (ABPmer DTM):** Using the base layer bathymetry DTM, the alignment of the 0.5 m below CD elevation[15] was extracted to describe the extent of the shallow shoreline platform fronting the intertidal areas.

3.3.7 Can features or structures be introduced to retain sediment?

There are several ways in which sediments have been retained *in situ* as part of past beneficial use projects (see also Section 2.3) and these include the following:

- **Shingle barrier**. Dredged shingle has been successfully used to create a natural barrier at sites such as Horsey Island, Shotley Foreshore, and along the Trimley shoreline. In each of these three sites, the area behind the barrier was then infilled with maintenance dredged mud to stabilise the barrier. Depending on the elevation that the mud then settled to behind the shingle frontage this soft sediment then created either marsh or mudflat.
- **Fencing with posts, polders and/or bales**. This approach has been used for two of the recharge sites at Lymington Boiler Marsh.
- **Coir logs.** Coir logs have been used for small scale projects such as the Levington project. .

While these three approaches have been used for previous intertidal projects there may well be other mechanism that could be appropriate. For example, for the Marker Wadden project in the (tide less freshwater) Marker Mere embayment near Amsterdam, dredged ‘sand bunding’ was used with some quarried stone on the exposed west face. Clay bunding was used to contain soft fluid silt in the Allfleet’s Marsh project, although this was done in a managed realignment site in the months before the tide was introduced (see also Section 2.3). There are also options for using geotextile membranes/tubes (Wortelboer, 2014), or perhaps other more recent and innovative technologies such as biodegradable fencing.

In general, the larger projects which will require greater volumes of dredge sediment will need more robust and larger structures to ensure retention of sediment. Consideration will need to be given though as to how the natural environment can be used to best effect. For example, the existing vegetation of a marsh can be used to naturally trap sediment where suction dredged materials is pumped across it.

No spatial map can be used to illustrate this concept but the ‘platform’ layer that was created (see previous section) can be used as a guide to understanding the extent of any potential recharge area.

3.3.8 Is the area used for recreational boating?

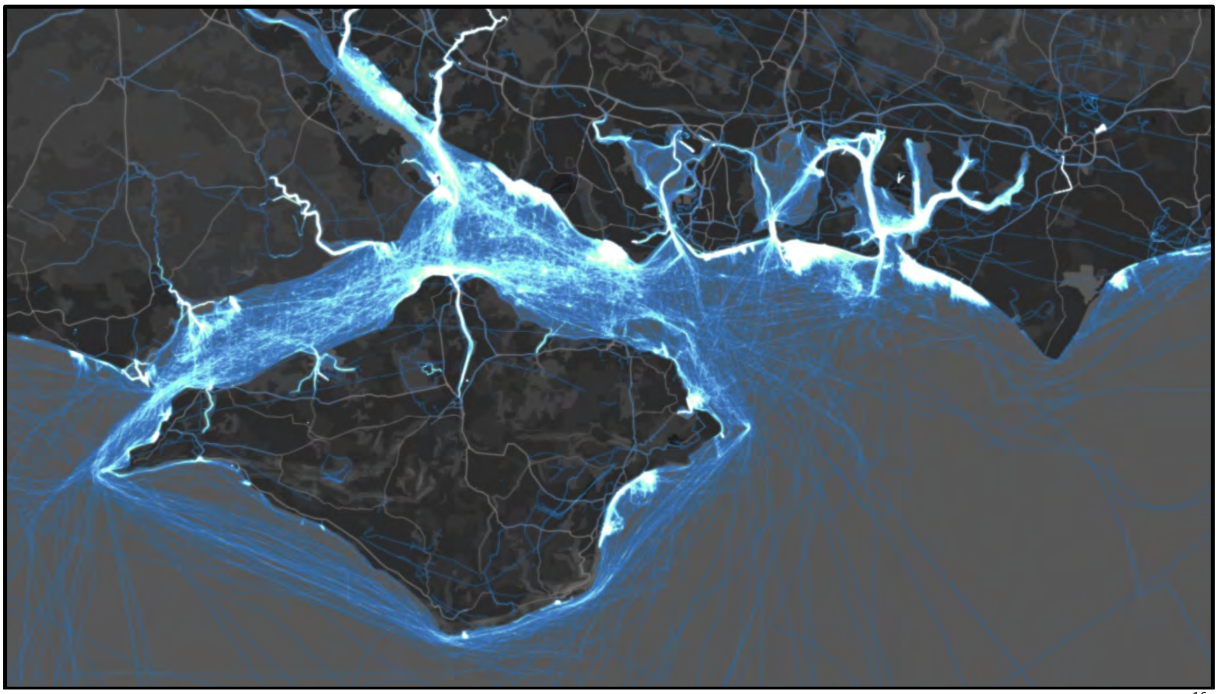
For any recharge project that is undertaken in the Solent, it will be important to consider whether there could by any conflict with recreational boating. To help describe this aspect, the following three layers have been uploaded into the BUDS Map.

- **Layer 7a) Sailing Areas (Royal Yacht Association (RYA)):** This layer from RYA mapping describes the area of recreational navigation including cruising routes, sailing areas, racing areas, general boating areas. This area encompasses a large swathe of the Solent.
- **Layer 7b) Cruising Routes (RYA):** This layer from the RYA mapping specifically describes the cruising routes for recreational craft.

15 The depth relative to CD, rather than Ordnance Datum (OD), was used to ensure a degree of consistency in the analysis across the Solent.

- **Layer 7c) Vessel Movements (ABPmer):** Using data collected by ABPmer in 2015 (following a review of vessel AIS (Automatic Identification System) data for the MMO (2014b)), this layer presents a dataset of vessel movements.

As shown by these layers, much of the Solent is used for boating. However, it should be noted that there are also many hot spots for nearshore recreational watersports such as swimming, walking, canoeing, kitesurfing, rowing, stand up paddling, and surfing. Whilst, as with other issues such as nature conservation or shellfish waters, it is difficult to exclude, or select out, sites on the basis of such activities alone, it is important that these aspects are noted during site selection, as well as project design and implementation. One source of information for nearshore activities could be a map from the Strava Labs Application, which describes the spatial activity pattern for nearshore as well as recreational sailing (see Image 14).



Source: Strava Labs 2017[16]

Image 14. Strava 'heat map' describing the spatial intensity of recreational activities

3.3.9 Is the site close to a source of sediment?

One of the most important considerations when developing a beneficial use project, and selecting a suitable site, is related to the availability of an appropriate source of sediment. There are also several subsidiary issues to consider in this context, including: the volume of the sediment, the frequency/reliability of this source, the appropriateness of the sediment grain size, the proximity of the source to the beneficial use site and the dredging methods used.

In terms of volumes and reliability, this will depend on whether the material is obtained during a capital dredge (ideally suited to one-off projects), or whether smaller and more consistent volumes are to be available from regular and ongoing maintenance dredging of marinas, harbour basins and navigation channels. For the purposes of this study, it is largely the maintenance sediments that are considered. This is both because they are reliable and predictable, but also because the sediment type is likely to be more consistent and also because they generally yield finer sediment which is more appropriate to intertidal habitat restoration.

16 Please note that this is not a layer on the BUDS mapping product.

Proximity is an important factor because the costs incurred for deposition are related to the distances over which sediment has to be moved; with longer distances involving longer turnaround times and greater fuel costs for dredge/transporter barges. In addition, the technical complexity of the recharge work, and the time it will take to unload a barge, will also influence the costs. Therefore, it is important to also understand how the sediment is dredged in order to determine the techniques that might need to be used for the recharge.

Understanding the spatial relationship between the sites that have a reliable and suitable source of sediment and intertidal areas that could use this sediment is therefore a key consideration. As discussed in Section 1, there is a good understanding about the overall volumes of sediment that are dredged and the locations where they are deposited. However, to describe the regional patterns in greater detail for this study, the following tasks were undertaken and related layers advanced/created and displayed within the BUDS Map.

- **Layer 8a) Location Ports and Harbours (ABPmer, based primarily on RYA data):** To describe the location of the ports and harbours where dredging takes place, data from the RYA was obtained. This was supplemented by an extra review by ABPmer to fill in any gaps.
- **Layer 8b) Dredge Locations Volumes (ABPmer, based primarily on MMO and Defra data):** To understand the volumes of dredged sediment that is being excavated on a regular basis (for maintenance work), a review was carried out using the following sources:
    - **MMO public register**[17]: This online register provides information on the sediment volumes and the types of dredge material from major ports/marinas within the Solent;
    - **MMO Marine Information System (MIS)**[18]: This online GIS WebMap resource describes the locations and extents of historic and current dredge licenses. It also includes the most recent marine licences. For this review, each site on the map was cross-referenced with the current dredge licence in the public register, and the most recent permitted sediment removal/disposal volumes for each individual site were recorded; and
    - **Maintenance Dredge Protocol (MDP) Documents**: Further information on the volumes, frequency, types of dredge material and maintenance dredge and disposal methodologies available were collected from publicly available MDP baseline documents. The outcome of this process is shown in Image 15 (see also Appendix B).
- **Layer 8c) Dredge/Disposal Schematic (ABPmer; from consultation, depicting disposal grounds using Cefas datalayer)**: To build upon the information collated from the above sources, and also to fill any gaps, a consultation exercise was undertaken with a wide range of interested parties and specialists throughout the Solent (see also Section 3.4). This was done to draw upon their local knowledge and obtain a more detailed understanding of the dredging activities, methods and disposal routes. In addition the established disposal locations were obtained from the Cefas database. As a product of that process, layer 8c presents a summary schematic representation of dredging activities in the Solent (see Image 16).

In addition to the information that was presented within the BUDS mapping system, an overview and tabular summary of activities in the Solent is presented within Appendix B. This provides a proportional representation of the maximum quantities of silt material licensed to be disposed of at sea via ongoing (maintenance) dredge campaigns, and therefore provides an upper estimate of the amount of material potentially available for beneficial use projects within the Solent area.

17 https://marinelicensing.marinemanagement.org.uk/mmofox5/fox/live/MMO_PUBLIC_REGISTER
18 http://defra.maps.arcgis.com/apps/webappviewer/index.html?id=3dc94e81a22e41a6ace0bd327af4f346

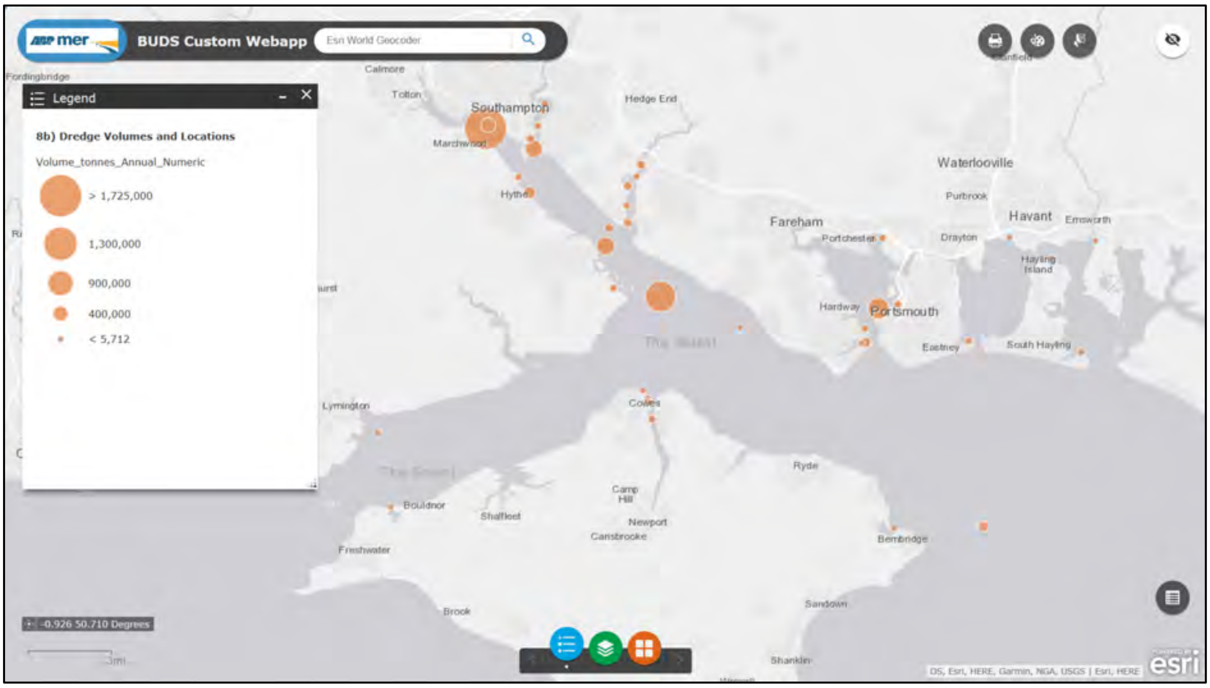


Image 15. **Maintenance dredge volumes (Layer 8b) based mainly on MMO marine licences**

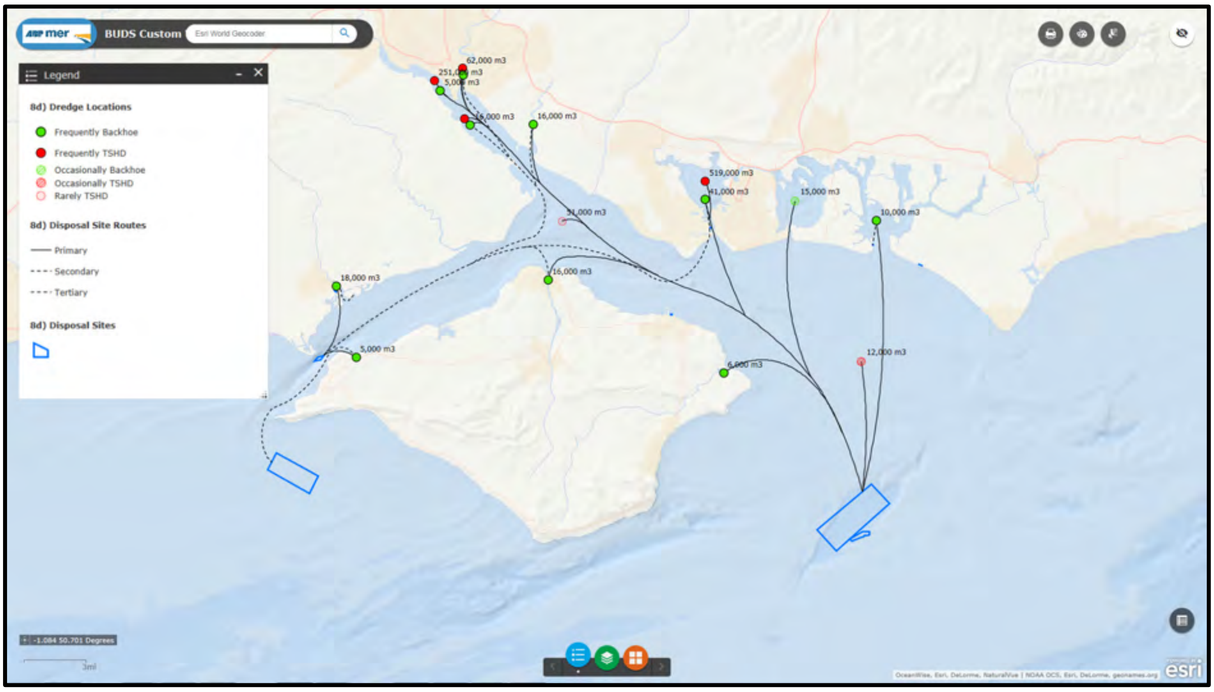


Image 16. **Illustration of dredging and disposal activities in the Solent (Layer 8d)**

3.3.10 Can the site be accessed by appropriate vessels?

One of the central technical challenges with beneficial use projects is the process of actually delivering the sediment to the intertidal, or shallow subtidal areas. There are several ways in which this can be done (and six key methods are summarised in Section 2.3), with the preferred option being influenced by multiple factors such as: project scale, site location, existing vessel size(s), coastal topography/bathymetry, distance to the site and the amount of time available.

To help evaluate the general feasibility of a beneficial use project, it is helpful to understand whether dredging vessels can actually get to, or near, the site in question in the first place. In theory, the majority of intertidal areas can be accessed by pumping from a vessel, but this will come at a large cost in some cases. To inform judgements on this issue, bathymetric data for the whole of Solent was obtained (from the English Channel Model (ABPmer 2016b)) and compared against the depths that are required for access by large and small vessels. This is on the basis that large and small vessels, and the different ways in which they might operate, define the spectrum of what can be achieved and the minimum and maximum areas that could be accessed.

In simple terms, it is assumed that the largest vessels which could be used to pump material ashore are the dredgers which maintain the Southampton or Portsmouth approach channels. Such vessels are expected to need around 7 to 8 m of water depth. In Southampton Water, for example, UK Dredging's Bluefin Trailer Suction Hopper Dredger (TSHD) has a loaded draft of 6.7 m[19]. Therefore, assuming it needs around 0.5 m depth of water, it will only be able to safely get into areas with a minimum of 7.2 m depth of water. The minimum area that these plants could cover at all states of the tide is therefore defined as around 7.2 below CD (although they could clearly have time restricted access to wider areas at higher states of the tide).

At the smaller scale, split barge hoppers can get much closer inshore and bottom dump material, especially at high water. This has been demonstrated by the work that has been done at Lymington where these barges have been able to deposit materials (and then float away) at baseline intertidal elevation of around 0.8 to 1.2 m above CD but also achieve deposit elevations of 1.7 to 2 m above CD (Black and Veatch 2017). This would represent the maximum areas that could be covered.

Although it is not possible capture all these issues and nuances in a single spatial layer, the following depth levels have been added to the BUDS map to give a broad indication as to the minimum and maximum areas that can be covered by the range of vessels operating ion the Solent.

- **Layer 9a) Minimum Vessel Access Area (ABPmer DTM)**: Using the base layer bathymetry the following contour alignments have been extracted:
    - Maximum Vessel Access Area (+2 m CD) to describe the area that might only be covered by hopper barges at high water;
    - Minimum Vessel Access Area (-6.5 m CD) to describe the area that might be covered by larger TSHDs barges at low water as well as small craft; and
    - The alignment of the 0 m CD) is also shown as a further indication of the maximum extent of 'intertidal' level.

This layer is illustrated in Image 17.

19 http://www.ukdredging.co.uk/UKD_Fleet/UKD_Bluefin/

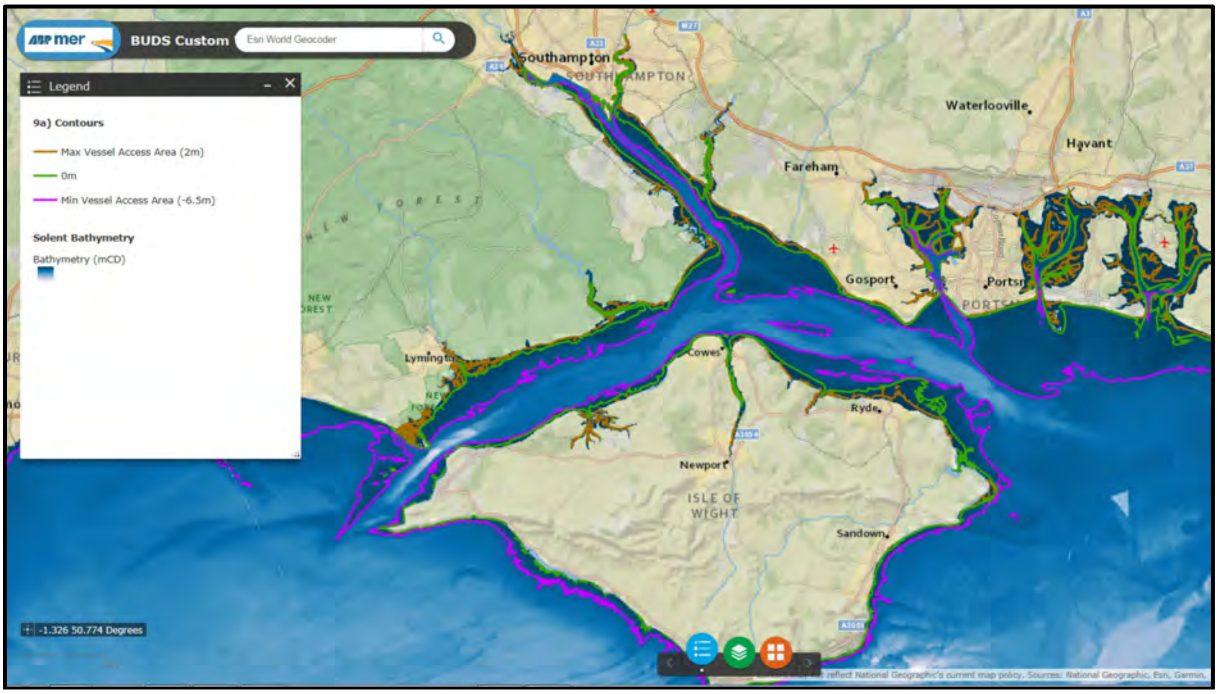


Image 17. Solent bathymetry with depth contours as a guide to vessel access areas

3.3.11 Are there any sites which have been identified before?

As the final consideration for this review, a number of sites were identified that have previously been used, or considered for use, as beneficial use project sites. They were identified from the South Marine Plan Review (MMO, 2014a), a review of extant MMO licences (which highlights the new Lymington project) and the three sites selected following the Southampton University (2010) review.

There are only a few such sites and the rationale for selecting them is not necessarily the same as the one used here for this BUDS study. They are captured in a single layer as follows.

- **Layer 10a) Previous Sites (actual or proposed):** A list of previous and ongoing beneficial use projects sites and trials in the Solent based especially on past reviews and including sites used or proposed for: beach nourishment, sustainable relocation, actual intertidal recharge and trial studies[20].

Many of these sites and the studies that underpinned them are also reviewed in Section 2.5.

This layer is illustrated in Image 18.

20 Additional information out to the Poole Harbour area is also shown on this map.

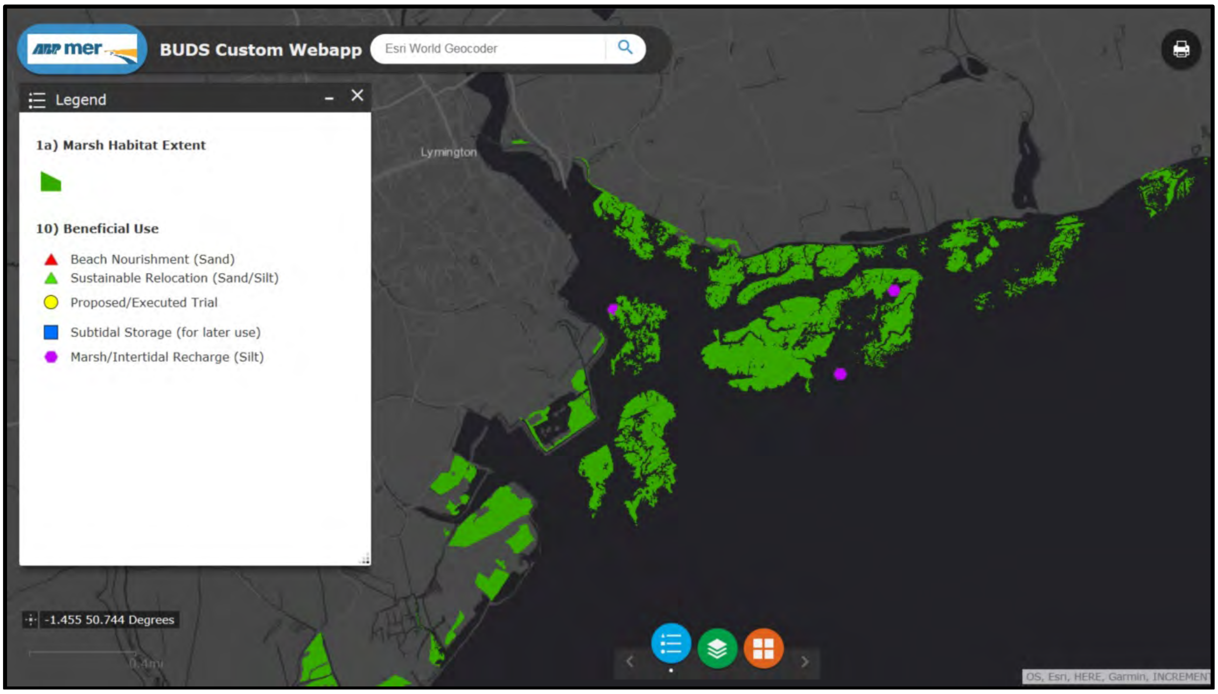


Image 18. **Previous sites (actual or proposed) focussing on Lymington Area (Layer 10a)**

3.4 Consultations and workshop

As described in Section 2.1, when reviewing dredging activities and exploring the strategic opportunities for beneficial use it can be difficult to obtain all the necessary background information about the industry. A lot of information is available in the public domain (e.g. MMO online licence register), but it can be challenging to then select out the specific detail that is required to make decisions about beneficial use options. Therefore more specific detail needs to be obtained directly from the key participants in the sector. Local consultation is also needed in order to highlight certain key issues (whether environmental or technical) to help inform judgements about the best beneficial use sites.

A key part of this project therefore involved consultation with a wide range of interested stakeholders to seek their views on the industry and the future opportunities. For this work, all the main ports, harbour authorities, marina owners and industry specialists were contacted. They were introduced to the project and asked the following:

- Where they dredge?,
- What technique they use?,
- What sediment type it is?,
- What are the volumes and frequency of dredging?,
- Where they deposit?, and
- Whether they have any ideas about future beneficial use options?.

Local authorities, Natural England and non-governmental organisations (NGOs) (e.g. Wildlife Trust and RSPB) were also invited to comment about areas that need coastal protection of environmental enhancement. Around 50 different people were contacted as part of this process. All parties were also asked whether they were interested in the project aims or in contributing to future partnerships to drive future projects. As a final stage in this process, a BUDS project workshop was held at ABPmer offices on 6 December 2017 (see Image 19).

Source: ABPmer

Image 19. BUDS project workshop at ABPmer offices on 6 December 2017

At this BUDS workshop event, there were 24 attendees from a wide range of organisations. The aim of the workshop was to tap into the knowledge of all those present to identify potential locations for carrying out beneficial use work. Further details and notes from this workshop are presented in Appendix D.

4 Site Review

4.1 Introduction

For this first phase of the BUDS project, several possible locations for beneficial use work have been identified based on an initial high level review. These were determined by using the criteria mapping analyses (as described in Sections 3.2 and 3.3) and by consulting with a range of stakeholders (as described in Section 3.4 and Appendix D). The results of this review are described further in this chapter.

Prior to considering these possible beneficial use opportunities, Section 4.2 highlights some relevant factors. These are presented to provide a context for this review. Section 4.3 then identifies a selection of sites and other relevant issues across the Solent. Finally, Section 5 summarises five priority recommendations for the next phase of the Solent BUDS Project. These recommendations include pursing further site-specific investigations at those sites where beneficial use work could or should be carried out as a priority. They also include suggestions for ongoing BUDS project implementation and oversight.

4.2 Key considerations

4.2.1 Stakeholder feedback

As a first consideration, it is important to emphasise that a lot of positive feedback was provided by the consultees during this project. This has not only helped with this BUDS study but it also shows that there is a general willingness to realise projects in the face of the known challenges. The technical challenges and historical issues associated with beneficially using sediment continue to be highlighted though (as per Section 2.2) and these will need to be continually recognised and confronted in the future. However, this positivity provides encouraging signs that there will be support for the next phase of the BUDS project.

4.2.2 Focussing on larger projects

Another key consideration, when either reviewing the BUDS mapping outputs or determining the options for future BUDS project implementation, is that comparatively large-scale projects are more likely to have clear and quantifiable long-term benefits than smaller-scale initiatives. Therefore there is a greater likelihood that an effective partnership can be built around a larger proposal because it will have inherently more potential beneficiaries, funders and funding mechanisms. This is a key lesson from the cost:benefit review presented in Appendix A and, for this reason, selecting a large-scale project has been a focus for this review.

Smaller scale projects could and should still be implemented and encouraged though and several possibilities for such initiatives have been identified in this study. However, for this review such schemes were seen as being less relevant to any further BUDS partnership and more relevant to individual operators, ports and harbours who can consider and progress them as appropriate. It will be very valuable, however, for the Solent Forum to help with such projects by contributing to the development of guidance and the provision of strategic oversight. This oversight can be through the maintenance of the BUDS mapping product or by communicating the lessons that are learned (whether technically or in policy terms) from progressing a larger-scale initiative. They can also come by dovetailing the Solent Forum's work to other relevant initiatives such as the RSPB's SEABUDS project.

4.2.3 Technical approaches

For this high level review, the specific technical details of any project have not been considered. These will need to be addressed for the next phase of the work, based on site-specific considerations and partnership feedback. Sections 2.3 and 2.4 have reviewed some of the key methods that are known to exist and have been applied in the Solent. However, Section 2.6 also highlights that nothing yet has really been undertaken at a large scale so anything done in the future may well need to be very innovative. For this review therefore it is best to consider the possible beneficial use methods on the basis of the following two simplified categories of approach:

- Placement of sediment directly on deteriorating intertidal areas to protect and enhance existing habitats; and
- Placement of sediment over shallow sublittoral areas to raise bed levels and 'create' new intertidal areas.

In the future, there could be either small or large scale projects that adopt the former approach while the latter approach is only likely to be achieved at a large scale. However, major projects could also use a combination of both approaches simultaneously. With the larger and more ambitious projects though there will be an increasing need for more, and larger, sediment retention structures to minimise sediment losses, to allow the sediment to build up and also to mitigate for temporary environmental effects during implementation. Such walls/bunds would not only help to retain sediment but also protect eroding marsh edges. Some smaller scale projects, such as those progressed recently at Lymington, can be undertaken without any such features. However, any medium or large-scale initiative is likely to need enwalled or bunded areas.

When considering the technical practices, it should also be noted that, even where a beneficial use site (and relevant sources of sediment) has been agreed, it may well not be possible for all sediment excavated from each individual dredge campaign to go to such a re-use site (due to constraints of time, tide and vessel access particularly). Instead it will usually be more appropriate for a proportion of sediment from any campaign to be used beneficially when suitable tidal conditions and project timings allow. This is the approach that is being adopted at a small-scale for the ongoing Lymington recharge works (see Section 2.5).

4.2.4 Working in partnership

In moving to the next stage, it is envisaged that only partnership working will be effective. Having multiple beneficiaries funding and supporting an integrated win-win initiative is likely to be the only way in which significant projects can be achieved.

Alongside considering the ways in which tasks and responsibilities can be shared, care should be taken to ensure that the approach adopted does not put any extra and disproportionate cost burden on dredging operators and harbour authorities who are not, typically, the beneficiaries. Instead, there needs to a broad strategy for implementation that takes account of established dredging practices and works with industry partners to make best use of the available sediment resource.

Care should also be taken to ensure that the locations identified in this document are not automatically seen as potential sediment re-use sites, irrespective of the practicalities associated with undertaking such work and without consideration of the benefits and funding mechanisms. This is because there will still be hurdles to be overcome before a site can be considered to be a viable deposit ground.

4.3 Site review

4.3.1 Western Solent

Following this Phase 1 BUDS review, it is clear that the 'stand out' area for carrying out a large-scale recharge initiative is the north side of the western Solent, in the lee of Hurst Spit and along to Lymington (see Image 20). This is the best location for several reasons. Firstly, it has a large expanse of remaining marsh along an exposed shoreline. Therefore, preserving this marsh will have a clear function for flood protection and wave energy reduction. Furthermore, these marshes front a section of coast that has a 'hold the line' policy and a hinterland that is low lying and includes the populated areas of Milford on Sea and Lymington. The marshes are also part of the designated SPA and furthermore shield the socio-economically valuable moorings and harbours of Keyhaven and Lymington. In recent years, it has been necessary for LHC to start building (at a high cost) large rock-armour breakwaters at the Lymington Harbour entrance. There are therefore clear social, economic and environmental benefits from doing work at this location.

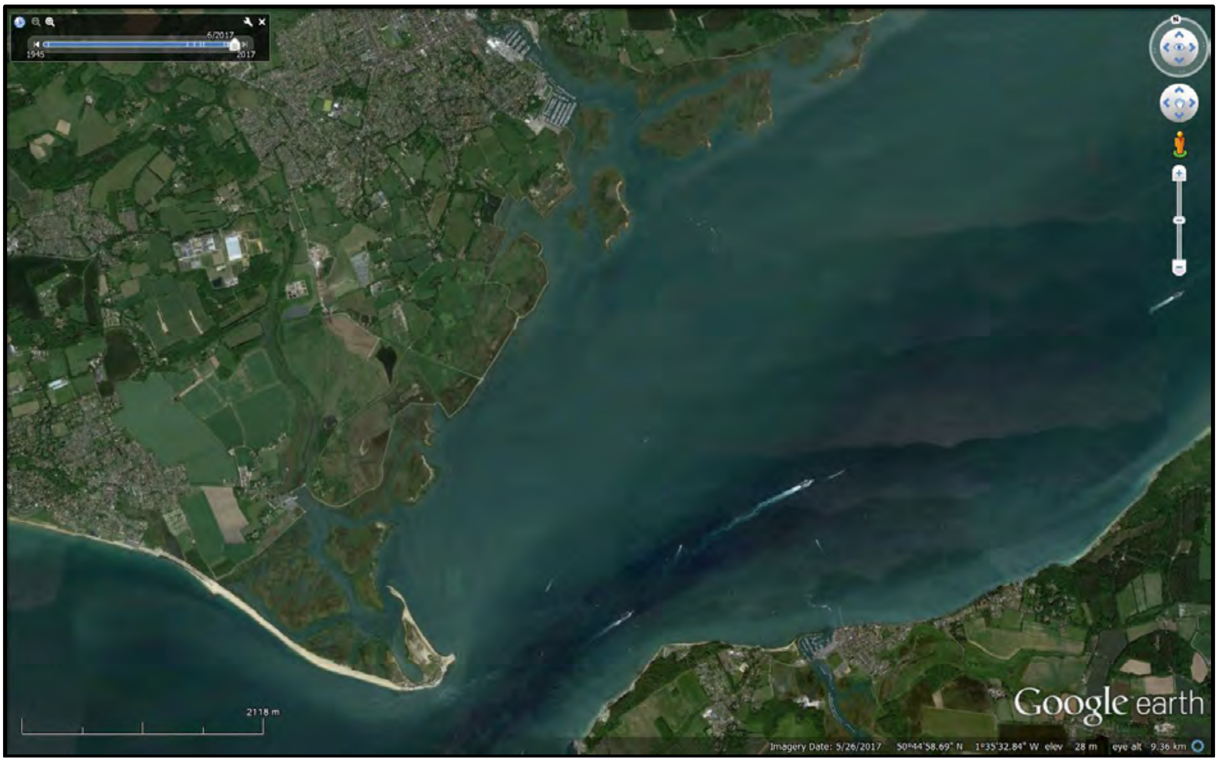


Image 20. Main site for large-scale project on Hurst, Keyhaven and Lymington frontage

These marshes were much more extensive during the early part of the last century, but are now eroding rapidly. They are likely to be gone by around 2040 (Cope *et al*., 2008), if not sooner[21], which will leave the hinterland increasingly vulnerable. The marshes are also of a poor quality and are not only deteriorating from external marsh edge erosion but also internally from die-back processes. This means that there is ecological value in restoring these marshes due to their deteriorating quality as well as their reducing extent. In addition, due to the historic marsh retreat, there is also plenty of lower intertidal and shallow subtidal habitat (from the eroded marsh area) that could form a platform for carrying out recharge work.

21 It will be worth revisiting these habitat loss projections based on the detailed monitoring that has been carried out over the last decade.

There will be technical challenges with delivering dredged material to this site and the area will require structures/bunding to define and contain the deposition area at a large scale. Boat moorings are threaded through the creeks in this area of high recreational value and the effect on these (whether temporary or permanent) will need to be considered. There is however a regular and reliable source of sediment that is available from annual maintenance dredging work in the Lymington Estuary, but also additional from potential sources in the Yar, Medina, Beaulieu and Southampton Water.

It was also noted during the BUDS workshop that recharge work in this area could be used to facilitate proposals for the management and rollback of Hurst Spit. Intervention on the spit is proposed to protect this section of the north Solent shoreline and this is likely to be accompanied by a need for habitat restoration work as mitigation and compensation measures. Therefore, any marsh recharge in this area could be progressed as part of an integrated approach that both manages the spit and provides the impact offsetting measures for that management. These offsetting measures could have ecological value both by creating new marsh but also by delaying the loss of existing marsh thus delivering extra 'hectare years'[22] of habitat benefit. Thus an initiative at this location could have multiple benefits.

Away from the 'Hurst Spit to Lymington' frontage, there are also some other known or possible opportunities for small-scale work in the rest of the western Solent. In particular, the Buckler's Hard Yacht Harbour in Beaulieu is planning to conduct a new (15,000 m^3) deepening exercise in the very near future and is keen to explore the opportunities for beneficially using the sediment arisings. They have already conducted contaminant testing to check that the materials will be suitable. This would be a small scale initiative that is likely to be confined to the Beaulieu Estuary (perhaps at Gull Island at the estuary mouth or further upstream closer to the harbour[23]).

On the Isle of Wight, it is also possible that small initiatives might be undertaken in the Yar, Newtown Harbour or the Medina Estuary. A range of possible intervention measures have been, and are being, considered for the Yar but any work in this system is likely to be very small in scale. In the Medina further active consideration is being given to small-scale beneficial use alternatives and an update to the sediment management plan for this system is currently proposed that could identify specific future projects.

A novel idea was also mooted in the workshop of recharging the intertidal along the coastal section between Gurnard and Newtown (including Thorness) as a natural enhancement to the defence. This is something that could perhaps be done in a relatively low-cost way following the Koehoal model (see Section 2.3). The flood protection imperative is not as great on this coastline when compared to areas like Keyhaven to Lymington; however, a lower cost approach might be appropriate here. Care will be needed to ensure that the sediment feeds into the net drift[24] and there would need to be an acceptance of the risk associated with likely sediment losses. It is worth exploring the idea of a trial study at this site (learning lessons from the past 'trials' in Southampton Water – see Section 2.5).

4.3.2 Central Solent

In Southampton Water, there are expanses of deteriorating marsh along the south/west bank of the estuary and recharging these could contribute to the 'hold the line policy' that extends throughout

22 The concept of 'hectare years' as a quantitative measure of coastal restoration value emerged from recent developments at Lymington. It refers to the cumulative area of habitat that is delayed from loss. In other words, how much of the eroding marsh habitat is available for how much longer (than it would otherwise have been) as a result of the proposed intervention. This concept of benefit is likely to apply to any other beneficial use work in the Solent.

23 It is notable that Keeping Marsh just to the north of Beaulieu marina was formed with recharge material around 17 years ago. The dredged sediment had to be kept in the river are due to concerns about exporting *Bonamia* infection to oysters. It has since become an ecologically valuable reed-bed habitat with a bird hide on site.

24 In a net easterly direction according to the SCOPAC review www.scopac.org.uk/scopac_sedimentdb/nwiow/index.htm

most of the estuary. Along these marshes, there are a few areas where relatively small-scale initiates might be carried out for providing flood protection and other economic gains, as well as nature conservation enhancement (further details are provided below. Such projects could be linked to mitigation/compensation initiatives for coastal developments in the estuary and the wider Solent. However there are few sites where particularly large-scale projects might be undertaken at the present time.

There is likely to be a good, and quite novel, economic case for carrying out smaller-scale beneficial use initiatives on the Eling Marshes in the upper estuary. This is because these marshes support the foundations for a number of power supply pylons and any initiative which protects these will have economic value from helping to preserve them. In addition, there would be the ecological gains from the creation and protection of marsh habitat. The upper part of the estuary needs to be maintained through a combination of large TSHD and smaller back-hoe dredger campaigns. Therefore, there is a nearby source of sediment, as well as a need to ensure that any works do not adversely affect commercial navigation.

Just to the south of Eling, the Marchwood marshes front a waste water treatment works which is however not in the flood plain so it may not benefit greatly from a recharge initiative. Further south, the northern section of the Hythe marshes is narrowing and leaving a small area of hinterland vulnerable. Therefore some form of small-scale restoration may be useful here. However, other coastal defence works are also proposed at this site. Further towards the mouth of Southampton Water, some small or moderate scale work could also be done on the Calshot Marshes. However, there are already separate plans in place for enhancing the habitats here as part of the Fawley Waterside Development. Any effect on, or benefit for, these plans would need to be considered further.

On the north bank of Southampton Water the main areas of marsh lie along the Hamble Estuary. A separate study has been carried out in this system by Hamble Harbour Authority (HHA) (see Section 2.5), and some ideas for small-scale enhancement woks are being considered for this system at the present time.

During the BUDS workshop, an interesting and novel idea was cited of using Bramble Bank at the mouth of the estuary as a recharge platform. This site could technically be used for island formation. However, given its location at the mouth of Southampton Water and the lack of any history of marsh habitat, any such initiative will be especially challenging and introduce risks where there is no demonstrable economic rationale. It is therefore not recommended that this be pursued in the near future. This kind of idea is worth recognising though because it is an indication of what might be achieved through large-scale recharge work, and of the spectrum of interesting ideas that can emerge when the core principles and benefits of recharge are considered and debated.

4.3.3 Eastern Solent

Within the eastern Solent, there are opportunities for a number of small-scale projects as well as some larger-scale work. The marshes within the three harbours are generally retreating and there is a good case to be made for taking action to restore them (for nature conservation reasons, but also to provide a degree of enhanced wave/flood protection[25]). In some cases the recharge could involve restoring isolated marsh islands that would help to provide valuable and remote waterbird roosts sites as well as help to achieve targets for offsetting long-term marsh habitat losses under the Regional Habitat Creation Programme. Where required, these restorations could provide mitigation or

25 In contrast to the western Solent there are no marshes on the most wave exposed coastal frontages and instead they are all within the harbour areas. Therefore, the coastal protection benefits of any recharge will be less clear cut and the conservation management aims will have greater relative weight.

compensation associated with coastal works such as the City Deal developments. However, the marshes in the harbours are not readily accessible to large dredging plant and therefore particular consideration will need to be given to the methods that are to be adopted.

Portsmouth Harbour has a 'hold the line' policy throughout and for the most part the standard of its defences are high to protect the surrounding infrastructure. There are also limited areas of the hinterland within the flood zone, but there are some sea walls filled with landfill materials in the harbour (and also Langstone) which will be a particular priority for protection.

There is an area with a comparatively lower standard of defences and a fronting marsh fringe on the west side of the harbour near Holbrook (western side of the harbour). There are also lower standards of defences, but with fronting mudflats occur alongside Gosport and Alverstoke on the western side of the harbour mouth (i.e. within the Haslar, Stoke and Workshouse Lakes) as well as at Portchester to the north of the harbour.

In the harbour, there are extant proposals for localised coastal defence works around Gosport, as well as between Portchester to Paulsgrove (there are also recent defence works to protect Tipner Lake to the east). Of these areas, the Workhouse Lake site (near Gosport) was highlighted at the BUDS workshop as being an area that could benefit from a small-scale recharge (possibly using sediment from Haslar Marina).

In terms of locations for large-scale initiatives, then the main candidates would be the three marsh islands at the top of the harbour (separated by the Bombketch, Spider and Paulsgrove Lakes) as shown in Image 21). Any restoration of the degraded marshes here would mainly have a nature conservation value through habitat protection and enhancement as well as by retaining isolated bird roost areas. This could be undertaken as a compensation measure (whether for reginal coastal defence works or for other development such as City Deal housing developments).

Image 21. Potential large-scale project sites on the Portsmouth Harbour islands

Recharging and building up these islands would also help to provide some wave protection to the inner harbour (i.e. including the Portchester area), or at the very least prolong the level of existing wave protection that is currently provided by these marshes and islands. A main advantage of undertaking beneficial use in Portsmouth Harbour, over other harbours, is that there would be a regular, large, source of sediment from ongoing and anticipated maintenance dredging works (see Image 16).

In Langstone Harbour, there is again a mainly 'hold-the line' policy (except for an area of 'no active intervention' on the eastern side of Hayling Island). There is also very little residual marsh on the outer margins of the harbour, where recharge work could be carried out to enhance coastal protection. There are however some larger areas of marsh still present fronting Farlington Marshes, at the central/northern side of the harbour and this could be a key area for future recharge work (see Image 22). The shoreline policy at Farlington is also 'hold the line', and carrying out a recharging initiative on the fronting marshes here would help to protect the hinterland marshes and the flood storage functions that they provide (as well as potentially helping to deliver the RHCP target for saltmarsh restoration).

Image 22. Potential large-scale project site fronting Farlington Marshes

Farlington appears to be a good location for beneficial use, because it has large intertidal and shallow subtidal platform that could be used for recharge. The intertidal area in front of Farlington also includes deteriorating and redundant sea walls that could be used as part of the necessary sediment retention infrastructure. Challenges at this site will include difficulties of vessel access and sediment availability. While some sediment could be provided from local sites like Kendall's Wharf, any substantial volumes would need to be derived from Southampton Water or Portsmouth Harbour. Consideration would also need to be given to effects on seagrass bed habitats in the harbour. There may also be other smaller areas in Langstone Harbour such as the western side of the harbour mouth at Eastney Lake (near to the Southsea Marina) could be a potential recharge location.

In Chichester Harbour, there is a 'hold the line' policy for the majority of the defences, and a 'managed realignment' policy for the western side of Thorney Island. There are also several fringing marshes and several marinas that need to be dredged. In total, there are comparatively small volumes of sediment dredged each year from this harbour, and therefore there are only likely to be small-scale opportunities for beneficial use work. The opportunities for such small projects have been, and are being, considered. It is known, for example, that Emsworth Yacht Harbour is considering whether it is possible to pump silt onto local mudflat habitats and small-scale work has been done at Birdham Pools (to retain relatively contaminated sediments).

As part of future proposed improvements to the coastal defences, works on the East Hayling Island frontage could be considered in the near future (Gavin Holder, ESCP, pers. comm.). Therefore, it will be valuable now to think about whether beneficial use can play a part in any coastal defence recommendations for this part of the Solent. It may be that recharge of the marshes along this section of the shoreline can be done as one part of this work. It is noted that Gutner Point emerged as a recommendation for beneficial use work following the Southampton University study in 2010 (this study used a very different selection criteria and approaches when compared to this ABPmer BUDS review).

During the BUDS workshop it was noted that there are several possible managed realignment sites in Langstone and Chichester Harbour. It is possible that landside placement of mud could be undertaken to increase saltmarsh versus mudflat (i.e. to speed up the natural accretion process if needed urgently) as well as to perhaps create roost islands (although internal bunding would probably be needed to create such features).

On the Isle of Wight, active consideration is being given to using sediment at a small-scale in Bembridge Harbour (e.g. for beach level raising). At Fishbourne and Wotton Creek, no dredging is taking place and therefore any sediment would have to be imported from elsewhere. There are no known or obvious beneficial use opportunities in this estuary, although the top end of the creek has a 'managed realignment' policy. If implemented, the realignment would open up Wootton Old Mill Pond, with concerns for the effect downstream. This process may well be done through a gradual change to the levels of regulated tidal control but in theory delivering dredge sediment to this site could also reduce the tidal prism change effects on Wootton. In this small estuary with no dredging, vessel access would be difficult and the sediment may well have to come by road.

5 Recommendations

5.1 Summary

Based on the general principles set out in preceding sections, five key recommendations have been set out for the Solent Forum to take forward into the second phase of the BUDS initiative. In pursuing these, it should be highlighted that this work will be in-keeping with the call for adopting a natural capital approach as set out in the Government's 25 year environment plan. This needs to influence thinking, particularly in relation to the status of beneficial use projects within FCERM policy.

5.1.1 Develop a large-scale project for Keyhaven to Lymington frontage

The clearest, and most urgent, case for a large-scale project is in the western Solent between Keyhaven and Lymington. A major beneficial use project in this area would contribute to flood protection and could also compensate for the effects of future Hurst Spit works. It may also be used compensate for wider development initiatives elsewhere in the Solent. It could use sediment from the Lymington, Yarmouth, the Medina and Southampton Water. It is recommend that the Solent Forum look to develop a beneficial use initiative in this area by working with key beneficiaries (Environment Agency, New Forest District Council, New Forest National Park Authority) and stakeholders (Western Solent Harbour Authorities, SNCBs and NGOs) to develop detailed proposals for this frontage.

5.1.2 Develop large-scale project(s) in the East Solent (e.g. fronting Farlington)

A few potential opportunities exist for undertaking larger-scale beneficial use within the three eastern Solent Harbours. However, more work will be needed to clarify which of them will be best to take forward. Based on this Phase 1 review, however, it looks like the most appropriate location will be the marshes in front of Farlington. That is because undertaking beneficial use at this site offers an opportunity to deliver the greatest benefits for conservation (both for the recharged saltmarshes themselves as well as for the grazing marshes of Farlington), is in-keeping with a 'hold the line' SMP2 policy and would help to maintain the freshwater flood storage functionality of the Farlington Mashes. Away from Langstone Harbour, marsh islands could also be built up at a large scale in Portsmouth or Chichester Harbour. There will need to be further dialogue with a range of potential beneficiaries (Environment Agency, East Solent Coastal Partnership, Solent Local Enterprise Partnership, and Coastal Developers (such as City Deal Portsmouth) and stakeholders (Eastern Harbour Authorities, SNCBs and NGOs) to agree the benefits and inform the selection of suitable locations.

5.1.3 Work with regulatory bodies to develop regional guidance

In addition to progressing key large-scale projects (and prioritising work in the western Solent) it will be valuable for the Solent Forum BUDS project to help develop guidance and provide clarity regarding the principles and objectives for future beneficial use projects. This was a specific recommendation that emerged from the workshop discussion.

Such guidance could be developed with key regional stakeholders and project partners, alongside other wider initiatives (e.g. the SEABUDS work). It would help to bring about joined-up thinking between the regulators, advisors and industry partners such that there is a clear understanding about the objectives, benefits, costs and technical feasibilities of any proposed project. These factors will need to be understood and agreed to help projects that are listed in this review to be taken forward.

For such guidance, it will be valuable also to clarify some of the key legal/regularity principles to understand how these will influence the benefits and beneficiaries associated with any such project. For example there is a need to be clear about whether these projects can be treated as a compensatory or conservation measure under the Habitats and Birds Directives or as an environmental restoration under the Water Framework Directive.

In large part, however, it is expected that the main guidance lessons will automatically emerge as a natural function of the Solent Forum seeking to progress the large scale initiative(s).

5.1.4 Continue to maintain and populate the BUDS map

As part of the guidance development process it is recommended that the BUDS criteria map is maintained and updated over time as required. During the workshop, recommendations were provided and some extra content was identified that could be added to the mapping (see Appendix D). This mapping and the guidance could include reference to the high-level smaller-scale project ideas that have emerged from this Phase 1 Review, and maintain an audit of new and locally developed ideas that emerge over time.

5.1.5 Consider the case for a small-scale project at Eling Marshes

Of the potential small-scale projects that have been identified during this review, the one that is likely to have the largest socio-economic value is at Eling Marsh in the upper reaches of Southampton Water. That is because there is erosion at the base of the electricity pylons at this site. It is worth examining the approaches that could be taken to build up these marshes and protect the pylon infrastructure (with stakeholders including ABP, Environment Agency, Natural England and the Environment Agency).

5.2 Summary

In summary it is recommended that the next project phases involve actively progressing one or more of the large-scale projects while also helping to develop guidance and providing oversight (e.g. through maintaining the BUDS mapping product). This oversight would help both large-scale projects and smaller-scale schemes that individual operators and harbour authorities would like to progress.

In moving to the next stage, it will be important to build partnerships around the large-scale initiatives. A key objective should be to create regionally strategic intertidal disposal sites that can be used by a range of parties as appropriate and as conditions allow. This approach is expected to be vital for ensuring that more dredged sediment can be used beneficially in the Solent. Particular care should be taken though, to ensure that any extra undue cost burden for this is not put on individual parties (especially dredging operators and harbour authorities) who are not, typically, the beneficiaries.

It is noted that the idea of a tax on at-sea disposal was mooted at the BUDS workshop and has also been promulgated elsewhere. Once again, care should be taken here. This may provide a source of funds but to tax disposal would place an unfair burden, especially without simultaneously providing further funding and facilitating processes that will allow alternative approaches to be adopted. The failure of the Holes Bay project presents a stark lesson in this respect (see Section 2.2).

The idea of developers contributing a proportion of funding for restoration project(s) on the basis of the 'polluter pays' principle would make sense. However, the main funding streams would need to come from multiple partners, with core project beneficiaries contributing from established funding mechanisms (flood protection funds especially) or collaborating in bids for major project research monies. Essentially, there is a need to pursue projects which have clear benefits and a self-explanatory socio-economic rationale to which developers can then provide some contributions.

In particular, it is now hoped that future project funding and implementation can be facilitated by elevating the importance and recognition of natural capital delivery. Adopting a natural capital approach (with a greater recognition of the ecosystem services provided by coastal habitats) would be in keeping with the clear aims set out in the Defra 25-year environment plan.

Finally, it is also recognised that pursuing the larger-scale projects that are proposed here would represent relatively novel and pioneering projects in both a national and European context. This is because only small-scale marine habitat restoration projects have been progressed in the UK and Europe so far (as described in Section 2.6). However, there is a demonstrable economic case for such work in the Solent, and an opportunity for this region to provide a leading example in the strategic beneficial use of dredge sediments, as well as in the placing of a natural capital approach at the heart of coastal management and flood protection decision making.

6 References

ABP Research & Consultancy Ltd (2001). Trial Recharge Hythe to Cadland Foreshore July 2001. ABP Research & Consultancy Ltd, Report No. R.791

ABPmer (2014). Sediment Compatibility and Opportunistic Use Pilot (SCOUP) Getting Beneficial Use Working Demonstration ABP Marine Environmental Research Ltd, Project Proposal Informed by stakeholder meeting attended by ABP, ABPmer, Boskalis, CEDA, East Solent Coastal Group, Solent Protection Society, Environment Agency, The Crown Estate, Natural England SCOPAC,

ABPmer (2015). Lymington to Yarmouth Ferries: Mitigation and Monitoring 9th Report for the Environment Management Panel Report for Wightlink Ltd ABP Marine Environmental Research Ltd, Report No: R.2512 December 2015

ABPmer (2016a). Coastal Habitat Creation Conference 2016. Using Dredge sediment and other 'wastes' to benefit our coasts. http://www.abpmer.co.uk/buzz/why-don-t-we-do-more-beneficial-use-of-sediment-schemes/

ABPmer (2016b). Cowes Harbour Commission English Channel Regional Hydrodynamic Model Calibration. March 2016. R/4327/1. ABP Marine Environmental Research Ltd, Report No: R.2492

ABPmer (2017). White Paper: Using Dredge Sediment for Habitat Creation and Restoration: A Cost Benefit Review, A summary of the techniques, costs and benefits associated with using fine dredge sediment to 'recharge' intertidal habitat, ABPmer Internal White Paper, Report No. R.2865.

Ahti & Marine Space Ltd. (2016). River Hamble Soft Sediment Habitat Retention. Feasibility Study Date of Issue 12 August 2016

Ausden, M., Dixon, M., Lock, L., Miles, R., Richardson, N., and Scott, C. (2016). Dredged sediment – still an under-used conservation resource!? British Wildlife December 2016

Black and Veatch (2012). Lymington Intertidal Habitat Restoration Preliminary Monitoring Report V2 December 2012 121378-0960 Report for the Lymington Harbour Commissioners V1/ December 2012

Black and Veatch (2017) Lymington Harbour Commissioners Saltmarsh Recharge By Bottom Dumping – Phase 3 Final Monitoring Report

Bolam, S.G., Waldock, R., and Paipai, E. (2003). Beneficial use of finegrained dredged material: success story so far. In: Proceedings from the International Conference of Dredging, Casablanca, October 2002, pp. 78–89.

Bolam, S.G. and Whomersley, P. (2005). Development of macrofaunal communities on dredged material used for mudflat enhancement: a comparison of three beneficial use schemes after one year. Marine Pollution Bulletin 50: 40–47.

CEDA (2010). Dredged Material as a Resource: Options and Constraints. A CEDA Information Paper - June 2010. Available at: http://www.dredging.org/documents/ceda/downloads/publications-2010-6-ceda_information-paper-dredgedmaterialasaresource.pdf [last accessed March 2018]

Cope, S.N.M., Bradbury, A.P. and Gorczynska, M. (2008). Solent Dynamic Coast Project. A tool for SMP2. Available at: http://www.newforest.gov.uk/nssmp/6652 [last accessed March 2018]

Cundy, A.B., Long, A.J., Hill, C.T., Spencer, C,. and Croudace, I.W. (2002). Sedimentary response of Pagham Harbour, southern England to barrier breaching in AD 1910. Geomorphology, 46, 163-176.

Defra (2018). A Green Future: Our 25 Year Plan to Improve the Environment. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/673203/25-year-environment-plan.pdf [last accessed March 2018]

Dixon, M., Morris, R.K.A, Scott, C.R., Birchenough, A., and Colclough, S. (2008). Managed coastal realignment: lessons from Wallasea, UK. Proceedings of the Institution of Civil Engineers Maritime Engineering Print ISSN: 1741-7597 Volume: 161, Issue: 2 June 2008 Page(s): 61-71

Eftec/ABPmer (2017). Assessment of natural capital in the Suffolk marine pioneer. Final Report. For Defra May 2017

Environment Agency (2017). Southmoor Managed Realignment. Environmental Statement Final, 9 November 2017.

Foster, N.M. (2014). Towards understanding and improving decision-making for the conservation and sustainable use of intertidal mudflats and saltmarshes. University Of Southampton Faculty of Engineering and The Environment. PhD June 2014

HELCOM (2015). HELCOM Guidelines for Management of Dredged Material at Sea Adopted by HELCOM 36-2015 on 4 March 2015. Available at: http://www.helcom.fi/Lists/Publications/HELCOM%20Guidelines%20for%20Management%20of%20Dredged%20Material%20at%20Sea.pdf [last accessed March 2018]

HR Wallingford (2004). Beneficial use of dredged materials in Chichester Harbour. Detailed assessment of the preferred sediment disposal site. Report EX 5009. December 2004 for Chichester Harbour Conservancy.

IADC (2009). Facts about: Dredged Material as a Resource An Information Update from the IADC – Number 1 – 2009. Available at: https://www.iadc-dredging.com/ul/cms/fck-uploaded/documents/PDF%20Facts%20About/facts-about-dredged-material-as-a-resource.pdf [last accessed March 2018]

LHC (2016). Lymington Harbour Commissioners Annual Report, 2016. Available at: http://www.lymingtonharbour.co.uk/content/S635774893988568069/Annual%20Report%202016.pdf [last accessed March 2018]

Lowe, S. (2012). 'Lymington Harbour habitat replenishment scheme: Summary of works'. The Crown Estate, 18 pages. ISBN: 978-1-906410-35-3

Maryland Environmental Service (2017). Poplar Island restoration. Available at: http://www.poplarislandrestoration.com/ [last accessed March 2018]

MMO (2014a). Use of Beneficial Dredged Materials in the South Inshore and South Offshore Marine Plan Areas. A report produced for the Marine Management Organisation, pp 57. MMO Project No: 1073. ISBN: 978-1-909452-31-2. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/358069/MMO_1073_Beneficial_Use_Final.pdf [last accessed March 2018]

MMO (2014b). AIS Open Source Data and Methods: Technical Report. A report produced for the Marine Management Organisation

MMO (2016). South Marine Plan – draft for consultation. Available at: https://www.gov.uk/government/publications/draft-south-marine-plan [last accessed March 2018]

Murray, L. (2008). "Dredged Material as a Resource". Terra et Aqua, September, Number 112, pp. 3-10. Available at: https://www2.iadc-dredging.com/wp-content/uploads/2017/02/article-dredged-material-as-a-resource-112-1.pdf [last accessed March 2018]

OSPAR (2014). Guidelines for the Management of Dredged Material. Available at: www.ospar.org/documents?d=34060 [last accessed March 2018

Paipai, E. (2003). Beneficial Uses of Dredged Material: Yesterday, Today and Tomorrow. Available at: www.iadc-dredging.com/ul/cms/terraetaqua/document/1/3/0/130/130/1/terra-et-aqua-nr92-01.pdf [last accessed March 2018]

PIANC (2009). PIANC Report no 104-2009 Dredged Material as a Resource: Options and Constraints. www.pianc.org

RSPB (2018). Sustainable Shores Technical Report, February 2018. RSPB, Sandy

Southampton University (2010). Scoping Study. Site analysis for potential beneficial dredge spoil use for respiration and recharge of intertidal soft sediment resources within the Solent

The Environment Bank (2015). Investing in natural capital Saltmarsh restoration on the Deben Estuary Project EB03046. August 2015.

Van Eekelen, E.M.M., Sittoni, L., van der Goot, F., Nieboer, H.E., Baptist, M.J., Boer, J. and Tonneijck, F.H. (2017). The Living Lab For Mud: Integrated Sediment Management Based On Building With Nature Concepts. Available at: https://www.ecoshape.org/uploads/sites/2/2017/11/Ceda-2017-paper-Van-Eekelen-Sittoni-et-al-The-living-lab-for-mud-integrated-sediment-management-based-on-building-with-nature-concepts.pdf [last accessed March 2018]

Vroom, J., Van Maren, D.S, Marsh, J., and Cado van der Lelij, A. (2016). Effectiveness of the mud motor near Koehool; Results and interpretation of a tracer study, Delft, Deltares report 1209751-004.

Wortelboer, R.J.M (2014). Beneficial Use of Dredged Sediments Using Geotextile Tube Technology. Proceedings of the South Baltic Conference on Dredged Materials in Dike Construction Rostock, 10-12 April 2014 ISBN: 978-3-86009-409-9: http://www.dredgdikes.eu/wp-content/uploads/20_Wortelboer_WEB.pdf [last accessed March 2018]

Web sites

www.abpmer.maps.arcgis.com/apps/webappviewer/index.html?id=84f75915f4d64d3f84d82e7b8923e9ba

http://defra.maps.arcgis.com/apps/webappviewer/index.html?id=3dc94e81a22e41a6ace0bd327af4f346

www.ecoshape.org/en/projects/mud-motor

http://www.ecrr.org/Portals/27/Trimley,%20Suffolk.pdf

https://marinelicensing.marinemanagement.org.uk/mmofox5/fox/live/mmo_public_register

www.scopac.org.uk/scopac_sedimentdb/nwiow/index.htm

https://solentlep.org.uk

http://www.ukdredging.co.uk/UKD_Fleet/UKD_Bluefin/

7 Abbreviations/Acronyms

ABP	Associated British Ports
AIS	Automatic Identification System
ArcGIS	Geographic Information System Software
BUDS	Beneficial Use of Dredge Sediment in the Solent (Solent Forum)
CCO	Channel Coastal Observatory
CD	Chart Datum
CEDA	Central Dredging Association
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CPA	Coast Protection Act
DAS	Disposal At Sea
Defra	Department for Environment, Food and Rural Affairs
DTM	Digital Terrain Model
EA	Environment Agency
Eftec	Eftec Ltd
EMODnet	European Marine Observation and Data Network
ESCP	East Solent Coastal Partnership
EUNIS	European nature information system
FCERM	Flood and Coastal Erosion Risk Management
FEPA	Food and Environment Protection Act
FZ	Flood Zone
GIS	Geographic Information Systems
HELCOM	The Baltic Marine Environment Protection Commission
HHA	Hamble. Harbour Authority
HMNB	Her Majesty's Naval Base
IADC	International Association of Dredging Companies
IMO	International Maritime Organisation
LEP	Local Enterprise Partnership
LHC	Lymington Harbour Commissioners
LiDAR	Light Detection and Ranging
MCA	Multi-Criteria Analysis
MCZ	Marine Conservation Zone
MDP	Maintenance Dredge Protocol
MESH	Mapping Atlantic Seabed Habitats
MIS	Marine Information System
MMO	Marine Management Organisation
MOD	Ministry of Defence
N/A	Not Applicable
NGO	Non-Governmental Organisations
OD	Ordnance Datum
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PBC	Poole Borough Council
PIANC	The International Navigation Association (Permanent International Association of Navigation Congresses)
Ramsar	Wetlands of international importance, designated under The Convention on Wetlands (Ramsar, Iran, 1971)
RHCP	Regional Habitat Compensation Project

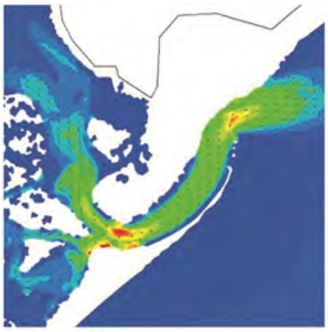
RNSA	Royal Naval Sailing Association
RSPB	Royal Society for the Protection of Birds
RYA	Royal Yachting Association
SAC	Special Area of Conservation
SCOPAC	Standing Conference on Problems Associated with the Coastline
SCOUP	Sediment Compatibility and Opportunistic Use Pilot
SDCP	Solent Dynamic Coast Project
SEABUDS	Sea-change in the Beneficial Use of Dredgings (RSPB)
SMC	Sea Mounting Centre
SMP	Shoreline Management Plan
SNCB	Statutory Nature Conservation Bodies
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TSHD	Trailing Suction Hopper Dredger
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
UKD	UK Dredging
US	United States
WebApp	Web Application
WebGIS	Geographic Information Systems Resource
WebMap	Interactive Display of Geographic Information

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Appendices




Innovative Thinking - Sustainable Solutions

ABP mer

A Review of Techniques, Costs and Benefits

This appendix presents a 'white paper' report that was prepared by ABPmer in September 2017 as part of our internal research programme. It reviews the costs and benefits associated with using dredge sediment to enhance and protect coastal defences and intertidal habitats. It is hoped that improving our understanding about project costs, alongside having a better indication of their benefits, will help to assist with future project implementations in the Solent.

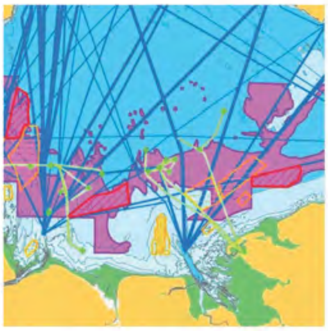
Internal White Paper

Using Dredge Sediment for Habitat Creation and Restoration: A Cost Benefit Review

A summary of the techniques, costs and benefits associated with using fine dredge sediment to 'recharge' intertidal habitat

September 2017




Innovative Thinking - Sustainable Solutions

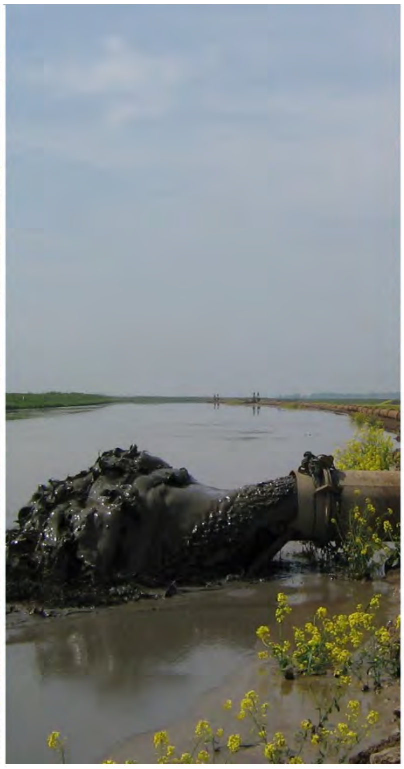
ABP mer

Page intentionally left blank

Using Dredge Sediment for Habitat Creation and Restoration: A Cost Benefit Review

A summary of the techniques, costs and benefits associated with using fine dredge sediment to 'recharge' intertidal habitat

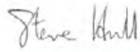
September 2017


Document Information

Document History and Authorisation	
Title	Using Dredge Sediment for Habitat Creation and Restoration: A Cost Benefit Review
	A summary of the techniques, costs and benefits associated with using fine dredge sediment to 'recharge' intertidal habitat
Document type	Internal White Paper
Issue date	September 2017
Document ref	R.2865
Project no	R/1400/1739

Date	Version	Revision Details
10 September 2017	1	Version for Internal Review
13 September 2017	2	Version for Circulation

Prepared (PM)	Approved (QM)	Authorised (PD)
Colin Scott	Susanne Armstrong	Stephen Hull
		

Suggested Citation

ABPmer, (2017). White Paper: Using Dredge Sediment for Habitat Creation and Restoration: A Cost Benefit Review, A summary of the techniques, costs and benefits associated with using fine dredge sediment to 'recharge' intertidal habitat, ABPmer Internal White Paper, Report No. R.2865.

Contributing Authors

Colin Scott, Dr Stephen Hull, Dr Susanne Armstrong,

Acknowledgements

Much of the key information in this study is derived directly from a range of experts and practitioners that have been involved in beneficially using dredge sediment. We are therefore immensely grateful for their support and for the information they have provided. These specialists include: Ryan Willegers Lymington Harbour Commission (LHC); Jonathan Dyke (Suffolk Yacht Haven); John Brien (Harwich Haven Authority); Noddy Cardy (Maldon); Carol Reid (independent); Ben Carroll (MDL marinas); Rosie Miles (RSPB); Mark Dixon (independent); Dan Leggett (DLEnviro); John Burrows (Wightlink Ltd), William Coulet (Exo Environmental Ltd.) and Helmut Meyer (Federal Waterways and Shipping Agency).

Notice

ABPmer
Quayside Suite, Medina Chambers, Town Quay, Southampton, Hampshire SO14 2AQ
T: +44 (0) 2380 711844 W: http://www.abpmer.co.uk/

Contents

Tables

Images

1 Introduction

1.1 Report background

This ABPmer white paper reviews the techniques, costs and benefits associated with using muddy dredged sediment to restore and create intertidal habitat. It has been prepared in recognition of the fact that one of the major barriers to implementing such 'recharge' schemes is that they often incur extra costs when compared with standard practices for dredge material disposal. These extra costs then present challenges with securing necessary funding and this limits the extent to which such projects can be implemented (PIANC 2009, ABPmer, 2014).

Beyond just thinking about the fees incurred though, there is also a need for a much better understanding about their benefits. This is because there is often a lack of agreement, and clarity, about the value to society of such work and this also makes it difficult to secure funding. There is also a situation where the costs and benefits fall on different actors. In particular, the costs for undertaking (and consenting) dredging and disposal activities often falls to dredging operators, marina owners and harbour authorities. However, these parties are often the least likely to benefit. This disparity between the 'winners' and 'losers' leaves a situation where there is no incentive for 'losers' to participate.

As a consequence of this funding limitation (alongside a number of other issues which are noted in Section 1.2.4), large volumes of dredged material are disposed of as 'waste' each year and very little of this sediment (generally a small fraction of 1%) is used to deliver any direct biodiversity gain. Also, those projects which are implemented, often very successfully, are typically only small in scale. To-date, no genuinely large-scale initiatives have been implemented in the UK coastal zone. As navigational approaches and harbours are generally dredged every year, there are therefore ongoing opportunities to deliver Ecosystem Services gains that continue to be missed. It is hoped that improving and updating our understanding about the costs and benefits of sediment recharge projects will help to inform and address this particular constraint to their implementation.

> One of the major obstacles to using dredge sediment for habitat restoration is that extra costs may be incurred over standard disposal alternatives. This paper seeks to clarify the costs that can be incurred as well as the benefits that can accrue. This has been prepared to help inform future project implementations.

To throw some light on this subject, and promote further communication on it, this paper therefore reviews a selection of past and present projects that have employed a range of recharge techniques. It describes the lessons learned and what they tell us about how the opportunities for beneficial use of muddy dredged sediments can be realised. This paper then considers the costs and the benefits associated with these habitat restoration schemes based on: the fees they incur; the Ecosystem Services benefits they can deliver for society; and the findings from a hypothetical beneficial use test case.

To place this review in context, this paper also summarises the existing policy situation and identifies some of the other beneficial use opportunities (in addition to habitat restoration) that are available. It is hoped that this review will inform and support the implementation of future projects, especially any that are planned at a large-scale to deliver substantial societal benefits.

1.2 Existing situation

1.2.1 Policy and guidance context

Every year around the UK, large volumes of sediment are dredged and disposed of at sea to maintain safe navigation and keep ports, harbours and marinas functioning. This is a vital socio-economic activity and one that is, necessarily, accompanied by a range of environmental, legal and policy considerations as well as consenting requirements. These requirements include those for Marine Licensing, Environmental Impact Assessment (EIA), Habitats Regulations Appraisal (HRA); and compliance testing under the Water and Waste Framework Directives.

These requirements are well understood by those involved in this sector because of the extensive history of navigation dredging as well as the sheer regularity with which such dredging needs to be undertaken (i.e. often annually and in perpetuity). That said, there is also an evolving consenting landscape which, over time, introduces new requirements, perspectives and evidence tests. These arise as new legislation is enforced, as new advice or guidance is provided and as new project and case-law lessons emerge.

While the legal and consenting landscape may shift, there has been a consistent, long-term 'desire' to see dredge arisings used beneficially for environmental and/or socio-economic activities. For example, the need to seek beneficial use opportunities was identified within the 1996 International Maritime Organisation (IMO) London Protocol and other dredge management reviews and guidance (OSPAR, 2014; HELCOM, 2015). It is also a requirement of marine licensing processes under the 2009 Marine and Coastal Access Act (as it was under the preceding FEPA/CPA[1] consenting arrangements).

In addition, the 2008 Waste Framework Directive specifies the need to adopt a hierarchy for which disposal at sea is a last resort. Under this approach, alternative/beneficial uses must be considered as the first step once the need for dredging is confirmed[2]. Identifying beneficial use opportunities is also set to become a policy under emerging Marine Planning Processes (MMO, 2016a) while the need to seek sustainable uses of dredged materials is also indicated in the National Planning Policy Framework (NPPF, 2012).

Motivated by this policy context, and the logic of the argument, many studies have been conducted over several years that have reviewed the value of dredge arisings and sought to illustrate that they are a valuable resource and not a problematic waste (CEDA 2010; IADC, 2009; PIANC 2009; Murray, 2008; Paipai 2003). These reviews often cite a contemporaneous and growing ground swell of support behind the idea of greater beneficial use, but they are also followed by only slight, if any, forward momentum in this field for various reasons.

This situation is, perhaps, even more true today. Certainly the 'ground swell' is still very evident and many parties have recently undertaken, or are currently engaged in, investigations into how sediments can be used more frequently for the combined purposes of coastal habitat restoration, flood protection and climate change adaptation. These include: the Marine Management Organisation (MMO, 2014 and 2016b), The Crown Estate, Royal Society for the Protection of Birds (RSPB) (in prep), The Central Dredging Association (CEDA) (in prep), Solent Forum (in prep) and the Thames Estuary Partnership. It may be that the combination of this impetus and the positive results from recent case examples (see Section 2) will lead to more momentum on this occasion.

[1] FEPA -Food And Environmental Protection Act 1985; CPA - Coast Protection Act 1949.
[2] MMO/UK GOV.: https://www.gov.uk/guidance/do-i-need-a-marine-licence

1.2.2 Types of beneficial use

Prior to considering how dredged sediments are used for intertidal restoration, it should be emphasised that a range of other beneficial use options exist. These can be divided into three category: engineering uses, environmental enhancements and agricultural/product uses (Harrington and Smith, 2013).

The environmental uses include, in particular, 'sustainable relocation' (HELCOM, 2015; CEDA, 2010, London Protocol, 1996). This is where arisings are placed within the same sediment cell that they were derived from (e.g. subtidally deposited within the source estuary). This helps to ensure that the sediment remains within the local system. A summary review by CEDA (2010) identified that 30% of dredged material is used in this way across the rivers, estuaries and inshore coastlines of Europe.

To identify the amount that is sustainably relocated in England and Wales, the Defra 'Disposal At Sea' (DAS) database for the period 1986 to 2012 was obtained and reviewed for this paper. This indicates that a total of around 727 million tonnes (or 27 million tonnes year^{-1}) of maintenance dredge sediment[3] was deposited at licenced disposal sites over this period. Over the last five years, from 2006 to 2012, the average volume of maintenance dredge excavations was 24 million tonnes year^{-1}. Of this annual average, around 9.4 million tonnes year^{-1} (40%) was sustainably deposited in estuaries (especially large systems such as the Humber, Wash and Severn) or in harbours such as Chichester and Poole. The great majority of this material has been used to maintain general sediment supply within estuaries and harbours rather than to create or restore intertidal habitat at a specific location.

There are also several other non-environmental beneficial use options that exist. These include applications within engineering projects, coastal defences, landclaim, beach recharges, agricultural enhancements, landfill capping/lining or in agriculture (London Protocol, 1996; Sheehan *et al.*, 2008; PIANC, 2009; Harrington and Smith, 2013; MMO, 2014; HELCOM 2015 Guidelines; CEDA in prep.). According to values quoted by Harrington and Smith (2013), between 20 to 30% of dredged material is used beneficially for all types of applications in Ireland, United States, and the Netherlands, whereas as much as 76% and 90% is used in Spain and Japan respectively.

In recent years there have been a number of other studies that have considered, or are now investigating, the multiple ways in which dredged sediments can be reused (including intertidal restoration), instead of dumping them at sea. Such recent initiatives include the CEAMaS project[4] which was completed in 2015 and the ongoing Interreg 2 seas USAR (using sediment as a resource) project[5] and the CEDA (in prep) beneficial use review. The USAR project, for example, is examining innovative approaches such as whether dredged material can be used to make compacted scour blocks as wave breaks.

1.2.3 Extent of beneficial use for intertidal restoration

While there is a clear recognition about the value of dredge material and a desire to see it used beneficially (as described above), there is an evident discontinuity between policy and practice because only a small proportion is actually used in this manner. Certainly very little is used for intertidal restoration. It is encouraging that around 30% of the annual dredge sediment resource is sustainably relocated and notable that a number of beach recharge projects have been carried out.

3 A further 134 million tonnes were deposited from capital dredge activities over this period.
4 www.ceamas.eu
5 www.wrt.org.uk/project/usar/

However, finer silt materials are only rarely used to directly protect coastal habitats and are instead disposed of at licenced deposit sites. Therefore, relatively few intertidal recharge projects have been implemented (as summarised in Section 2.1).

It can be difficult to obtain a clear up-to-date quantification of the amount sediment that is directly used for habitat restoration because there is no database which provides all the necessary information about dredge volumes, sediment types and locations. The marine licensing process does provide useful information and, more recently, valuable online mapping[6] of licenced dredging and disposal sites. However under these licensing processes[7] beneficial use projects are not consistently separated out from normal 'disposal to sea' operations, so it is difficult to identify discrete projects.

Based on past studies, however, and some extra analysis for this review, it appears that only a fraction of 1% of the available resource is used beneficially in this way. For example, Bolam and Whomersley (2005) (quoting Bolam *et al.*, 2003) estimated that around 40-50 million m^{-3} $year^{-1}$ of sediment was available and deposited at sea (at the time of that review), of which less than 1% was used for intertidal restoration nationally. Covering a similar period of time, Paipai (2003) provided a breakdown of the annual proportions and found that the annual tonnages of silt in England and Wales ranged from 29 to 57 million tonnes (approximately 22 to 44 million m^{-3} $year^{-1}$[8]) between 1992 to 2000. During the early years of that period, the proportion of available silt that was beneficially used was typically around 0.07% $year^{-1}$. However, this increased slightly over time with a peak value of 0.8% occurring in 1998 due, largely, to mitigation works carried out by Harwich Haven Authority.

> There are many ways in which dredge sediment can be beneficially used as well as a clear policy drive to see such projects implemented. However, the rate of project implementation for environmental measures remains limited. It is valuable that around 30 to 40% of the annual maintenance dredge resource is sustainable relocated (kept within the sediment system) but only a fraction of 1% is used directly for habitat restoration. This fraction can be particularly small in years when no notable projects are undertaken, or in areas away from Essex and Suffolk, where projects are most commonly undertaken.

A more recent investigation for the South marine plan area (MMO, 2014) indicated that 'a relatively modest' amount fine sediments (17,000 tonnes) had been reused in this region over a decade. This equates, very approximately, to 0.05% of the total available dredge resource on the basis that at least 30 million tonnes of material had been, or would be, dredged (mostly yielding silt during capital dredging campaigns, between 2011 and 2018). The value of 17,000 tonnes also equates to around 0.1% of the regularly available maintenance dredge resource. This is on the basis that licensed maintenance dredging campaigns in the South could cumulatively provide as much as 1.6 million tonnes $year^{-1}$ over the next few years (again this would be mainly silt).

To examine this issue further, it is possible to compare the disposal volumes in the Defra 'Disposal At Sea' (DAS) database against known projects. Over the decade from 2003 to 2012 the database shows

6 http://defra.maps.arcgis.com/apps/webappviewer/index.html?id=3dc94e81a22e41a6ace0bd327af4f346
7 Apparently it was easier to separate out in the past when there were two licence streams and when beneficial use projects were licensed as construction applications (Andrew Birchenough, Cefas, Pers. Comm. Nov 2016).
8 Using a 1.3 conversion factor for 'soft silt mud' HELCOM (2015)

that some 268 million tonnes (wet weight) were deposited offshore during this time (of which 250 million tonnes was from maintenance dredging and 18 million tonnes from capital dredging). This converts, very approximately[9], to 179 million m^3. Over this same period, in the region of 850,000 m^3 of silt was used beneficial for some form of intertidal habitat restoration nationally (see Section 2.1). This represents roughly 0.5% of the total available resource (although larger proportions, of sand particularly, will have been used beneficially in other ways).

The fact that this national percentage estimate is marginally higher than that quoted for the MMO South marine plan area will probably be because larger and more frequent projects have been carried out in Essex and Suffolk over this period. This includes the especially large Allfleet's marsh recharge initiative (550,000 m^3) which was undertaken on land prior to a managed realignment. To date however no particularly large-scale and sustained projects have been undertaken directly on intertidal habitats in the UK.

1.2.4 Barriers to intertidal beneficial use

There are many reasons why only a limited number of generally small-scale intertidal recharge projects have been carried out. These 'barriers to implementation' have been examined within many of the studies that have been cited above (CEDA 2010; IADC, 2009; PIANC 2009; Murray, 2008; Bray, 2008; Paipai 2003) as well as more recently by studies conducted by ABPmer (2014)[10] and the MMO (2014). A summary of these key reasons is presented in Table 1.

Among the central concerns though are that the use of finer (silt) sediment to protect and enhance the ecology of coastal marshes and mudflats is viewed as being difficult (and costly) and considered to pose greater environmental risks (with implications for damage to existing habitats/species or temporary water quality changes). The extra practical cost of beneficially using silts, and the additional fees incurred for obtaining consents, are therefore often seen as a showstopper to implementation. Crucially, also, there is no statutory leadership or sector-specific legislation on this subject that can be used to overcome these key hurdles.

In contrast to silt, larger volumes of sands and gravels are used for activities such as beach nourishment and flood protection and coastal infrastructure. In part, this reflects the fact that there is a clearer understanding, and consensus, about the economic motives for using such materials for such projects. Therefore, if more intertidal habitat restoration projects are to be realised using finer dredge arisings, an equivalent level of clarity and consensus is needed about the motives and costs for doing such work.

This lack of a full understanding about the costs and benefits of intertidal silt-recharge projects is, therefore, a key barrier to implementation and is considered to be a key information gap to be filled if future projects are to be undertaken, especially at a large scale (PIANC, 2009; ABPmer, 2014). Some of the key issues listed in Table 1 are also likely to be magnified for any attempts at large-scale intertidal beneficial use projects. In particular, larger-scale projects using silts will be accompanied by greater levels of uncertainty regarding: technical feasibility; the full range of costs and benefits; and environmental impacts (e.g. loss of or damage to existing habitats/species).

9 Using a 1.5 conversion factor for mixed sediment created by averaging between the factors for various sediments including 'mud (containing organic matter)'; 'soft silt mud' and 'sand' as quoted within HELCOM (2015).

10 This involved an ABPmer-hosted meeting in March 2014 which was attended by a range of interested stakeholders (The Crown Estate, Environment Agency, Natural England, Boskalis, ABP, Solent Protection Society) to clarify the barriers to beneficial use and the actions that could be undertaken to resolve them.

Table 1. Issues/barriers currently which constraining beneficial use of dredge sediment

Issues	Summary of the Barrier(s)
Leadership	There is an absence of statutory leadership and no Government department taking ownership of, or championing, this subject.
Legislation and Consenting	There is no centralised legislation pertaining to dredging. In large part because of this, and the multiple separate legal drivers, the consenting process is very complex and lengthy. This means that it is generally easier to get a disposal licence.
Economics: Cost	It is often cheaper to dispose of sediments subtidally and offshore than to use them beneficially for habitat restoration. This is because there are often extra technical challenges (and costs) for sediment handling, vessel change, installation of bunds etc.
Economics: Funding	Linked to the preceding point there is also a need for funding sources and to clarify who benefits - especially because the current situation is that the parties which could benefit are not necessarily the ones to incur the costs (i.e. the port/harbour operators). Also, funding for schemes under Flood and Coastal Risk Management (FCRM) process is not assured.
Market malfunction and poor co-ordination	There is an onus on the ports/harbours/marinas to re-use or recycle material but no corresponding requirement of coastal managers to find materials to recycle (i.e. there is supply without clear demand). Also, the available sediment may not match with FCRM scheme requirements and there are often issues of timing, with mismatches occurring between when sediment is available and when it is needed (or can be used/consented for use).
Sediment type and associated technical challenges	It is considered easiest to use coarser sand/gravel sediments rather than silt for mud and marsh recharge.
Uncertainty of impact	There are concerns over potential environmental impacts arising from habitat recharge works.

Source: Derived from ABPmer (2014)

The ABPmer (2014) review identified a range of possible actions to address these barriers of which clarifying the costs and benefits is one and is a motive for the production of this white paper. Another generic action highlighted by Murray (2008) is to maintain communication about projects with a view to gain trust between the public, regulators and other stakeholders. It is hoped that this white paper can also contribute to this required and ongoing process of communication.

1.3 Review methods

As described above, the costs and benefits of intertidal sediment recharge schemes are clearly subjects which warrant consideration to confirm whether such initiatives can be effectively implemented. This clarification is especially needed to understand whether large scale beneficial uses of muddy sediments can be undertaken in the UK for the first time. However, these are not issues that have been examined in much depth previously and in part this will be because there is no simple 'one size fits all' approach to beneficial use. Instead, there are multiple ways to carry out recharge work and multiple different levels of cost and degrees of benefit depending upon the particular site-specific conditions.

It is possible however to understand this subject through reference to different known strategies and case examples. To set a context for this review, therefore, Section 2 provides an initial overview of the four main technical approaches and the general status and costs of intertidal sediment recharge in the UK. Then Section 3 considers what is known about the benefits. Section 4 presents a cost benefit analysis framework and illustrates its application to a hypothetical intertidal sediment recharge. Section 5 presents conclusions and recommendations.

To inform this review of the practices and costs, information has been collated from a range of available published and unpublished documents as well as from a number of experts in the field. Indeed, because there is limited amount of written reporting on this subject, the main and most valuable information in this review comes direct from specialists as listed in the acknowledgments section at the start of this paper. To preserve the flow of text, each individual personal communication has not always been quoted here, but we would like to emphasise again that this study could not have been done without the support of these participants.

2 Intertidal Recharge Practical Review

2.1 Completed project and techniques

A summary of the main intertidal recharge projects that have been undertaken in the UK over the last 20 years or so is presented in Table 2. These are specifically projects that have used fine sediment placed directly onto intertidal marshes and mudflats.

Table 2. Intertidal or low shore recharge works over the last 20 years (1997-2017)

Operational Approach	Project	Year(s)	Volumes
Backhoe Extraction to Backhoe Placement (see Section 2.2)	Maldon (and Northey Island), Blackwater	2001 to present	Approx. 2,000 m^3 yr^{-1}
	Loder's Cut Island, Deben	2015	Approx. 800 m^3
Back-hoe Extraction to Pumped Placement (see Section 2.3)	Boiler Marsh, Lymington (Wightlink Project)	2012 and 2013	4,500 m^3 marsh recharge mitigation over two annual campaigns
Cutter Suction Extraction to Pumped Placement (see Section 2.4)	Lymington Intertidal Restoration (Lymington Harbour Commission Project)	2012 and 2013	3,125 m^3 marsh recharge mitigation over two annual campaigns
	Levington Marina, Orwell	Several years/ Annual	Approx. 10,000 m^3 yr^{-1}
	Blue Lagoon, Poole Harbour	Several years/ Annual	Very small scale regular work of around 600 m^3 yr^{-1}
Suction Extraction to Pumped/'Rainbowed' Placement (see Section 2.5)	Allfleet's Marsh, Wallasea, Crouch	2006	550,000 m^3 - one-off large scale placement on managed realignment before inundation
	Horsey Island, Hamford Water	1998 to 2006	After initial phases of shingle and silt import in early 1990s 107,750 m^3 used over four campaigns in two areas.
	Shotley (North), Orwell	1997	22,000 m^3 maintenance 'dredgings' pumped behind a 75,000 m^3 retaining gravel bund (fronting 2 km earth wall)
	Trimley, Orwell	2003	22,000 m^3 for gravel bund (1.4 km long 50-60 m in front of seawall) then backfilled with mud (volume of silt not known)
	Shotley (South), Orwell	2003	15,000 m^3 of dredged gravel and silt (retained using clay and gravel bund)

Source: www.omreg.net

In total there have been around 12 such projects over the last 20 years. Some of these have been one-off initiatives while others have been undertaken more regularly. There may be other projects that have been conducted that are not on this list and this may include other initiatives that have used a combination of silt and shingle recharge techniques. There will also be projects (such as recent initiatives at Lymington) which have involved placing material on the shallow subtidal areas which are not included here as they do not involve direct intertidal recharge. However, these nearshore 'subtidal placement' projects may well have indirect benefits for intertidal habitat.

For the intertidal recharge projects listed in Table 2, a range of different techniques were adopted for the dredging excavations and then for their subsequent placement. The most suitable approach at any given location will be dependent upon several factors including:

- The sediment type;
- The level of sediment contamination;
- The availability of appropriate equipment;
- The proximity of an appropriate receptor habitat; and
- The advice of regulators and stakeholders.

To recognise and describe this variability of approach, the projects in Table 2 are divided into the following four 'operational categories' based on the excavation and deposition approaches:

- Back-hoe Extraction translocated for Back-hoe Placement (Section 2.2);
- Back-hoe Extraction translocated for Pumped Placement (Section 2.3);
- Suction Dredge with direct Pumped Placement (Section 2.4); and
- Suction Dredge translocated for Pump/Rainbow Release (Section 2.5).

The following sections (Sections 2.2 to 2.5) review each of these categories of operation further and consider the outcomes and costs from selected project examples.

2.2 Back-hoe extraction and back-hoe placement

This is probably the simplest, and in many ways also the most effective, strategy for delivering dredged sediment to a receptor site especially at a small-scale. It involves excavating sediment with a back-hoe into a hopper, relocating to a receptor site and then depositing materials by a reversal of the same excavation/backhoe approach. This technique ensures that the sediment remains relatively well consolidated (with low water content) which maximises its stability at the deposit site.

This technique has been undertaken regularly at Maldon (Blackwater Estuary, Essex) for several years. Each year around 3,000 tonnes of channel maintenance (approximately 2,000 m^3) is taken from the upper Blackwater Estuary channel and harbours and then placed, mainly, on a saltmarsh spit on the north bank of the Chelmer River (immediately downstream of the Hythe Quay at Maldon). The material is dredged by an excavator mounted on a hopper barge itself and the barge then moves to the high water margins of the receptor marsh where the reverse operation takes place (see Image 1).

The approach has been used to nourish the Chelmer River saltmarsh spit (see Image 2) since 2001 and this nourishment followed on from an early marsh restoration initiative that was undertaken here in 1993. That original restoration and the ongoing recharge has repaired the marsh which was breaking up and causing erosion behind (Nottage and Robertson, 2005). The sediments deposited through this recharge approach are rapidly colonised by plant species and, consequently, the Chelmer Marsh has continued to grow and provide increased erosion protection over time. Therefore, while the sediment volumes are not large, this project has shown that repeated year-on-year small-scale applications of consolidated material deliver clear benefits.

Photos: ABPmer September, 2016

Image 1. Maldon saltings recharge showing barge-mounted excavator and recharge area

The costs for this work are likely to be in the region of £1,000 per barge load and each year around 25 barge loads are required for the Chelmer Marsh (with each barge carrying around 120 tonnes or around 80 m^3). Thus the annual cost is estimated to be around £25,000. In addition to this work, on an intermittent basis, material has historically been placed on the south bank of the river west of Northey Island. More recently this work has been carried out on Northey Island itself. At these sites, this work often takes place on the exposed drying intertidal (whether at the excavation and receptors sites).

An almost identical approach, incurring comparable fees, was adopted on Loder's Cut Island in the upper Deben Estuary in September 2015. This was as a one-off exercise that involved total of 16 barge loads being taken from Ferry Quay at Woodbridge and transported around 800 m to Loder's Cut Island. This 'Cut' is an adjacent and small navigation channel which was historically formed by manual (by-hand) excavation in this part of the estuary.

Photo: Jim Pullen UAV Surveys

Image 2. View of the recharged Chelmer River spit downstream of Maldon

For this work, a small 65 ft (20 m) barge was used that had an aft-mounted excavator and a carrying capacity of 75 tonnes (or around 50 m^3) each. This was suitable for use in the constrained and busy upper estuary. Like the work at Maldon, the material from each barge was back-hoed out on the top of the tide with the barge being floated in and out over one high water period.

A visit to the site a year later (see Image 3) indicated that the material had remained in place. It was still present as an elevated strip of around 0.1 ha in size (around just 15 m by 7 m) that had remained *in situ* with only some slumping on the channel or 'cut' side. Birds were observed roosting on the raised mound shortly after completion of the work. One year later the upper margins of this deposited strip had a thick cover of *Salicornia* spp. as well as occasional Sea Aster (6-7 plants) and one *Spartina* plant. There were also signs of invertebrate burrows and bird feeding on the unvegetated lower margins on the channel/cut side.

Photos: ABPmer September, 2016

Image 3. Loder's Cut Island recharge showing barge-mounted excavator and recharge area

This work cost in the region of £14,000 for the work itself plus a further £2,500[11] for the MMO licence. At this small-scale and at this location the main benefits are from: restoration of marsh habitat itself; provision of a potential bird roosting area and the fact that it will be helping to direct and maintain flows through a navigable 'cut'. The benefits also come from allowing the work to take place at all. This is because there are no real alternatives and taking materials offshore or into lower reaches of the Deben would have been more costly. Local subtidal relocation in the upper reaches would have adversely affected navigation in the constrained and silted upper reaches of the Deben Estuary.

2.3 Back-hoe extraction translocated for pumped placement

This technique typically involves a 'double-handling' approach in which dredge arisings are excavated using a back-hoe approach, but then transported in a hopper barge to a separate location where the sediment is then pumped to a receptor site. This double-handling approach is appropriate for projects where the receptor site is distant from the extraction location and especially where it is inaccessible to hopper barges. This technique has the advantage of allowing a high degree of targeted control over the location, rate, nature and extent of the sediment deposition to receptor sites that are otherwise difficult to access. It does, though, incur additional costs to cover the extra vessels, equipment and working time that are required.

It was necessary to use this strategy for the Wightlink Ltd. Boiler Marsh recharge project at Lymington. This project, which was carried out in 2012 and 2013, involved using sediments dredged from the Lymington marinas and navigable channel to recharge a discrete and deteriorating habitat at the heart of a large saltmarsh to the east of the harbour entrance. Back-hoed material was placed in a hopper barge which was then used to transfer the material along a tidally constrained creek. The

11 £700 being the actual fee under tiered Marine Management Organisation (MMO) licencing and the bulk of this fee being for sediment contaminant testing.

hopper barge was then moored alongside a spud platform and from there the sediment was pumped into marsh (see Image 4 to Image 7).

Photo: ABPmer March, 2013

Image 4. Wightlink recharge showing hoppers moored at spud barge and pumped deposit

The sediment was pumped from the barges at relatively high densities of up to 50% silt (ABPmer, 2013) and much of it settled quickly out of the water column and was retained within the deposit site and close to the site of the discharge. At the deposit site a series of 10 polder and hay bale fences had been placed for sediment retention. These fences were effective although a proportion of sediment left the area though the outer boundary. However, this exported material evidently settled close to the site and did not disperse widely (ABPmer, 2015) (see Image 5).

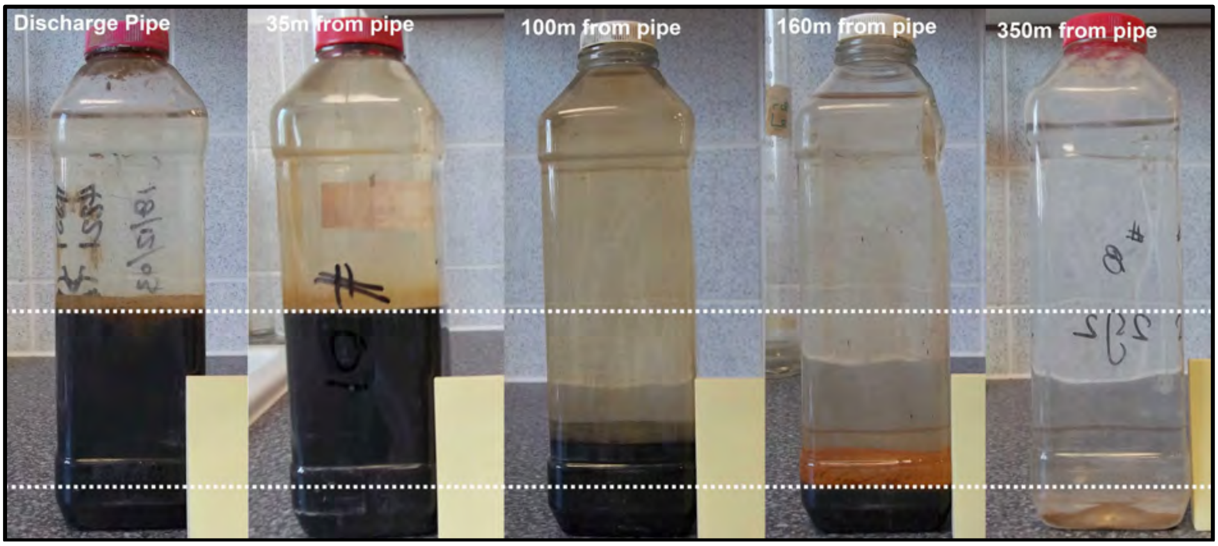


Image 5. Water samples in recharge area (3 on left) and outside (2 on right) in marsh creek

This recharge project was designed to offset potential effects on intertidal habitats arising from ferries operating between Lymington and Yarmouth. Crucially, this approach was designed to provide this mitigation in an adaptive manner so that, were impacts to be greater than anticipated, more restoration could be undertaken beyond the first two proposed campaigns. The approach proved to be successful over two campaigns (ABPmer, 2015), with the sediment still being retained at the deposit site after several years (long-term monitoring ongoing). The outcome has been an improvement to the quality of the habitat at the deposit site which changed from eroding clay mounds and anoxic channels to a mixture of mud, marsh and clay habitat (ABPmer, 2015).

This Wightlink Ltd project also reduced the rates at which the marsh surrounding the deposit site decays (a value calculated using a distinct 'hectare-year' metric that has been used on other Lymington projects). This was because the recharge was deliberately located at the end point of a large channel which was cutting through the marsh. Without intervention, the channel was going to soon fracture the marsh into two parts and then accelerate the rate at which the whole marsh eroded.

This delay to the loss of marsh also provides benefits from delaying the moment when the inner harbour and mooring areas of Lymington become exposed. It also, potentially, delays the moment at which the Lymington Harbour Commission (LHC) needs to extend construction of rock armoured harbour protection. This erosion of the Boiler Marsh has been taking place since at least the 1940s and the marsh habitat is expected to be lost entirely (assuming there is no intervention) by around 2040. It is inherently difficult though to quantify the benefits from delaying loss or delaying the costs incurred from the consequences of loss.

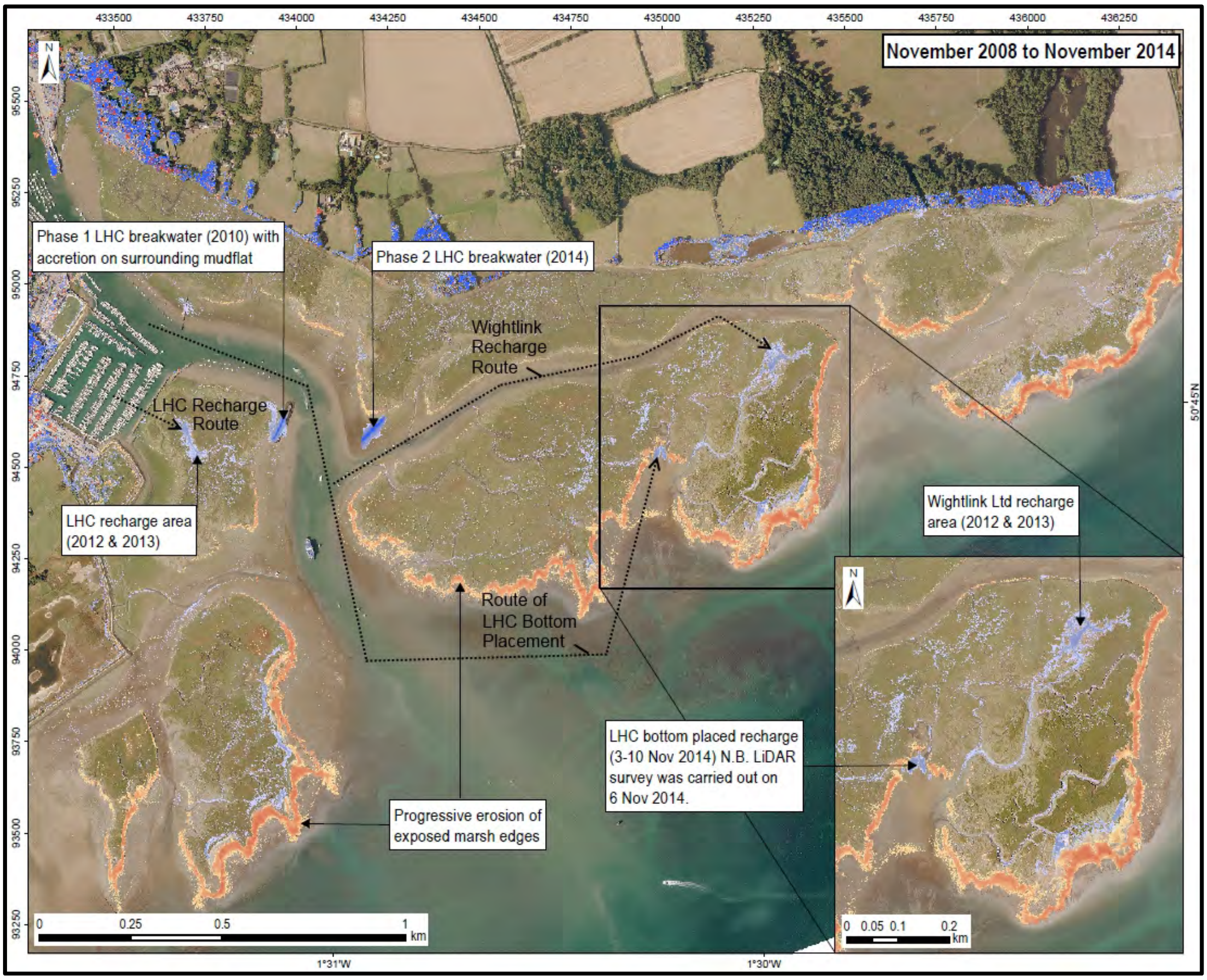
Photo: Land and Water Ltd, 2012

Image 6. Wightlink recharge work showing spud barge and discharge pipe to recharge area

This project was however atypically costly. The estimated total fee for this work was £500,000. This high fee was incurred for many reasons including the need to: accommodate a rapid turnaround following a public inquiry judgement; install fencing in difficult weather conditions at locations that were difficult to access; pay fees for leasing the compound site and for berthing/mooring; incur costs for the dredge material (with these fees equating to the extra costs incurred by the on-site contractor for operating under tidal constraints as compared against the fees incurred for offshore disposal without such constraints); as well as costs for a monitoring programme and hosting and overseeing a management panel and, where required, securing legal advice.

For the Wightlink project, several different pieces of equipment were needed to convert the back-hoe excavated material to a pumped discharge. However, it is also recognised that new equipment is now available that can undertake this whole process within the same craft and without the need to double handle. For example such an approach was used at Brightlingsea Marina where the hopper that receives the back-hoed materials has an integrated pressure jet that breaks the sediment up and integrated pump and pipe that allows for remote sediment dispersal into the adjacent tidal channel[12]. This is likely to be a cheaper approach than double handling. It was also helpful at Brightlingsea, where, although the project is relatively small scale, the working conditions are quite complex and the tidal working windows are relatively small.

[12] https://www.youtube.com/watch?v=56lfRtfQ3dA



Environment Agency LiDAR Data

Image 7. Lymington Recharge activities against a 'LiDAR difference' backdrop[13]

2.4 Cutter suction dredger and direct pumped placement

This approach involves having a cutter-suction dredger working within a marina/harbour which then pumps sediment directly to a receptor site that is located nearby. There are a few examples of this approach and two particular examples are at Suffolk Yacht Haven (SYH) near Levington on the Orwell, Essex and further recharge project undertaken in 2012 and 2013 at Lymington by the Lymington Harbour Commission (LHC).

At Levington, recharge work has been undertaken using this approach since the late 1990s, with the first licence being issued in 1997/98. At this site, maintenance dredge arisings from the marina are pumped directly to adjacent foreshore areas (formerly the sediment had been pumped to land behind). In some areas sufficient material has remained to raise the tidal height of the foreshore to allow saltmarsh plants to colonise.

13 The difference plot illustrates the elevation changes between 2008 and 2014; marsh lowering/erosion areas are red, while marsh raising/recharges areas are blue.

Today, there are four intertidal locations surrounding the Suffolk Yacht Haven that are used for the placement of sediment from the marina. These receive around 10,000 m^3 of material excavated each year to maintain depths in the marina. Recently, in 2014/15, the material was pumped to a more distant but also more sheltered degraded marsh area ('North Marsh') which lies some 500-600 m away. At this site the soft fluid sediment was retained in the creek using a system of coir logs held in place by wooden posts (see Image 8).

Photo: ABPmer, February 2016

Image 8. North Marsh recharge site after receiving sediment from Suffolk Yacht Haven

As the material is pumped directly to site there is a low percentage of sediment in the water (perhaps 10%) as it is released to the discharge site. As it is very fluid there is inevitably a lot of dispersion of sediment into the wider environment. This dispersed material is understood to be retained locally within the estuary/creek system (which would match observations made at Lymington following the Wightlink work). During a site visit in February 2016 for instance it was clear that fluid mud was still being retained in the creeks behind the coir logs at the North Marsh site (see Image 8).

This is another example of a site where the beneficial approach is demonstrably the most cost-effective strategy. For this project, beneficially using maintenance dredge sediments on the adjacent marshes in this manner is cheaper than exporting the materials to a more distant location (even within the Orwell). The Suffolk Yacht Haven (SYH) owns the equipment and uses its own staff to carry out the work and therefore there are no sub-contractor costs, but all fees for the maintenance and implementation of the work fall to SYH. Very roughly, such costs are approximately £80-90,000 per year (for wages £40,000; insurance £5,000; fuel £15,000; maintenance £25,000). The process of repeat licencing was considered to be very low at around £2,000. On this simple basis, the annual beneficial deposit of 10,000 m^3 silt to the local intertidal areas incurs a fee of £8-9 m^{-3}.

At Lymington a similar technique was used by the LHC with a cutter suction dredger being employed to dredge the Yacht Haven Marina and then pump sediment direct to the adjacent marsh (see Image 7)[14]. This recharge work was undertaken as mitigation for losses of intertidal habitat caused by constructing a rock armour breakwater. As with the Wightlink Ltd recharge work at Lymington (see Section 2.3), the idea here was to achieve the mitigation by reversing a process of ongoing marsh decay which is occurring rapidly on the Lymington site. In this case both the recharge and the protection then afforded by the breakwater were designed to act in tandem to deliver a long term gain (Black and Veatch, 2012).

[14] A similar but very small scale initiative is also carried out at Blue Lagoon Poole where sediment from an access channel is pumped to higher areas of the intertidal.

A 0.5 ha area of decaying marsh habitat was raised up using around 3,125 m^3 of sediment which was pumped directly from the nearby Lymington Yacht Haven over two campaigns (1,625 m^3 in 2012 and 1,500 m^3 in 2013). At the point of the discharge the sediment concentration in the water was 25% and the majority of the sediment (at least 80%) was estimated to have been retained within the defined recharge area (Lowe, 2012, and Black and Veatch, 2012). In contrast to the Levington example, the delivery of the retaining materials was quite complex because the marsh island was not easily accessible. This work cost a total of £100,100 (£61,500 in 2012 and £38,600 in 2013).

In more recent years, the LHC has also undertaken additional habitat replenishment work in which material is back-hoed into a hopper translocated to the lower marsh edge and 'bottom dumped into the shallow subtidal. This approach is similar to sustainable relocation in which sediment is excavated and then disposed of subtidally within the local sediment cell (see Section 1.2.2). However, the intention here is to get as close as possible to the marsh edge and create a sacrificial bund that reduces wave energy hitting the marsh behind.

To date, three LHC subtidal deposit campaigns have been undertaken (November 2014, January 2015 and January 2016) with volumes increasing on each occasion (2,000, 6,086 and 8,695 m^3 respectively). The effectiveness and benefits of this work are still being examined through monitoring but this approach is expected to be much better than taking the sediment out of the system to offshore deposit sites. The extra value for the purposes of this review is that three different recharge approaches have now been conducted at Lymington and this offers a very valuable opportunity to compare and contrast the costs and benefits of these different approaches with offshore disposal options.

2.5 Suction dredge translocated for pump/rainbow release

This method involves a cutter-suction dredger that carries out the sediment removal and placement. It is typically used for larger projects (e.g. for deepening harbour and port approach channels) and on projects where sediment needs to be translocated some distance from the dredging site. Due to the size (draft) of the dredger, it cannot then approach too close to the area that is being recharged and, therefore, the approach is to 'rainbow' the material in or to pump it in a more targeted fashion via a pipeline.

This approach has been used on a number of occasions as part of the beneficial use initiatives undertaken by the Harwich Haven Authority (and often in partnership with the Environment Agency and Defra) including at: Shotley foreshore (Orwell Estuary), Trimley foreshore (Orwell Estuary), Horsey Island (Hamford Water) and Allfleet's Marsh (Wallasea Island, Crouch Estuary) (Image 9 and Image 10). Many of these projects have been well monitored so that we have a good understanding about how they have functioned.

The Shotley and Trimley work involved the use of sediments from the Port of Felixstowe as mitigation measures. At Shotley (North), a trial recharge was carried out in 1997 involving the use of clay/shingle material to create a fronting bund, followed by silt and sandy gravel recharge behind. Six years later, in 2003, a similar approach was undertaken at Trimley. Before these initiatives, almost all the marsh in front of Shotley North had been lost while at the Trimley site, the foreshore had been eroded to clay. These recharges were carried out to raise intertidal elevations and therefore improve degraded foreshore areas, protect vulnerable sections of seawall and reduce flood risk to hinterland areas (including the Trimley Nature Reserve).

In 2003, further work was undertaken at Shotley (South) which included the creation of clay bunds around the Shotley Marina that were then infilled with silts. These measures were undertaken as mitigation for potential impacts arising from the Trinity III terminal development at Felixstowe (Royal HaskoningDHV, 2013).

Both gravel bunded sites (at Shotley (North) and Trimley) have functioned well and achieved a stable habitat configuration after a period of shingle roll back. A key distinction between them is their tidal elevation, with the habitat created behind the shingle bunds being different at the two locations. Shotley is 0.75 m higher than Trimley and, hence, the Shotley silt has been colonised by marsh plants, while the Trimley site has remained mainly as mudflat. In total, around 23 ha of intertidal habitat is believed to have been enhanced by this work (Royal HaskoningDHV, 2013).

Photo: Defra, May 2006

Image 9. Allfleet's Marsh recharge showing dredger and sediment entering retaining bund

As this approach requires much larger equipment it is inherently more expensive and the fees can be temporally very variable in response to shifts in the market. At Allfleet's Marsh the earthwork to build the new sea walls cost around £1.5 million while the recharge cost closer to £1 million[15]. This equates to the equivalent of just under £2 m^{-3} for the dredge sediment used and is based on the extra cost incurred to take the material to Wallasea rather than dispose of it at sea.

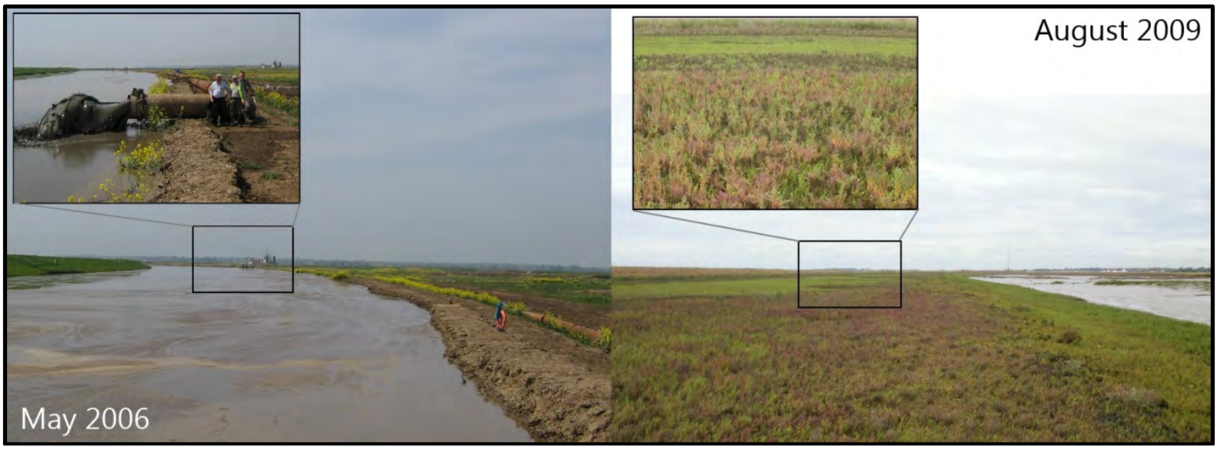


Photo : ABPmer 2006 and 2009

Image 10. Allfleet's Marsh during final recharge and then 3 years later with dense plant coverage

15 The realignment cost around £7.5 million.

This technique was also used on a number of occasions to protect the exposed north side of Horsey Island. Horsey Island lies at the centre of the Hamford Water coastal inlet (Essex) and, due to its location and size, the island plays an important role in providing wave protection for the wider 'Walton Backwaters' and the shoreline behind. The recharge work was carried out using shingle and silt to protect deteriorating coastal defences and eroding habitats. The sediments were derived from capital and maintenance dredging work at Harwich and Felixstowe and there were six phases of work over several years (ABPmer, 2016), as follows:

- **Phase 1 1988**: Installation of Thames Lighter Barges to act as wave energy breaks;
- **Phase 2 early 1990s:** Importation of shingle and sand (148,000 m^3) over several phases (starting with 18,000 m^3 in 1990) to create a new barrier along the alignment of the lighter barges;
- **Phase 3 1992:** Small-scale trial of silt recharge onto saltmarsh (<1,000 m^3) undertaken at the south-east corner of the island;
- **Phase 4 1998:** First major importation of silt (20,000 m^3) over 2.7 ha of mudflat behind the sand and shingle barrier to raise intertidal levels, stabilise the barrier and create marsh habitat;
- **Phase 5 2001 and 2003:** Second and third importation of silt in 2001 (15,750 m^3) and 2003 (25,000 m^3) to 'top up' intertidal area behind the sand and shingle barrier;
- **Phase 6 2005/06:** Importation of silt (47,000 m^3) over two phases in November 2005 (21,000 m^3) and January 2006 (26,000 m^3) on to a separate area of deteriorating saltmarsh to the west of the sand/shingle barrier to raise and restore this degraded habitat and protect the sea wall.

These phases of work have been successful because the mud and shingle have been relatively stable. The shingle barrier retreated shoreward after deposition but showed greater stability once the mud was placed behind it (ABPmer, 2016). A recent photograph of the site is shown in Image 11. Like the Trimley and Shotley (North) projects, this has demonstrated how both coarse and fine-grained dredged sediments can be used effectively to build up and restore intertidal habitats and enhance coastal protection. No details on the costs of this work are available but it has protected around 900 m of the shoreline as well as restoring around 15 ha of intertidal habitat (marsh, mud and shingle).

(Jim Pullen UAV Surveys April 2017)

Image 11. Horsey Island with recharged shingle barrier fronting recharged marsh and mudflat

In addition to this completed work, there is also a proposal to beneficially use 98,000 m^3 of material, again from the Harwich approaches, in front of selected sites near Mersea Island. The fee for the supply and delivery of this material has been quoted as £3/ m^3 (or £294,000) before consideration of the fees for the planning and marine licence submissions. As with the Allfleet's Marsh work, the costs here represent the addition fees incurred over and above those that would apply for standard at sea disposal. In this case the costs for these submissions have been around £80,000 but that fee did rely heavily on in-kind and voluntary work by local specialists and surveyors to the tune of an estimated further £70,000 (i.e. half as much again as the costs of the works).

2.6 Summary of costs for intertidal recharge projects

2.6.1 Indicative costs for dredging and disposal

Before considering the cost of the recharge work itself, it is recognised that standard fees are incurred for the dredging work against which the "differential costs" for alternatively beneficial using the sediment should be compared. This includes costs for buying, hiring, or maintaining equipment for a project as well as further costs for survey work and works licences.

Where the operator owns the equipment there will be annually-incurred fees for maintaining this which might be around £20,000-£40,000 although there can be additional fees for certain elements. There are also fees that need to be incurred for securing licences, consents and undertaking post consent monitoring. This can be a large part of the fees. The very small Loder's Cut project for example had an estimated cost of £21 m^{-3}. Of this around 20% (£3 m^{-3}) was for the licencing (mainly sediment testing) while the remainder 80% (£17.5 m^{-3}) was for the practical work itself. For the slightly larger projects undertaken by the Lymington Harbour Commission (LHC), the fees for licensing and monitoring were typically around 10% of the overall costs.

In addition to these ongoing costs, there are then major fees for actually undertaking or sub-contracting dredging and disposal work itself. Here the cost will vary substantially depending upon whether it is local and small plant that is used or whether larger equipment needs to be subcontracted in. One key influencing variable is the distance between the dredging (excavation) site and disposal locations because this dictates the fuel costs and the rate at which each barge can be emptied and refilled. For example, using cost details provided by the LHC, the steaming distance from Lymington to the Hurst Fort disposal site is around 5 km (or approx. 3 nm) and has had a dredge/disposal cost of £8.70 m^{-3} on average over the last three winters. Similar values of around £9-10 m^{-3} apply in other UK locations where the deposit ground is relatively close. At greater distances the fees can be double these values (around £14- 18 m^{-3}) with even higher costs for complex dredging projects. For example, comparatively high costs are incurred by Solent marinas in the Hamble, Itchen and Chichester Harbour, where material needs to be taken some 25 to 45 km (or approx. 13-24 nm) to the Nab deposit ground. In such cases the steaming time can be up to 5.5-6 hours for each deposit and be very much dependent on the weather.

There can also be large temporal variability in the costs in response to the dredging market. This is especially the case where large plant are required (e.g. from projects such as Horsey Island or Allfleet's Marsh) and where costs are influenced by plant availability and the degree to which such plant are diverted onto extant national and international projects.

2.6.2 Indicative costs for beneficial use

Set against the kind of fees described above, intertidal recharge does not always have to be more costly. It can be either cheaper, cost neutral or more expensive depending upon circumstances. However, the key cost is the operational work itself which is influenced by factors such as the volume of sediment, the time taken to empty and refill each barge, transport distance, the complexity of the initiative, the extent to which bespoke equipment needs to be brought in and the need for sediment retaining fences to be introduced. To demonstrate the variability of the costs incurred for beneficial use, the fees obtained from a selection of examples for this review are shown in Table 3. These show the general project expressed as costs m^{-3}[16].

One example of beneficial use being cheaper than an 'at sea disposal' alternative is at Levington. Here the equipment is owned and maintained by SYH as the marina operator and any alternative to pumping onto adjacent intertidal areas would incur additional fees to cover greater steaming distances, even if that was to a position locally within the Orwell Estuary. Using its in-house equipment in this way (see Section 2.4), SYH incur a cost of around £8-9 m^{-3}.

The projects at other Essex and Suffolk estuary sites (Maldon and Loder's Cut) will also be cheaper than the alternatives. This is because a higher cost would be incurred for the longer-distance transport (needed to dispose at sea) and also because these beneficial use projects use local plant and specialists so that they do not require any substantial changes to the equipment or mobilisation fees.

Another, very different, example of a cost beneficial project is from the Meyer shipyard on Ems Estuary (Germany) (Helmut Meyer, Federal Waterways and Shipping Agency Pers. Comm.). In 2015 the cost of dredging and then translocation over 60 km to a disposal area in the estuary was 14.5 € m^{-3} (based on dry weights). However, moving it 7 km to a nearby site for beneficial use (in this case to improve agricultural land) was less than half that (6.8 € m^{-3}). In addition to these transfer fees, it cost around 5.2 € m^{-3} for the extra work required for aspects such as: pipeline construction, pumping to the fields, building dams, dewatering, re-cultivation and natural compensation measures. Therefore the cost of beneficial use of the sediment was cheaper at 12 € m^{-3} than subtidal disposal. While this is not an intertidal recharge, the principles are the same and this shows the benefits of reducing the haulage distances and then what can be achieved with this cost saving.

Where projects are novel and require new equipment or preparatory work then the rates can be several '£10s' m^{-3}. This applies where recharge needs to be pumped in larger volumes directly onto higher intertidal elevations, because that requires extra costs for the construction of retaining fences and well as additional distinct equipment in certain cases. For the LHC at the Lymington Yacht Haven Marina in 2012 and 2013 (see Section 2.4) that used this approach, there was a total fee of £100,100 (£32 m^{-3}). Here, the main key cost elements were the fencing work in Year 1 (2012) and the subcontracting of larger plant in Year 2 (2013). However if the costs for fencing and sub-contracting are excluded then the fee was £10-11 m^{-3} (with monitoring) and closer to £5 m^{-3} (without monitoring). If such intertidal recharge work was carried out each and every year with regularity using local plant, then the costs for these big ticket items (fences and equipment) would proportionally reduce. Costs may reduce to a level where there is little difference from standard offshore disposal (or perhaps the fees would be lower).

For the slightly larger Wightlink projects on the other side of the Lymington Estuary that were carried out at the same time, and according to similar methods, but on a less accessible site, the overall costs were atypically large at £550,000 (or £122 m^{-3}). This was due to many factors listed in Section 2.3 including: the need for large plant to be mobilised, the distances covered, tidal constraints of operating plant, the need to double handle material and other fees.

In Table 3 cost details about the new shallow subtidal beneficial use at Lymington has also been included. This involves bottom dumping of sediment in the shallow subtidal area fronting the adjacent marshes. For this work the fees have been £10 m^{-3} on average over the last three winters. This is a 'slightly' greater fee than the rate for established offshore 'at sea' disposal which is £8.70 m^{-3} with the additional fees being due to extra licence, monitoring and reporting costs. If this project

16 These are not the "differential costs" between the available at sea disposals and beneficial use approach. If such difference costs were applied then the fees expressed would be much lower.

were allowed to continue then, over time, these extra fees are likely to reduce such that this could become the cheaper alternative to established disposal. It will be valuable to understand whether this happens and also the extent to which this project delivers benefit for the adjacent intertidal habitats over time.

Table 3. Indicative fees for selected recharge work (expressed as £m^{-3} of sediment moved)

Project	Sediment Composition and Retention	Distance	Estimated Cost £ m^{-3}
Direct intertidal recharge examples (see also Table 1)			
Maldon, Blackwater	Backhoed and 'dewatered' sediment; no fencing	1.5 to 2.5 km	£12.5 m^{-3}
Loder's Cut Island, Deben	Backhoed and 'dewatered' sediment; no fencing	800 m	£20.5 m^{-3}
Boiler Marsh Lymington (Wightlink Project)	50% sediment in pumped with water; 10 poldered fences with 3 m high stakes. Hay bales inlaid into fences and placed below them (to stop under cutting)	2 km	£122 m^{-3} as average over two years (2012 to 2013)
Lymington Intertidal Restoration (Lymington Harbour Commission Project)	25% sediment in pumped with water; polder fences/faggots, coir mats and a hay bale structure as well as corrugated plastic sheeting where needed	200 m	£32 m^{-3} as average over two years (2012 to 2013)
Suffolk Yacht Haven (SYH) Levington, Orwell	10% sediment in pumped with water; various techniques between locations includes: wattle hurdles, faggots (bundles of twigs) or coir logs	300-600 m	£8-9 m^{-3}
Other examples (not necessarily direct intertidal recharge)			
Lymington Intertidal Restoration (Lymington Harbour Commission Project)	Sediment bottom dumped in the shallow sublittoral fronting Boiler Marsh	1 to 2 km	£10.02 m^{-3} as average over three years (2014 to 2016)
Ems Estuary (Germany) Federal Waterways and Shipping Agency	Sediment pumped with water onto agricultural fields	7 km	6.8 € m^{-3} in 2015

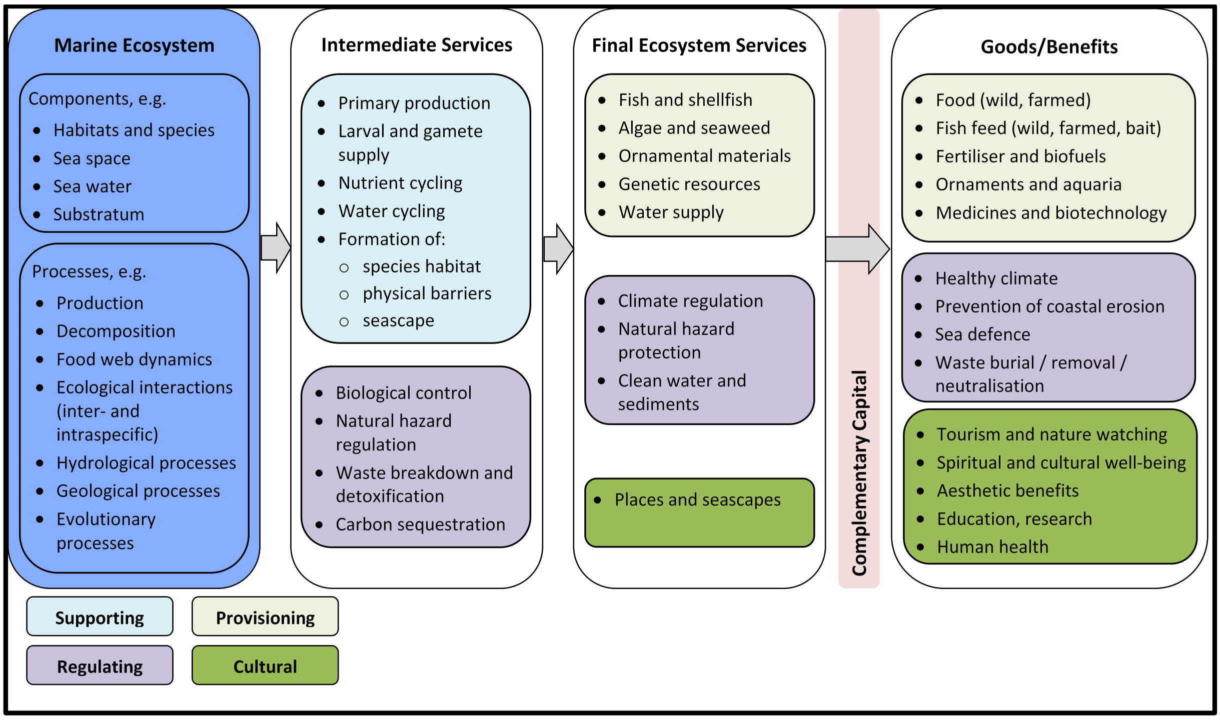
Overall therefore the costs are variable but it is the regularity and certainty of activity that is crucial to achieve cost effective interventions. It is also likely that projects involving larger volumes will bring economies of scale and reduced cost m^{-3}, although, to date, only relatively small scale low volume projects have been undertaken (typically between 1,500 m^3 to 10,000 m^3).

3 Project Benefits

3.1 Understanding benefits

In order to fully understand the merits of intertidal sediment recharge projects, there is a need for clear information on project benefits. There is little project specific information on the quantified benefits of completed intertidal sediment recharge projects. This section therefore largely focuses on the generic benefits of saltmarsh and mudflat creation.

The National Ecosystem Assessment Follow-on project (NEAFO) developed a framework for describing marine ecosystem services (Turner *et al.*, 2014) (see Image 12) and the benefits that humans derive from them. This framework is useful in supporting valuation of environmental benefits as it focuses on the final ecosystem services benefits that humans derive from ecosystems and thus avoids the risk of double counting.



Source: Turner *et al.*, 2014

Image 12. Marine Ecosystem Services Framework showing key benefits to humans

Key benefits associated with the creation of marine habitats (principally mudflats and saltmarsh) through implementation of beneficial use projects include:

- **Food**: enhanced fish production (Colclough *et al.*, 2005; Brown *et al.*, 2007); shellfish and aquaculture.
- **Healthy climate**: carbon sequestration (Chmura *et al.*, 2003; IUCN, 2009).
- **Prevention of coastal erosion**: (Pennings and Bertness 2001; Aspden *et al.*, 2004).
- **Sea defence**: reduced costs of maintenance; delay/avoidance of requirement for new defences (Möller, 2006).
- **Waste burial/removal/neutralisation**: avoidance of impacts at disposal site (Kay *et al.*, 2005; Peterson *et al.*, 2008).

- **Tourism and nature watching**: increased opportunities for nature watching (Bakker *et al.*, 1997; Fletcher *et al.*, 2011).
- **Spiritual and cultural well-being**: increased recreational opportunities, non-use benefits (UK NEA, 2011).
- **Aesthetic benefits**: improved visual appearance (UK NEA, 2011).
- **Education/research**: opportunities to study restoration (UK NEA, 2011).
- **Human health**: the values for health and well-being (UK NEA, 2011).

Various estimates of the monetary value of marine ecosystem services and of the specific contributions from saltmarsh and mudflat habitats are available from The Economics of Ecosystems and Biodiversity (TEEB) database (Balmford *et al.,* 2008) and other online sources. However, care needs to be taken in seeking to transfer habitat values to other situations because the values often reflect bundles of marine Ecosystem Services relating to a specific location which may not be transferable to different situations (UNEP-WCMC, 2011).

Available data does, however, indicate that the Ecosystem Service values of intertidal habitats such as saltmarsh can be high. For example, a review of European wetland valuations by Brander *et al.* (2008) concluded that saltmarsh had a value of approximately £1,400 ha^{-1} yr^{-1} (across a range from £200-£4,500 ha^{-1} yr^{-1}), while intertidal mudflats were around £1,300 ha^{-1} yr^{-1} (ranging from £200-£4,300 ha^{-1} yr^{-1}). This was based on default 'indicative economic values' for habitats on the basis of providing the following 'bundled' ecosystem services of: water quality improvement, recreation, biodiversity and aesthetic amenity.

Importantly, these bundled values do not include benefits associated with carbon sequestration or flood protection. Both carbon sequestration and flood protection are potentially important additional ecosystem services benefits provided by saltmarsh compared to mudflat. In particular, healthy saltmarsh can sequester significant quantities of carbon (around 200 gC m^{-2} yr^{-1} (Chmura *et al.*, 2003)). Assuming a current non-traded price of carbon of £64 per tonne (2017 prices) (DBEIS, 2017) this equates to a value of around £469 ha^{-1} yr^{-1} in 2017. As non-traded carbon prices increase significantly over time, the economic value of carbon sequestration will also increase over time. For example the non-traded carbon price is estimated to reach £300 per tonne of CO_2 over the next 50 years.

Flood protection benefits associated with saltmarsh restoration can also be large. For example, Costanza *et al.* (2008) estimated that restored saltmarsh in the US provided an economic value of US$8,236 ha^{-1} yr^{-1} in reduced hurricane damages. However, such benefits are very site specific. For many UK saltmarshes, the main benefit may relate to reduced maintenance costs for landward flood defences. For example, Shepherd *et al.* (2007) estimated that fronting saltmarsh provided a net saving of £4,950 km yr^{-1} in flood defence expenditure on the Blackwater Estuary. The presence of healthy saltmarsh may also avoid the need for the construction of new flood defences. King and Lester (1995) indicated than an 80 m width of saltmarsh could avoid a construction cost of £4,800 m^{-1} of new sea defence. Hudson *et al.* (2015) indicate that the construction costs of impermeable revetments and seawalls can range between £700 – 5,400 m^{-1} (at 2007 prices)

There is limited information on wider non-use values associated with intertidal habitat restoration/ creation projects, but Willingness-to-Pay studies have indicated that non-use values can be significant. For example, Luisetti *et al.* (undated) estimated a non-use benefit of around £2,000 yr^{-1} for a hypothetical 81.6 ha managed realignment project on the Blackwater Estuary (around £25 ha^{-1} yr^{-1}). However, it is unclear whether the non-use value of saltmarsh might be different from mudflat and thus whether there is any additional non-use value associated with the creation of saltmarsh in place of mudflat.

From the above, it is clear that the creation of saltmarsh and mudflat habitats can generate significant benefits, but that the scale of the benefits can be quite site specific, particularly flood protection benefits. In addition, the scale of intervention can also affect the per-hectare benefits with a reduction in per-hectare benefits with increasing size of the intervention (Brander *et al.*, 2008 and Luisetti *et al.* (undated)).

4 Cost Benefit Analysis Framework

An initial cost benefit analysis (CBA) framework that can be used to support an analysis of the costs and benefits of intertidal sediment recharge projects is presented in Table 4.

It is noted that beneficial use schemes may result in both costs and benefits to individual services, often depending upon timescales. For example, the placement of dredged material at the beneficial use site may give rise to short-term impacts on ecological functions that support fish/shellfish production. However, the recharge work may then benefit these fish/shellfish functions and related ecosystem services in the longer term as the site then exhibits ecological recovery (e.g. by providing feeding and nursery grounds).

Table 4. Illustrative cost benefit framework for beneficial use projects

<table>
<tr><th>Potential Costs</th><th>Potential Benefits</th></tr>
<tr><td>Any additional cost of using dredged material beneficially compared to sea disposal option e.g.:
▪ Infrastructure at beneficial use site (mooring, pipelines, sediment retention structures);
▪ Additional costs of transporting/ discharging material at beneficial use site;
▪ Additional costs of alternative dredging methods.</td><td>Benefit associated with habitats created at the beneficial use site:
▪ Provisioning:
o Food through fish/shellfish habitat provision.
▪ Regulating:
o Healthy climate (carbon sequestration);
o Waste burial/removal/neutralisation;
o Prevention or slowing of coastal erosion;
o Improvements to the quality/longevity of sea defences.
▪ Cultural:
o Tourism and nature watching;
o Spiritual and cultural wellbeing;
o Aesthetic benefits.</td></tr>
<tr><td rowspan="2">Cost associated with damage to/loss of existing habitat within/outside of footprint of beneficial use project:
▪ Provisioning:
o Fish/shellfish – damage to existing habitats supporting fish/shellfish production.
▪ Regulating:
o Healthy climate – loss of carbon sequestration function.
▪ Cultural:
o Tourism and nature watching – loss of/damage to existing functions;
o Spiritual and cultural wellbeing – loss of/damage to existing functions;
o Aesthetic benefits.</td><td>Benefit associated with the reduction in environmental impacts at existing disposal site:
▪ Provisioning:
o Fish/shellfish.
▪ Regulating:
o Healthy climate.
▪ Cultural:
o Tourism and nature watching;
o Spiritual and cultural wellbeing.</td></tr>
<tr><td>Benefit to other users at disposal site
▪ There may be potential benefits to other users such as marine aggregates, for example, through reduced contamination of aggregate material</td></tr>
</table>

Project scale and location will also have major implications on costs as well as the scale and nature of the benefits and the duration of any temporary effects. Small projects generally accrue smaller gains that may be limited in duration (including for aspects such as water quality improvement, fish/shellfish habitat, biodiversity, coastal defence enhancement or cultural (existence) values). Larger projects, or smaller scheme regularly implemented, have the potential to have inherently larger, longer-term and more varied benefits, including wider cultural values (such as aesthetics and amenity).

There may also be a benefit to these functions and related Ecosystem Services at the former dredge disposal site as a result of a reduction in disposal volumes. The purpose of the CBA process is to identify all of the relevant costs and benefits and to seek to monetise them where data allow. Such information can be used to estimate costs and benefits over time and understand whether a project is likely to provide an overall benefit (i.e. have a benefit:cost ratio of >1).

4.1 Identifying the winners and losers

Identifying an overall benefit is helpful in making the case for carrying out more beneficial use projects. However, it is very important to understand who the potential 'winners' and 'losers' are as a result of a beneficial use/recharge project, particularly as 'losers' are unlikely to have much incentive to participate in such projects. Indeed this is a particular issue for beneficial use projects where the party providing the material may incur additional costs compared to an option of marine disposal. Table 5 identifies the potential winners and losers from intertidal recharge beneficial use projects. The range of stakeholders and the scale of costs/benefits they will experience will vary from project to project.

Table 5. Illustrative Winners and Losers from Beneficial Use Projects

Potential Winners	Potential Losers
▪ **Flood and coast protection authorities** (Environment Agency (EA), local authorities) – reduced maintenance costs for existing flood defences; delay/avoidance of requirement for new capital works; ▪ **Private landowners** – reduced maintenance costs for existing flood defences; delay/avoidance of requirement for new capital works; enhanced levels of protection of landside assets; ▪ **Foreshore/seabed owner** – increased revenues for additional use; ▪ **Conservation bodies, environmental NGOs** – achievement of conservation targets; ▪ **Commercial fisheries** – fish nursery function; ▪ **Aquaculture** – opportunities for shellfish production; ▪ **Recreational users** – gain of amenity at BU site and former dredge disposal site; and ▪ **Wider society** – healthy climate, non-use benefits.	▪ **Port and harbour authorities, third party dredging organisations such as marinas, private wharves and terminals** – additional costs for disposal of dredged material; ▪ **Conservation bodies, environmental NGOs** – damage to existing biodiversity; ▪ **Commercial fisheries** – damage to existing fish nursery function; ▪ **Aquaculture** – damage to existing shellfish production; and ▪ **Recreational users** – loss of amenity at beneficial use site.

Identifying the costs and benefits potentially experienced by different stakeholders helps to make explicit the potential trade-offs involved in a beneficial use project. This information can then be used to rebalance the costs and benefits, for example through Payment for Ecosystem Services. In case of beneficial use projects, significant transfers might include:

- Payments from flood protection authorities or private landowners to those incurring additional costs associated with the project (port authorities or private operators);
- Payments from SNCBs/environmental NGOs to those incurring additional costs associated with the project (port authorities or private operators);
- Accessing other sources of public funding (e.g. EU Interreg or LIFE funding[17]) in recognition of societal benefits of projects; and
- Granting those incurring additional costs from the project rights over habitat benefits which could be used to offset impacts from future development projects (habitat banking).

Lower levels of transfer might occur in relation to benefits realised by other marine users or foreshore/seabed owners. However, for these transfers to happen there needs to be sufficient certainty that benefits will accrue and on the scale of those benefits. It is recognised this is a challenge when working in dynamic marine environments.

4.2 Illustrative cost benefit analysis

To bring together the information presented in the preceding sections, this final section considerers the comparative monetary costs and benefits of a hypothetical beneficial use project (Box 1) involving the placement of muddy sediments derived from maintenance dredging of a navigation channel. In this example, the main benefits associated with the project are assumed to be:

- Additional benefits of saltmarsh compared to mudflat in relation to the following 'bundled' ecosystem services: water quality improvement, recreation, biodiversity and aesthetic amenity (after Brander *et al.*, 2008);
- Additional benefits of carbon sequestration within healthy saltmarsh compared to mudflat (after Chmura *et al.*, 2003); and
- Additional flood protection provided by healthy saltmarsh compared to mudflat.

Two different benefit scenarios have been considered in relation to flood protection. The first assumes that the creation of healthy saltmarsh reduces the costs of maintenance of the flood defences (based on Shepherd *et al.,* 2007). The second assumes that the creation of healthy saltmarsh avoids the need to construct a new flood defence in years 20 and 21 of the scenario (based on King and Lester, 1995), thus avoiding significant capital expenditure.

Estimation of the potential scale of benefits under these scenarios has been used to identify the level of additional cost associated with beneficial use that might be justified by these benefits. The additional costs have been assessed in relation to an average 'at sea' disposal cost of £10 m^{-3}.

Net Present Value (NPV) of benefits has been calculated over a period of 100 years using Treasury Green Book discount rates[18].

Based on the first scenario, the benefits are estimated to exceed costs up to a unit cost for intertidal sediment recharge of around £15 m^{-3} (£5 m^{-3} more expensive than standard sea disposal). Based on documented costs of intertidal sediment recharge projects (Table 3), this is towards the lower end of those costs. The main contribution to benefits derives from increased carbon sequestration (68% of total benefits value), with some contribution from flood protection benefits (28% of total benefits value).

17 The recent UK referendum decision to leave the EU may mean that the sources of available funding will change over time.

18 A discount rate of 3.5% has been used for years 1 to 30; 3% for years 31 to 75, and 2.5% for years 76 to 100.

Box 1. Hypothetical Beneficial Use Project:

It is assumed that a harbour authority has a requirement to dispose of 100, 000 m^3 muddy dredged sediment per annum to maintain navigable access to its quays. The material is currently dredged using a trailer suction hopper dredger and disposed to an offshore disposal site at a cost of £10 m^{-3}. It is proposed to beneficially use the material to support the re-establishment of saltmarsh along a 5 km length of coastline which is experiencing significant saltmarsh erosion. The recharge area comprises approximately 50 ha of mudflat habitat occupying a strip around 100 m wide along the 5 km length of the eroding marsh. It is proposed to deposit sediment to a depth of 1 m to raise the elevation of the mudflat to a level that is suitable for saltmarsh colonisation. The existing saltmarsh and mudflat are component habitats of a Special Protection Area, Special Area of Conservation, Ramsar Site and Site of Special Scientific Interest (SSSI).

The hinterland supports important infrastructure and residential areas and flood protection benefits would justify maintenance of flood protection. It is assumed that placement of material occurs over a five year period working sequentially along the coastline. Placement of the material is designed to convert existing mudflat habitat into saltmarsh with full saltmarsh function being achieved over a period of 5 years. For simplicity, it is assumed that there are no significant impacts outside of the footprint of the placement and thus no significant negative environmental effects associated with the placement. It is also assumed that there are no significant environmental benefits associated with cessation of disposal at the existing disposal site over this time period.

For the second scenario, the benefits are estimated to exceed costs up to a unit cost for intertidal sediment recharge of around £40 m^{-3} (£30 m^{-3} more expensive than standard sea disposal costs). This is at the upper end of costs identified in Table 3. The main contribution to benefits in this scenario derives from avoided flood protection costs (88% of total benefits value) with some contribution increased carbon sequestration (11% of total benefits value). Alternatively, if a lower capital cost for flood defences is used (construction cost of £1,000 m^{-1}), towards the lower end of values cited by Hudson *et al.* (2015), the benefits are estimated to exceed costs up to a unit cost for intertidal sediment recharge of around £20 m^{-3}. The analysis highlights the sensitivity of the benefits estimates to assumptions about flood protection benefits.

The scenarios demonstrate that there are potentially significant benefits associated with intertidal sediment recharge schemes. These benefits can help to justify beneficial use of dredged material in circumstances where the costs of beneficial use are greater than comparable costs for 'at sea' disposal.

Notwithstanding a potentially positive B:C ratio, intertidal sediment recharge projects may not progress because those paying the costs associated with such projects do not achieve any benefit. In the above scenario, the additional costs associated with intertidal sediment recharge would fall on the harbour authority, whereas the beneficiaries would primarily be the flood protection authority (and those benefitting from flood protection measures) together with the statutory nature conservation body (as a result of restoration of the damaged saltmarsh feature within the designated sites). Some level of funding towards the project from the flood protection authority and statutory nature conservation body is likely to be required to facilitate such a project.

5 Conclusions

This review has considered the lessons from past intertidal sediment recharge projects, including a number of relatively new initiatives undertaken in the last few years (most notably the three very different schemes undertaken at Lymington). This has included collation of detailed information on the costs of individual projects. Little, if any, information on the monetary benefits of such projects was identified by the review. A framework for comparing the costs and potential benefits of intertidal sediment recharge projects has been developed and applied. This framework incorporates impacts on ecosystem services and provides a consistent basis for evaluating projects. The main costs associated with intertidal sediment recharge are those associated with transport and placement of material but consenting and monitoring costs can also be significant. There may also be costs associated with the environmental impact of placement of the material on intertidal areas. Key benefits provided by intertidal sediment recharge projects are where the creation of saltmarsh on former mudflat or deteriorating marsh habitat provides additional carbon sequestration and flood protection.

The review indicates that both costs and benefits of intertidal sediment recharge projects are site specific. In some locations, the costs of intertidal sediment recharge projects are less than the alternative 'at sea' disposal option. In these instances, the benefits to society are effectively provided for free. In other situations, the costs of intertidal sediment recharge are more expensive than 'at sea' disposal. However, when taking account of the societal benefits of these projects, the overall benefits may exceed costs. In such circumstances, there is an overall benefit to society from such projects proceeding, but this may need to be facilitated by payments to those incurring costs (typically port and harbour authorities) by those deriving benefits (flood protection authorities and nature conservation bodies).

> The costs of intertidal sediment recharge projects vary greatly on a site-by-site basis. This depends upon a range of factors such as the location, method and scale of the operation. In some instances it can be cheaper than standard 'at sea' disposal options. However, where that cost is higher, there is every indication that the 'cost differential' can be reduced over time by regularly undertaking the work. However, the up-front expenditure of such projects is often large and an obstacle to project implementations (especially at a large scale). This review highlights the benefits that can accrue, presents a cost benefit framework for these projects and highlights the key cost benefit considerations for future projects. It is hoped that this will help to inform future projects and their funding applications.

The review indicates that the costs of intertidal sediment recharge projects can be driven down over time, particularly for repeat operations. Often for new projects there is an upfront fee for securing infrastructure, installing fencing, securing consenting and carrying out monitoring, but thereafter costs can be reduced year on year. One key way to realise future projects is to identify 'long term' sites where the consenting requirements and infrastructure are all set up so that sediment can be placed regularly on an ongoing basis. These would, of course, need to be close enough to a reliable sediment source.

The case for intertidal sediment recharge is likely to be strongest where costs for 'at sea' disposal are high or where such projects create saltmarsh in front of important flood defences, delivering important carbon sequestration and flood protection benefits.

The following points summarise the key conclusions of this review:

- Costs of beneficial use of muddy dredge material for intertidal sediment recharge are site specific. They may be cheaper, the same, or more expensive compared to 'at sea' disposal;
- Benefits of beneficial use of muddy dredge material for intertidal sediment recharge are also site-specific. The main additional benefits relate to creation of saltmarsh habitat which (compared to mudflat) provides additional carbon sequestration benefits and can provide flood protection benefits. Based on available data, flood protection benefits are potentially the greatest benefit associated with beneficial use schemes, although carbon sequestration benefits are also substantial (particularly in the long-term);
- There is uncertainty concerning the scale of non-use benefits and whether there are additional non-use benefits associated with saltmarsh compared to mudflat;
- Where the costs of beneficial use of muddy sediments for intertidal sediment recharge are less than 'at sea' disposal there is a strong case for pursuing beneficial use to achieve societal benefits;
- Where the costs of 'at sea' disposal are less than beneficial use of muddy sediments for intertidal sediment recharge, there may be a case for pursuing beneficial use where this can deliver significant benefits. This may particularly be the case where beneficial use projects provide significant flood protection benefits;
- The long-term nature of potential benefits needs to be recognised and therefore that there is a long pay-back period for such investments. It is therefore important to take a long-term view when considering the merits of such projects;
- The distribution of costs and benefits may often require payment transfers from beneficiaries to those incurring costs in that schemes might progress. This might typically entail payments from flood protection authorities and nature conservation bodies to port authorities; and
- Based on the scenarios explored, larger (>100,000 m^3 yr^{-1}) beneficial use schemes might typically justify an increase in cost of 50% to 400% compared to 'at sea' disposal costs.

6 References

ABPmer (2013). Wightlink - Replacement Lymington to Yarmouth Ferries: Second Annual Mitigation and Monitoring Report. Progress Report 2 and 6th Report for the Environment Management Panel. ABP Marine Environmental Research Ltd, Report No. R.2142 December 2013

ABPmer (2014). Sediment Compatibility and Opportunistic Use Pilot (SCOUP), Getting Beneficial Use Working. Demonstration Project Proposal (ABP Marine Environmental Research Ltd, Internal Report) Ref P.11560

ABPmer (2015). Lymington to Yarmouth Ferries: Mitigation and Monitoring 9th Report for the Environment Management Panel Report for Wightlink Ltd. ABP Marine Environmental Research Ltd, Report No. R.2512 December 2015

ABPmer (2016). Horsey Island Coastal Restoration - 10 Years On, Review of UK's first and largest mixed-sediment beneficial use projects. An internal white paper produced by ABP Marine Environmental Research Ltd, Ref 1400-16-13, March 2016.

Aspden, R.J., Vardy, S., and Paterson, D.M. (2004). Salt Marsh Microbial Ecology :Microbes, Benthic Mats and Sediment Movement. In: Fagherazzi, S. Marami, M. Blum, L.K. (eds).The Ecogeomorphology of Tidal Marshes, American Geophysical Union.

Bakker, J.P., Esselink, P., Van Per Wal, R., and Dijkama, K.S. (1997). Options for restoration and management of coastal salt marshes in Europe. In: Urbanska, K.M. Webb, N.R. Edwards, P.J. (eds) Restoration Ecology and Sustainable Development. Cambridge University Press.

Balmford, A., Rodrigues, A., Walpole, M., ten Brink, P., Kettunen, M., Braat, L., and de Groot, R. (2008). Review on the economics of biodiversity loss: scoping the science. Report produced for the European Commission under Contract ENV/070307/2007/486089/ETU/B2.

Black and Veatch (2012) Lymington Intertidal Habitat Restoration Preliminary Monitoring Report V2 December 2012 121378-0960 Report for the Lymington Harbour Commissioners V1/ December 2012

Brander, L.M., Ghermandi, A., Kuik, O., Markandya, A., Nunes, P., Schaafsma, M., and Wagtendonk, A. (2008). Scaling up ecosystem services values: methodology, applicability and a case study, Report to European Environment Agency

Bolam, S.G., Waldock, R., and Paipai, E. (2003). Beneficial use of finegrained dredged material: success story so far. In: Proceedings from the International Conference of Dredging, Casablanca, October 2002, pp. 78–89.

Bolam S.G. and Whomersley P. (2005). Development of macrofaunal communities on dredged material used for mudflat enhancement: a comparison of three beneficial use schemes after one year. Marine Pollution Bulletin 50: 40–47.

Bray, R.N. (ed.) (2008). Environmental Aspects of Dredging. Taylor and Francis IADC/CEDA, 2008. ISBN 978-0-415-45080-5

Brander, L.M., Ghermandi, A., Kuik, O., Markandya, A., Nunes, P.A.L.D., Schaafsma and M., Wagtendonk, A. (2008). Scaling up ecosystem services values: methodology, applicability and a case study. Final Report, EEA May 2008.

Brightlingsea Harbour Commissioners - Dredging Waterside Marina, Brightlingsea -February 2016: https://www.youtube.com/watch?v=56lfRtfQ3dA

Brown, S.L., Pinder, A., Scott, L., Bass, J., Rispin, E., Brown, S., Garbutt, A., Thomson, A., Spencer, T., Moller, I. and Brooks, S.M. (2007). Wash Banks Flood Defence Scheme - Freiston Environmental Monitoring 2002-2006. Centre for Ecology and Hydrology, Dorchester, 374p.

CEDA (2010). Dredged Material as a Resource: Options and Constraints. A CEDA Information Paper - June 2010: http://www.dredging.org/documents/ceda/downloads/publications-2010-6-ceda_information-paper-dredgedmaterialasaresource.pdf

CEDA (in prep.). Information and position papers on the beneficial use of sediments (Working Group on Beneficial Use of Dredged Sediment)

CEAMaS - Civil Engineering Applications for Marine Sediments Project: www.ceamas.eu

Chmura, G.L. Anisfield, S.C. Cahoon, D.R. and Lynch, J.C. (2003). Global carbon sequestration in tidal saline wetland soils, Global Biogeochemical Cycles, 17, 1-12.

Colclough, S., Fonseca, L., Astley, T., Thomas, K., and Watts, W. (2005). Fish utilisation of managed realignments. Fisheries Management and Ecology 12, 351-360.

Costanza, R., O. Pe´rez-Maqueo, M. L. Martinez, P. Sutton, S. J. Anderson, and Mulder, K. (2008). The value of coastal wetlands for hurricane protection. Ambio 37:241–248.

Department for Business, Energy and Industrial Strategy (2017). Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal. Last updated 15th March 2017. Downloaded from: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal#history

Department for Environment, Food and Rural Affairs (Defra)/Marine Management Organisation Marine Information System: http://defra.maps.arcgis.com/apps/webappviewer/index.html?id=3dc94e81a22e41a6ace0bd327af4f346

Fletcher, S, Saunders, J, Herbert, R. and Roberts, C. (2011). Description of the ecosystem services provided by broad-scale habitats and features of conservation importance that are likely to be protected by Marine Protected Areas in the Marine Conservation Zone Project area. Natural England.

Harrington J. and Smith G. (2013). Guidance on Beneficial Use of Dredged Material in Ireland. Cork Institute of Technology Report commissioned by the Environmental Protection Agency.

HELCOM (2015) HELCOM Guidelines for Management of Dredged Material at Sea Adopted by HELCOM 36-2015 on 4 March 2015 http://www.helcom.fi/Lists/Publications/HELCOM%20Guidelines%20for%20Management%20of%20Dredged%20Material%20at%20Sea.pdf

Hudson, T., Keating, K. and Pettit, A. (2015). Cost estimation for coastal protection – summary of evidence. Environment Agency Report –SC080039/R7.

IADC (2009). Facts about: Dredged Material as a Resource An Information Update from the IADC – Number 1 – 2009 https://www.iadc-dredging.com/ul/cms/fck-uploaded/documents/PDF%20Facts%20About/facts-about-dredged-material-as-a-resource.pdf

IUCN (2009). The management of natural coastal carbon sinks. IUCN, Gland, Switzerland. 53

Kay, D., Wyer, M.D., Crowther, J., Wilkinson, J., Stapleton, C., and Glass, P. (2005). Sustainable reduction in the flux of microbial compliance parameters from urban and arable land use to coastal bathing waters by a wetland ecosystem produced by a marine flood defence structure. Water Research, 39, 3320-3332.

King, S.E. and Lester, J.N. (1995). The value of saltmarsh as a sea defence. Marine Pollution Bulletin, 30, 180-189.

London Protocol (1996). 1996 Protocol to the Convention On The Prevention of Marine Pollution By Dumping Of Wastes And Other Matter, 1972 (as amended in 2006): http://www.imo.org/en/OurWork/Environment/LCLP/Documents/PROTOCOLAmended2006.pdf

Lowe, S. (2012). 'Lymington Harbour habitat replenishment scheme: Summary of works'. The Crown Estate, 18 pages. ISBN: 978-1-906410-35-3

Luisetti, T., Turner, K.R., Hadley, D., and Morse-Jones, S., undated. Coastal and marine ecosystem services valuation for policy and management. CSERGE Working Paper EDM 10-04 https://www.econstor.eu/obitstream/10419/48792/1/621202509.pdf

MMO (2014). Use of Beneficial Dredged Materials in the South Inshore and South Offshore Marine Plan Areas. A report produced for the Marine Management Organisation, pp 57. MMO Project No: 1073. ISBN: 978-1-909452-31-2: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/358069/MMO_1073_Beneficial_Use_Final.pdf

MMO (2016a). South Marine Plan Draft for consultation November 2016: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/565500/Draft_South_Marine_Plan.pdf

MMO (2016b). Research project into 'The location, condition and features of significant sites for habitat creation or restoration' https://www.gov.uk/government/publications/the-location-condition-and-features-of-significant-sites-for-habitat-creation-or-restoration

MMO/UK GOV.: https://www.gov.uk/guidance/do-i-need-a-marine-licence

Möller, I. (2006). Quantifying saltmarsh vegetation and its effect on wave height dissipation: Results from a UK East coast saltmarsh. Estuarine, Coastal and Shelf Science, 69, 337-351.

Murray, L. (2008). "Dredged Material as a Resource". Terra et Aqua, September, Number 112, pp. 3-10. https://www.iadc-dredging.com/ul/cms/terraetaqua/document/2/4/0/240/240/1/article-dredged-material-as-a-resource-terra-et-aqua-112-1.pdf

Nottage, A.S. and Robertson, P.A. (2005). The Saltmarsh Creation Handbook: A Project Manager's Guide to the Creation of Saltmarsh and Intertidal Mudflat. Royal Society for the Protection of Birds (RSPB), Sandy, 128p.

NPPF (2012). National Planning Policy Framework Department for Communities and Local Government March 2012, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/ 6077/2116950.pdf

OSPAR (2014). Guidelines for the Management of Dredged Material: www.ospar.org/documents?d=34060

Paipai, E. (2003). Beneficial Uses of Dredged Material: Yesterday, Today and Tomorrow: www.iadc-dredging.com/ul/cms/terraetaqua/document/1/3/0/130/130/1/terra-et-aqua-nr92-01.pdf

Pennings, S.C. and Bertness, M.D. (2001). Salt Marsh Communities. In: Marine Community Ecology. Bertness, M.D. Gaines, S. Hay, M.E. (eds) 289-316, Sinauer Sunderland Massachusetts, USA.

Peterson, C. H., Able, K. W., Frieswyk, De Jong, C., Piehler, M. F., Simenstad, C. A., and Zedler, J. B. (2008). Practical proxies for tidal marsh ecosystem services: application to injury and restoration. Advances in marine biology, 54, 221-266.

PIANC (2009). PIANC Report no 104-2009 Dredged Material as a Resource: Options and Constraints. www.pianc.org

Royal HaskoningDHV (2013). Create compensatory habitat to offset impacts: Case Study http://www.ecrr.org/Portals/27/Trimley%20and%20Shotley%20Intertidal%20Habitat%20Creation.pdf

RSPB (in prep). SeaBUDS Sea-change in the Beneficial Use of Dredgings. A review

Sheehan, C., Harrington, J.R., Murphy, J.P., and Riordan, J.D. (2008). "An Investigation into Potential Beneficial Uses of Dredge Material in Ireland", WEDA XXVIII and Texas TAMU 39th Dredging Seminar, St. Louis, USA

Shepherd, D., Burgess, D., Jickells, T., Andrews, J., Cave, R., Turner, R. K., Aldridge, J., Parker, E.R. and Young, E. (2007). Modelling the effects and economics of managed realignment on the cycling and storage of nutrients, carbon and sediments in the Blackwater estuary UK. Estuarine, Coastal and Shelf Science, 73(3), 355-367.

Turner, K., Schaafsma, M., Elliott, M., Burdon, D., Atkins, J., Jickells, T., Tett, P., Mee, L., van Leeuwen, S., Barnard, S., Luisetti, T., Paltriguera, L., Palmieri, G., and Andrews, J. (2014). UK National Ecosystem Assessment Follow-on. Work Package Report 4: Coastal and marine ecosystem services: principles and practice. UNEP-WCMC, LWEC, UK.

Turner, R.K., Hadley, D., Luisetti, T., Lam, V.W.Y., and Cheung, W. W. L. (2010). An introduction to socio-economic assessment within a marine strategy framework. Report to Defra.

UK NEA UK (2011). The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC,, UK National Ecosystem Assessment, Cambridge.

UNEP-WCMC (2011). Marine and coastal ecosystem services: Valuation methods and their application. UNEP-WCMC Biodiversity Series No. 33. 46 pp.

Westcountry Rivers Trust - European Union's Interreg 2 Seas Programme USAR (Using Sediment as a Resource) – ongoing project: http://wrt.org.uk/project/usar/

7 Abbreviations/Acronyms

ABP	Associated British Ports
ABPmer	ABP Marine Environmental Research Ltd
BU	Beneficial Use
CBA	Cost Benefit Analysis
CEAMaS	Civil Engineering Applications for Marine Sediments
CEDA	Central Dredging Association
Cefas	Centre for Environment Fisheries and Aquaculture Science
CPA	Coast Protection Act
DAS	Disposal At Sea
DBEIS	Department for Business, Energy and Industrial Strategy
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EIA	Environmental Impact Assessment
EU	European Union
FCRM	Flood and Coastal Risk Management
FEPA	Food and Environment Protection Act
HELCOM	Helsinki Commission - The Baltic Marine Environment Protection Commission
HR	HR Wallingford Ltd
HRA	Habitats Regulations Appraisal
IADC	International Association of Dredging Companies
IMO	International Maritime Organisation
Interreg	European Territorial Cooperation (ETC), [better known as Interreg]
IUCN	International Union for Conservation of Nature
LHC	Lymington Harbour Commission
LiDAR	Light Detection and Ranging
LIFE	EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU
MMO	Marine Management Organisation
NEA	National Ecosystem Assessment
NEAFO	National Ecosystem Assessment Follow-on
NGO	Nongovernmental Organization
NPPF	National Planning Policy Framework
NPV	Net Present Value
OSPAR	Oslo/Paris convention (Protection of the Marine Environment of the NE Atlantic)
PIANC	Permanent International Association of Navigation Congresses
Ramsar	Wetlands of international importance, designated under The Convention on Wetlands (Ramsar, Iran, 1971)
RSPB	Royal Society for the Protection of Birds
SeaBUDS	Sea-change in the Beneficial Use of Dredgings (RSPB project)
SCOUP	Sediment Compatibility and Opportunistic Use Pilot
SNCB	Statutory Nature Conservation Body
SSSI	Site of Special Scientific Interest
SYH	Suffolk Yacht Harbour
TAMU	Texas A&M University
TEEB	The Economics of Ecosystems and Biodiversity
UAV	Unmanned Aerial Vehicle
UK	United Kingdom

UK NEA	UK National Ecosystem Assessment
UNEP-WCMC	United Nations Environment Programme's World Conservation Monitoring Centre
US	United States
USA	United States of America
USAR	Using Sediment as a Resource
WEDA	Western Dredging Association

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

B Solent and Poole Harbour Dredging

B.1 Introduction

This appendix presents a review of dredge and disposal activities in the Solent. It is based largely on information collected from the MMO and Defra and includes details from current and recent marine licences. It contains information about the volume of material permitted to be removed, along with the volume of material permitted to be deposited at a given disposal site

It should be noted that the values summarised and tabulated in this appendix are the maximum permitted removal volumes and disposal quantities within each individual licence at a given site. The amounts of material that are actually deposited at each disposal site are likely to be less than the maximum permitted values. Additionally, the dry tonnage disposal quantities within individual licenses are calculated using approximate ratios. In reality the spatial variability of material types from individual dredge sites is likely to affect the values of disposed dry material considerably. Consequently the volumes/quantities summarised here should be treated as approximations[26].

Table B1 lists the licensed maintenance dredging campaigns in the mainland Solent estuaries and harbours, whereas Table B2 contains details for campaigns on the Isle of Wight. Licenced Poole Harbour campaigns are provided in Table B3.

B.2 Maintenance dredging within the East Solent

Much of the dredging within Chichester and Langstone Harbours is relatively small in magnitude, i.e. with annual disposals of less than 10,000 dry tonnes per year) and is localised to particular marinas using predominantly backhoe dredgers. A proportion of the silt material is occasionally deposited within the entrance to Chichester Harbour at the Treloar Hole subtidal beneficial use site.

The majority of silt material availability within the East Solent would come from maintenance dredge campaigns of HMNB Portsmouth, Portsmouth International Port and ABP's Southampton Nab Channel. At these locations maintaining berth depths and safe navigation throughout both ports results in maximum licensed annual disposal quantities of 231,000 dry tonnes (HMNB), *circa* 20,000 dry tonnes (Portsmouth International Port) and 17,500 dry tonnes (ABP) respectively. The primary method of material extraction used at these sites is Trailer Suction Hopper Dredging (TSHD). Whilst material obtained via maintenance dredging of the Nab Channel is predominantly gravel and therefore not suitable for saltmarsh restoration, the potential for this to be used for beach recharge schemes (or shingle barrier formation) should be noted.

Similar to Chichester/Langstone Harbours, a number of recreational marinas within Portsmouth Harbour have relatively small annual dredge commitments, with annual disposals under 10,000 dry tonnes achieved via localised backhoe dredging. An exception to this is Haslar Marina, with an annual commitment of over 30,000 dry tonnes. Small developments throughout the northeast side of the Isle of Wight have annual disposal commitments of less than 5,000 dry tonnes per year, achieved by local backhoe dredging.

26 This data, alongside more detailed locally-derived information collected through consultations (as described in Section 3.4), was used to develop the sector review schematic (as described in Section 3.3.9 and shown in Image 16).

B.3 Maintenance dredging within Southampton Water

To maintain the infrastructure at Fawley/Esso, and Marchwood, maximum annual dredge commitments are around 50-60,000 dry tonnes. This is alongside the main maintenance dredge commitments of ABP Southampton (262,500 dry tonnes per year throughout the River Test/Itchen berths and Southampton Water navigation channel). It should be noted that the licence for the latter is divided into three separate areas and covers the majority of Southampton Water. Within approaches to Southampton Water considerable additional dredge resource is available (*circa* 115,000 dry tonnes per year), but is mixed in material type (silt and gravel). Due to the large quantities of material associated with the above, the predominant dredging methodologies are either TSHD of Water Injection. Care has to be taken when considering the latter, as licensed removal volumes cannot be considered a raw resource due to the methodology of the dredge technique.

Recreational activity throughout this area of the Solent is high, with a number of marina developments within the Rivers Hamble and Itchen and marine parks on the south side of Southampton Water at Hythe supporting large numbers of both yachts and powerboats. The majority of these marinas have annual disposal quantities around 10,000 tonnes achieved via local backhoe dredging.

B.4 Maintenance dredging in the West Solent and Poole Harbour

A number of recreational marinas within East/West Cowes and Yarmouth (both Isle of Wight) highlight potential resource material within the west Solent area. These are variable in their annual disposal commitments of between 2,000 and 20,000 dry tonnes per year, achieved by localised backhoe techniques.

Disposal commitments within the navigation channel at Lymington (*circa* 13,000 dry tonnes over 3 years) has been used in past beneficial use schemes, with the material being pumped onto intertidal saltmarsh to the east of the navigation channel (MMO reference) during 2013. A new licence (issued in late 2017 after this review was carried out) now allows for 10,000 tonnes to be bottom-dumped in front of the adjacent Boiler Marsh annually.

In Poole Harbour, dredged material consists primarily of sand (and cannot therefore be considered purely for saltmarsh restoration), though the proportion of silt still results in a potential material disposal of around 33,000 dry tonnes per year. A portion of the silt material is used within a trial beneficial use scheme within the harbour, being deposited subtidally on the south side of Brownsea Island. Additional portions of sand are used for inshore re-nourishment schemes on local beaches at Poole and Bournemouth when the dredged material is deemed suitable.

B.5 Future Capital dredging throughout the Solent

As stated earlier within this section, the highlighting of potential material resource throughout the Solent area has been related solely to licensed maintenance dredge commitments. This was deemed to be the most suitable approach to take in order to identify material that is regularly (and reliably) available. No major capital dredges are now planned but if and when they occur, they could be considered a potential resource. Understanding future needs can only really be achieved via public consultation. A good example of this is at Beaulieu, where the Buckler's Hard Yacht Harbour would like to dredge around 15,000 m^3 (silt) in the near future. This and other aspects were considered within the consultation process (Section 3.4) and the workshop (see Appendix D).

Table B1. Details of licensed maintenance dredging campaigns in the Solent (2011 onwards) from MMO WebGIS

Applicant Name	Project Title	Licence Expiry (Licence Length)	Licensed Removal Volume (m^3)		Licensed Disposal Volume (dry tonnes)		Material
			Total	Annual	Total	Annual	
Birdham Pool Ltd.	Birdham Pool Approach Channel	27/03/17 (3 year)	8,000	N/A	9,500	N/A	Silt
Premier Marinas Ltd.	Chichester Marina	27/05/24 (10 year)	N/A	N/A	22,000	2,200	Silt
Marina Developments Ltd.	Northney Marina	20/12/24 (10 year)	75,000	N/A	82,875	N/A	Silt
Emsworth Yacht Harbour Ltd.	Emsworth Marina	30/04/19 (2 year)	10,000	N/A	7,000	N/A	Silt
Marina Developments Ltd.	Sparkes Marina	30/04/24 (10 year)	N/A	N/A	42,000	4,200	Silt
Tarmac Ltd.	Bedhampton Approach Channel	16/03/27 (10 year)	50,000	5,000	28,000	2,800	Silt
Premier Marinas (Southsea) Ltd.	Southsea Marina Approach Channel	16/11/25 (10 year)	100,000	10,000	49,215	4,921.5	Silt
Westminster Dredging Company Ltd.	HMNB Portsmouth	02/03/17 (3 year)	N/A	N/A	691,000	231,000	Silt[1]
RNSA	RNSA Moorings Gosport	27/04/27 (10 year)	13,400	N/A	7,504	N/A	Silt
Gosport Ferry Ltd.	Clarence Wharf	02/07/27 (10 year)	10,000	1,000	12,046	1,024.6	Silt
Dean & Reddyhoff Ltd.	Haslar Marina	11/09/21 (5 year)	111,000	N/A	161,454	32,291	Silt
Premier Marinas Ltd.	Gosport Marina	16/11/24 (10 year)	70,000	7,000	34,450	3,445	Silt
Portsmouth City Council	Portsmouth International Port	25/01/18 (3 year)	73,516	N/A	55,870	N/A	Silt
Premier Marinas Ltd.	Port Solent Approach Channel	08/03/25 (10 year)	60,000	6,000	46,800	4,680	Silt
Trafalgar Wharf Ltd.	Trafalgar Wharf Approach Channel	24/06/16 (3 year)	N/A	N/A	16,800	5,600	Silt
Marina Developments Ltd.	Swanwick Marina	31/10/23 (10 year)	N/A	N/A	100,000	10,000	Silt
John Willment Marine Ltd.	Universal Marina	11/12/15 (3 year)	N/A	N/A	25,350	8,450	Silt
Marina Developments Ltd.	Mercury Yacht Harbour	13/10/26 (10 year)	75,000	7,500	95,450	9,545	Silt
Marina Developments Ltd.	Port Hamble Marina	07/11/15 (3 year)	N/A	N/A	30,000 [1]	10,000 [1]	Silt[2]
Marina Developments Ltd.	Hamble Point Marina	13/10/26 (10 year)	75,000	7,500	95,450	9,545	Silt
Fawley Waterside Ltd.	Fawley Power Station	28/02/17 (1 year)	55,000	55,000	55,000	N/A[2]	Silt[3]
BP Oil UK Ltd.	Hamble Jetty and Approaches	03/04/20 (3 year)	100,000	33,333	96,025	32,008	Silt
ESSO Petroleum	Fawley Marine Terminal	15/04/26 (10 year)	1,076,923	N/A	538,462	53,846.2	Silt
Homes and Communities Agency	Hythe Marine Park	25/04/27 (10 year)	117,950	11,795	243,820	24,382	Silt

Applicant Name	Project Title	Licence Expiry (Licence Length)	Licensed Removal Volume (m^3)		Licensed Disposal Volume (dry tonnes)		Material
			Total	Annual	Total	Annual	
Marina Developments Ltd.	Hythe Marina village	31/10/25 (10 year)	55,000	5,500	35,750	3,575	Silt
Homes and Communities Agency	Woolston Riverside	14/05/14 (1 year)	N/A	N/A	30,000	N/A	Silt
Marina Developments Ltd.	Ocean Village	30/12/24 (10 year)	75,000	7,500	82,875	8,287.5	Silt
Marina Developments Ltd.	Saxon Wharf	13/10/26 (10 year)	70,000	7,000	45,500	4,550	Silt
Marina Developments Ltd.	Shamrock Quay	02/12/24 (10 year)	30,000	3,000	25,200	2,520	Silt
Westminster Dredging	SMC Marchwood (MOD)	02/03/17 (3 year)	N/A	N/A	48,000	16,000	Silt
Associated British Ports	River Itchen	31/10/25 (10 year)	769,230	76,923	500,000	50,000	Silt
Associated British Ports	River Test Berths	31/10/25 (10 year)	2,653,850	265,385	1,725,000	172,500	Silt
Associated British Ports	Southampton Water	31/10/25 (10 year)	615,380	61,538	400,000	40,000	Silt
Associated British Ports	Nab Channel	31/10/25 (10 year)	116,390	11,639	175,000	17,500	15% Silt, 85% Gravel
Associated British Ports	Solent Approaches	31/10/25 (10 year)	751,600	75,160	1,150,000	115,000	15% Silt, 85% Gravel
Lymington Harbour Commissioners	Lymington Approach Channel	31/10/16 (3 year)	N/A	N/A	13,000 [1]	N/A[1]	Silt

1 An updated licence has since been issued, but it not provided within the MMO WebGIS/portal. Quantities of material from the pre-existing licence have therefore been stated.

2 Currently the MMO WebGIS states that this licence uses water injection as the main dredge technique. Therefore in current form this material cannot be considered as a potential "source", but has been included to provide a quantitative indicator should the dredging technique be changed in future.

Table B2. Details of licensed maintenance dredging campaigns on the Isle of Wight (2011 onwards) from MMO WebGIS

Applicant Name	Project Title	Licence Expiry (Licence Length)	Licensed Removal Volume (m^3)		Licensed Disposal Volume (dry tonnes)		Material
			Total	Annual	Total	Annual	
Bembridge Harbour Improvements Ltd.	Bembridge Harbour	28/05/2018 (3 year)	18,000	N/A	15,552	N/A	Silt
Dean & Reddyhoff Ltd.	East Cowes Marina	28/02/2016 (3 year)	N/A	N/A	56,100	18,700	Silt
Cowes Harbour Commissioners	Shepards Wharf Marina	29/06/2026 (10 year)	24,000	N/A	17,136	N/A	Silt
Cowes Corinthian Yacht Club Ltd.	Cowes Corinthian Yacht Club	24/07/2027 (10 year)	16,670	1,667	22,490	2,249	78% Silt, 22% Clay
Cowes Yacht Haven	Cowes Yacht Haven Marina	05/03/2020 (7 year)	N/A	N/A	45,000	15,000	Silt
Royal Yacht Squadron	Jubilee Haven Marina	06/06/2026 (10 year)	8,000	N/A	5,712	N/A	Silt
Yarmouth Harbour Commissioners	Yarmouth Harbour	30/04/2024 (10 year)	N/A	N/A	9,965	N/A	80% Silt, 20% clay/ gravel

Table B3. Details of licensed maintenance dredging campaigns within Poole Harbour (2011 onwards) from MMO WebGIS

Applicant Name	Project Title	Licence Expiry (Licence Length)	Licensed Removal Volume (m^3)		Licensed Disposal Volume (dry tonnes)		Material
			Total	Annual	Total	Annual	
Lilliput Sailing Club	Lilliput Channel	31/10/2027 (10 year)	5,000	500	7,372	N/A	Silt
Poole Harbour Commissioners	Poole Harbour	30/09/2026 (10 year)	1,450,000	145,000	1,188,000	118,800	72% Sand, 28% Silt

C Metadata for GIS Mapping Work

A GIS mapping exercise was carried out to assemble existing spatial information that is needed to help select, or eliminate, locations where projects might be undertaken on the basis of these criteria. Data was collated from various sources to describe aspects such as: the coastal habitat types; the standard of coastal defences and the location of appropriate sources of dredged sediment. . New data was collated (and is presented in layers 8b and 8c) from work undertaken specifically for this BUDS study. This mapping is available online (see Section 3 of the main report for more detail); relevant metadata information is provided in Table C1 below.

Table C1. Metadata table showing the information included within the BUDS WebApp

Layer/Criteria	Source	Details	Date/Reference
Would the habitats benefit because they are in poor condition or eroding?			
1a) Marsh Habitat Extent	Environment Agency	Saltmarsh Extents Layer	2009 data downloaded Jun 2017
1b) Mud Habitat Extent	EMODnet	MESH Atlantic Composite EUNIS Habitat Map	2009 data version dated 9 Dec 2013
1c) Intertidal Habitat Condition	MMO/ABPmer	ABPmer review of Natural England SSSI condition reports and SDCP data showing where coastal squeeze is a cause. Full SSSI units shown where such a concern exists (based on Natural England dataset) (i.e. polygons). Also includes units which would benefit from beach nourishment (line data), based on a 2014 review of SMPs.	MMO, 2014a
Are the habitats fronting vulnerable sea defences that would benefit?			
2a) SMP Defence Policy (EA)	Environment Agency	SMP Management Policy for first 20 years	Downloaded Jun 2017
2b) Defence Type (EA)	Environment Agency	Flood defence layer. Information for 'tidal', fluvial and tidal' and 'coastal' defences.	Downloaded Jul 2017
2c) Defence Type (CCO)	Channel Coastal Observatory	Flood defence type layer	Downloaded Jul 2017

Layer/Criteria	Source	Details	Date/Reference
2d Defence Condition (ESCP)	East Solent Coastal Partnership	Coastal Defence Asset Review	Provided by ESCP 9 Oct 2017
2e) Defence Condition (EA)	Environment Agency	Environment Agency defence condition map	May 2017
Is the area behind the sea walls low lying or of high value?			
3a) Hinterland Vulnerability (FZ3)	Environment Agency	Flood Zone Map 3	Downloaded Aug 2017
3b) Hinterland Vulnerability (FZ2)	Environment Agency	Flood Zone Map 2	Downloaded Aug 2017
Is the area of nature conservation value?			
4a) Nature Conservation (SAC)	Natural England	Special Areas of Conservation	Downloaded Jun 2017
4b) Nature Conservation (Ramsar)	Natural England	Ramsar Wetland	Downloaded Jun 2017
4c) Nature Conservation (MCZ)	Natural England	Marine Conservation Zone (Tranche 1, 2 and 3)	Downloaded Jun 2017
4d) Nature Conservation (SPA)	Natural England	Special Protection Areas	Downloaded Jun 2017
Is the area important for fisheries?			
5a) Shellfish Waters	Natural England	Downloaded from Natural England's Magic data portal	Downloaded Jun 2017
Is the area shallow enough for low intertidal or subtidal placement?			
6a) Intertidal/subtidal platform	Various	Alignment of the 0.5 m below CD level using the Solent Bathymetry	English Channel Model (ABPmer 2016b)
Can features or structures be introduced to retain sediment?			
No separate layer added for this criterion because the nature and type of retention structures will be very site specific and dependent on project scale. The base aerial map can, however, be used to understand the existence of features such as old walls or bunds which may have a potential sediment retention functionality. The bathymetry data (in Layer 6a) can also help to describe whether a suitable subtidal platform exists on which recharge can be undertaken			
Is the area used for recreational boating?			
7a) Sailing Areas (RYA):	Royal Yacht Association	Describes Sailing Areas, Racing Areas, General Boating Areas.	Updated Aug 2016
7b) Cruising Routes (RYA):	Royal Yacht Association	Describes Cruising Routes	Updated Aug 2016

Layer/Criteria	Source	Details	Date/Reference
7c) Vessel Movements (ABPmer)	ABPmer	Review of recreational vessel AIS transit lines (using data supplied by the Maritime and Coastguard Agency)	ABPmer 2015 data and MMO 2014b
Is the site close to a source of sediment?			
8a) Location Ports and Harbours	ABPmer and Royal Yacht Association	Location of Ports, Marinas and Harbours	Updated Aug 2016
8b) Dredge Volumes and Locations	MMO, Defra	Collated from MMO public register and MIS plus MDPs	Review for Solent Forum BUDS Aug 2017
8c) Dredge/Disposal Schematic Made up of three layers ▪ Schematic Dredge Locations ▪ Schematic Disposal Site Routes ▪ Disposal Sites (Cefas)	ABPmer Review	Schematic from consultation with regional specialists and other sources (incl. Cefas disposal grounds map)	Review for Solent Forum BUDS Nov 2017
Can the site be accessed by appropriate vessels?			
9a) Contours Made up of three layers ▪ Maximum Vessel Access Area (+2 m CD) ▪ Maximum extent of 'intertidal' habitat (0 m CD) ▪ Minimum Vessel Access Area (-6.5 m CD)	Various	Depth contours derived from Solent Bathymetry (see bottom of table)	English Channel Model (ABPmer 2016b)
Are there any sites which have been identified before?			
10a) Previously Identified Sites	MMO, ABPmer and Southampton University Studies	Past review of beneficial use sites (actual or proposed)	MMO 2014b and Southampton University 2010
Bathymetry base map			
Solent Bathymetry (used as the basis for Layers 9a and	Various	Solent Digital Terrain Model collated from various sources	English Channel Model (ABPmer 2016b)

D Solent BUDS Workshop Notes

D.1 Overview

The Solent BUDS Workshop was held at ABPmer's offices on 6 December 2017. There were 24 participants from a wide range of organisations and the aim was to tap into their knowledge to identify potential locations for beneficial use work. The session began with an introduction to the project during which the key aim of the BUDS project was clarified as being:

> *"To bring about beneficial use of dredging within one or more Solent sites, using an incrementally phased approach to scope and cost sediment sourcing and sediment receiver sites, building a system of protocols and guidance".*

The introduction was followed by a brief overview of past beneficial use projects in the UK and a review of the Solent BUDS Criteria Mapping product that had been produced by ABPmer. Then, there was the workshop phase followed by a concluding discussion session. For the workshop, participants worked in three groups (with regional maps and the outputs of the Solent BUDS Criteria Maps) to review the opportunities for beneficial use in three regions of the Solent as follows:

- West Solent: West of Southampton Water and the Medina Estuary;
- Central Solent: Southampton Water; and
- East Solent: East of Southampton Water including the Medina Estuary.

The points/thoughts that arose during this workshop are set out below. These are divided into three categories:

- Section D.2: General points raised;
- Section D.3: Thoughts about key datasets that could be used to enhance the Solent BUDS Criteria Map; and
- Sections D.4 to D.6: Ideas for intertidal beneficial use sites in each of the regions (including ideas for managed realignments that might be recharged to create marsh habitat quickly[27]).

These details are presented to illustrate the breadth of the ideas and points raised. These have also been considered further as part of the main review (in Section 4 of the main report) and have helped to inform the main priority recommendations from the Solent Forum BUDS study that are presented in Section 5 of the main report.

D.2 General points raised

- It is necessary to take a strategic approach looking at the whole of Solent (both East and West) for approvals. This could lead to an agreed 'registry of disposal sites' with the priority recharge areas listed[28];
- It will be valuable to link this project, and the BUDS mapping work, to known coastal developments in the region (especially those that will require compensation measures which could contribute to the funding);

27 See also comments about Managed Realignment techniques in Section 2.3 of the main report
28 A key aim of the Solent Forum BUDS work is to achieve such as strategic approach with clear priorities for the future.

- Other possible funding sources could include, Natural England, Environment Agency, Southern Coastal Group, Harbour Authorities; marinas, and/or MMO;
- There were general discussions within each of the groups about the motives behind a project and a specific conclusion that areas should be identified which are relatively “unstable” (and in need of regular dredging) and also where there is a will by interested parties;
- The challenges of vessel navigation/access and or the extra costs of pumping rather than dumping were recognised;
- There are no large capital dredge events on the horizon now. So the focus will need to be on regularly using maintenance dredged sediments and sediment from (lots) of proposed smaller capital projects;
- There is a need to learn from projects as they are implemented and to accept a degree of risk (i.e. not necessarily seek to guarantee no harm at all). This will feed into guidance and contribute to a protocol for future beneficial use in the Solent;
- It will be necessary to use the correct sediment for the job, but to also think about what is needed in terms of bunding to both retain the recharge sediment and to provide ongoing erosion protection for existing or new marsh edges;
- Particular consideration should be given to providing tern nesting islands and high water roosts (especially with reduced disturbance) when selecting and designing schemes;
- In the Solent, where the distances to disposal (at Nab) are large, one key anticipated cost-benefit argument for beneficial use is that it should reduce these transport distances/costs;
- A tax could be placed on dumping to Nab and this will change cost benefit and could help to fund strategic project implementation; and
- Monitoring will be important (e.g. effects on nearby marinas/habitats), but the process of monitoring and lesson learning must be relevant and not necessarily paid for by the users each time. A strategic framework would help with this.

D.3 Key Datasets for Solent BUDS Criteria Map

- New layers should be added to describe the location of major proposed coastal developments. This could be obtained from sources such as the Solent Local Enterprise Partnership (LEP)[29] especially the Tier 1 and Tier 2 elements of the strategy. This information will be important for understanding the constraints, the new locations requiring coastal protection and the projects which are likely to have compensation requirements;
- On the BUDS mapping it would be good to add extra survey/habitats maps that are available now or which become available over time. This includes for example a map of Seagrass beds as a layer because the impacts to this species/habitat will need to be considered; and
- Data on historic saltmarsh extents should be added to illustrate the areas of change and the areas of greatest need[30];

D.4 Possible beneficial use sites in the East Solent

- There are a number of sites in Portsmouth Harbour where marsh islands and roost sites could be restored. At these sites a build-up of saltmarsh could also contribute to wave protection of areas such as Portchester;
- There are also some walls filled with landfill materials in Portsmouth Harbour and Langstone which will be priority area for protection (another project rationale);

29 https://solentlep.org.uk

30 CCO were consulted on this during the project prior to the workshop and did not have any datasets readily available but such datasets could be obtained in the future from mapping for the Solent Dynamic Coast Project and other sources.

- Small-scale work might be useful at sites such as Workhouse Lake (near Gosport) at the western side of the harbour mouth;
- The foreshore in front of Farlington in Langstone Harbour represents a potential area for marsh restoration and expansion (nearby Kendall's Wharf may be a source of sediment for recharge at this site);
- Islands could possibly be created along the western part of Langstone Harbour;
- There may be other smaller areas in Langstone Harbour (e.g. on its western side of the harbour mouth, at Eastney Lake site near to the Southsea Marina),
- Chichester Harbour is likely to have a number of opportunities (e.g. around Thorney Island), as all the marinas need to dredge;
- In the Medina, there may be potential for very small scale sediment "trapping" projects that could be carried out. The sediment management plan for this system is being revisited;
- There is a lot of sediment in Bembridge Harbour and there may well be possible opportunities at this site;
- There is also the delta at the mouth of the Alver (between Lee-on-the Solent and Gosport), where some form of intervention may be required;
- There are also a number of possible managed realignment sites in Langstone and Chichester Harbour. It is possible that landward placement of mud could be undertaken to increase saltmarsh versus mudflat (i.e. to speed up the natural accretion process), as well as to create roost islands; and
- There is also an SMP managed realignment policy at the top end of Wootton Creek, although it is unlikely that sediment recharge will be appropriate/possible for this site.

D.5 Possible beneficial use sites in the West Solent

- There is potential for beneficial use in the Lymington, Keyhaven and Hurst area. Here, new recharge projects could 'replicate' the success of past and ongoing Lymington projects. This could be linked to technical and compensatory requirements associated with the management of Hurst Spit (e.g. the need to fill in the channel in the lee of Hurst to facilitate barrier roll back). This would protect the sea defences and a flood plain area behind;
- Dredged sediment from Yarmouth (also Medina and possibly Keyhaven if dredging is needed there) could contribute to recharge work in the western Solent (especially along the Lymington to Hurst section);
- In Beaulieu where the Buckler's Hard Yacht Harbour needs to carry out a dredge in the near future and therefore this is also a source of sediment. Capital dredge arisings could be deposited on the marshes at the mouth of the river or elsewhere;
- The mudflat between Gurnard and Newtown (including Thorness) could be recharged with maintenance dredge arisings as a natural defence;
- Some form of smaller 'sediment trapping' projects could be undertaken within Newtown Harbour which is understood to be a 'sink' for sediment;
- Smaller projects may also be appropriate in the Yar, which is accreting at its upper end, but eroding in the central section; and
- It may be useful to look at managed realignment possibilities on this coastline as the beneficial uses of sediment could be used to enhance sites (e.g. Pennington/lagoons realignment near Lymington; or the scrapes/lagoons behind sea wall).

D.6 Possible beneficial use sites in Southampton Water

There are several possible small recharge sites in Southampton Water, as well as potential future coastal developments. Some of the key sites identified were as follows:

- There is likely to be value in carrying out work at Eling Great Marsh (in the upper reaches of Southampton Water). At this location there are pylons on the marshes which are vulnerable to edge erosion;
- The section of marsh between Cadland to Hythe marshes could have intertidal recharge, perhaps with shingle bunding in front to minimise loss back into the channel (the existing fronting cheniers are contributing to marsh damage so measures should try to stabilise these);
- The Fawley Marshes towards the mouth of the estuary near Calshot could be recharged, but habitat restoration proposals are already being developed for this area (linked to Fawley Waterside development);
- In the Hamble, a lot of thought has already gone into beneficial use projects by the HHA; small-scale projects using locally dredged sediment are emerging from this process;
- Along the eastern side of Weston to Netley Shore, it might be possible to push shingle seawards and pump maintenance dredging in behind;
- There could be value building up mudflat in the Itchen at Bitterne, near the Athelstan Road bend;
- The shallow 'island' feature of Bramble Bank could be subject to bunding and infilling to create a 'bird island'. This would be a particularly novel, challenging and ambitious project; and
- There are also possible managed realignment areas such as at Hook (Hamble), where recharge might be useful.

Contact Us

ABPmer

Quayside Suite,
Medina Chambers
Town Quay, Southampton
SO14 2AQ

T +44 (0) 23 8071 1840
F +44 (0) 23 8071 1841
E enquiries@abpmer.co.uk

www.abpmer.co.uk

ABP mer