Joint Defra / Environment Agency Flood and Coastal Erosion Risk Management R&D Programme

Scoping study: Updating the Beach management manual

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Environment Agency

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Steve Killeen

Head of Science

Executive summary

In the UK, over £370 million is spent on coastal defences every year, and this figure will need to double by the 2080s to meet the consequences of climate change and changing demographics. Beaches will play an important role either as the sole barriers to coastal flooding and erosion, or as part of manmade defences. Their maintenance and/or improvement will thus cover a substantial proportion of this expenditure. Beach management in the UK has evolved in design and execution over the last ten years, aided by guidance from the CIRIA *Beach management manual*, first published in 1996.

In order to continue to provide authoritative guidance to coastal managers on the best ways of managing beaches, this manual now needs updating. The manual should include the latest information on beach monitoring and maintenance, evaluation of the state and performance of a beach, and the design, procurement, execution and after-care of beach improvement schemes.

This revision is timely, not least because of increasing concerns about global warming. Sea levels are predicted to rise and increased storminess is predicted to cause greater problems in maintaining adequate defences against coastal flooding and erosion.

A new version of the manual could outline the results of recent research and summarise the experiences of a large number of beach management/recharge schemes that have been carried out since 1996. For example, new information is available on the strategies, quantities and types of sediment needed for the long-term maintenance of a beach. While this information is often difficult to obtain, sparse and/or incomplete, it is nevertheless valuable for optimising management practices.

Many beaches also play an important role in natural conservation and the enjoyment of tourists, holidaymakers and local residents. The optimum management of beaches as part of a coastal defence strategy needs to address the potential impacts on both humans and the natural environment.

This report provides details of a study carried out by HR Wallingford, Halcrow and CIRIA (Construction Industry Research and Information Association) to establish the scope for a new version of the 1996 *Beach management manual*. The aims of this study were to:

- draw up a compendium of recent UK beach recharge and beach recycling schemes;
- identify and consult with organisations, designers, funders, contractors, conservation bodies and so on;
- review the available literature (UK/overseas), liaise with other researchers and identify any further research needed;
- identify the problems and successes associated with past schemes;
- establish the work programme, specification and budget for the collation and synthesis of new information to update the manual.

A compendium of over 100 beach recharge/recycling schemes at some 80 locations in the UK was drawn up, with scheme “owners” approached to provide information on their design, implementation and performance. From this catalogue, more detailed case histories were put forward as potentially suitable for inclusion in the proposed new manual. The study also reviewed the substantial body of research undertaken, and scientific papers and reports on beach management schemes produced, over the last decade to ensure that this new knowledge could be included in the updated guidance.

A wide consultation on all aspects of beach management was carried out through Internet postings, letters and emails, along with a workshop attended by delegates from across the industry. This consultation aimed to identify the strengths and weaknesses of the original manual and what would be required of a second edition. It also sought to obtain information on past practice and experience, particularly where problems were encountered and overcome, since this would provide useful information to those involved in or considering similar beach management schemes.

The consultation exercise revealed that the present manual, whilst providing useful guidance to those designing major beach improvement schemes, was poorly used by those involved in routine beach management, such as operational staff within the Environment Agency. It was therefore decided that the revised manual should seek to reach more organisations and individuals with a practical interest in beach management, whether on a regular basis or in designing major improvement schemes.

The study concluded that the emphasis of the new manual should be on the role of beaches as coastal defence assets. Thus, its main objective should be to provide guidance on how to ensure beaches provide secure coastal defences.

To meet this objective, the new manual would need to:

- promote the management of existing beaches and the preservation or enhancement of their attributes as natural features and habitats, and/or as valuable amenity and recreational areas as well as coastal defences;
- provide guidance on the design and implementation of cost-effective beach improvement schemes;
- provide advice on achieving these objectives through performance-based asset management and 'best practice' guidelines.

Beach management will inevitably need to be undertaken to meet statutory requirements and legislation such as the Water Framework Directive (WFD) and the second generation shoreline management plans in England and Wales. The revised manual should provide up-to-date information on legislation, policies and guidance, explaining how these affect the management of beaches.

To ensure all these requirements are met and that subsequent updates can be carried out more frequently, it is recommended that the new manual be produced in a modular form, for example as a set of volumes rather than a single book and as an e-publication. The host website would also provide a convenient portal for further information and guidance as it became available, for example useful case histories, changes in legislation, new sources of data and publication of new research results.

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Dr Chrissy Mitchell	Science Project Manager
Mr Andy Gilham	Project board member
Mr Tim Kermode	Project board member
Mr Nick Lyness	Project board member
Mr Richard Thomas	Project board member

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1 Project background and aims

1.1 Background

The UK *Beach Management Manual* (BMM) was published by CIRIA (Construction Industry Research and Information Association) in 1996 (CIRIA, 1996a), and has now become a standard reference book for beach designers and managers. However, leading UK practitioners have recently expressed the view that the manual needs updating with the results of more recent research, as well as the experiences of many beach management and recharge schemes carried out since 1996.

A number of research projects have been undertaken in the last ten years, including some for the Department for Environment, Food and Rural Affairs (Defra) and the Environment Agency. These include studies on the lowering of beaches in front of coastal defence structures, of the impact of permeability on beach performance and on "barrier beaches", as well as the LEACOAST project. A revised BMM could outline the results of these and other research projects, so that up-to-date methods and information could be used in the design and management of beaches.

New information has also become available on the strategies, quantities and types of sediment involved in maintaining adequate beach levels, and on how beaches have performed. While sparse, sometimes incomplete and only available in unpublished literature, this information could nevertheless be valuable in optimising management practices.

As this scoping study progressed, additional reasons for revising the manual became clear. Firstly, predictions of global warming mean that beach management strategies should be reviewed in the light of a predicted accelerated sea level rise and possible increases in the severity and frequency of extreme weather events. An updated manual could provide the latest information on the likely effects of climate change on beaches, along with advice on mitigation methods.

A consultation exercise uncovered the need for the manual to focus more on monitoring, condition and performance assessments and the routine maintenance of existing beaches, rather than concentrating on major beach improvement schemes. This, in part, stems from the increasing importance of asset management in which the condition (or state) of coastal defences, and their likely performance during severe storm events, is continuously monitored and reassessed. The new manual should seek to provide guidance on how to carry out such reviews.

Future beach management will inevitably be required to meet statutory requirements and non-statutory plans, such as the Water Framework Directive (WFD) and the second generation Shoreline Management Plans in England and Wales. The revised manual will need to provide up-to-date information on legislation, policies and guidance, explaining how these will affect the management of beaches.

In conclusion, it is clear that the BMM needs updating in order to continue to provide authoritative guidance to coastal managers on good practice for beach management.

Before this major revision can be undertaken, however, we need to draw together information on the performance of past schemes, to consider what information might be needed in the future, and to identify short-term research needed to refine critical aspects of the planning, execution, maintenance and economic appraisal of beach management schemes.

1.2 Project aims

The principal aim of this project was to establish the scope for a second edition of the *Beach management manual* (BMM2) by:

- drawing up a compendium of recent UK beach recharge/recycling schemes;
- identifying and consulting with organisations, designers, funders, contractors, conservation bodies and so on;
- reviewing the available literature (UK/overseas), liaising with other researchers and identifying any further research needed;
- identifying the problems and successes of past schemes;
- establishing a work programme, specification and budget for the collation and synthesis of new information to update the BMM.

To achieve these aims, a number of objectives were identified, namely to:

- identify organisations and groups with an interest or involvement in beach management, to collaborate with and exchange information and ideas;
- identify useful information from the compendium of major UK beach management schemes to include in the updated manual;
- for a selection of five to ten such schemes, to review their outcomes including any problems encountered, lessons learnt and views on overall success (performance, value for money, environmental effects and so on);
- provide a business case, specification, outline programme and cost estimate to produce a second edition of the BMM, which would form the basis for discussion with coastal managers and potential funders.

The target audience for the revised BMM was deemed to be the Environment Agency, local authorities, UK consultants and contractors. The intention was for the project team to work with Natural England and the Countryside Council for Wales (CCW) to identify the scope for the full redevelopment of the BMM. Active consultation with coastal groups, leading coastal authorities, the Institution of Civil Engineers (ICE) Maritime Board and Environment Agency area teams was deemed to be critical to the success of the project.

2 Information gathering and consultation

2.1 Literature review

One of the aims of this study was to review the available literature to search for work carried out both in the UK and overseas, and to liaise with other researchers, in order to identify new information to update and strengthen the guidance in the new manual.

Research carried out for Defra and the Environment Agency was also reviewed to ensure that the new manual would disseminate important outcomes of this research and demonstrate its practical applications.

Given the limitations on time and budget, the literature review focussed mainly on UK-based information. A web-based review of some of this work is presented in the bibliography to this report.

The review was structured to address the following six subject areas:

1. Hydrodynamic and sediment transport processes
2. Beach morphological changes
3. Effects of management schemes on processes and morphology
4. Beach monitoring and data analysis
5. Practical beach management schemes (including design guidance and case studies)
6. Environmental, amenity and socio-economic aspects.

The following subsections summarise the sources discovered during this review. Where research has been carried out under the Defra/ Environment Agency *Flood and coastal erosion risk management programme*, research project codes (such as FD1001) are referred to. Further information on these projects can be found on the website http://www2.defra.gov.uk/research/project_data. Here, the project code can be entered to obtain details of contractors and reports generated by the research.

2.1.1 Hydrodynamic and sediment transport processes

A number of research projects funded by both Defra/Environment Agency and other bodies have sought to improve the understanding and modelling of hydrodynamic and sediment transport processes. .

The ANEMONE suite (Advanced Nonlinear Engineering Models for the Nearshore Environment) was developed under FD0204 by HR Wallingford. This suite of one- and two-dimensional models simulates nearshore hydrodynamics, including wave transformation and run-up on beaches, and in some models the effects of permeability. These models have been used to predict sediment transport and map coastal hazards.

Complementing this series are a number of modelling advances in sediment transport. The CAMELOT (Coastal Area Modelling for Engineering in the LOng Term) programme (FD1001), for example, developed models to help predict the evolution of coastal

morphology, both spatially down to coastal sub-cells, and temporally to cover coastal processes over several decades. From this project, models such as COSMOS-2D (predicting changes in cross-shore beach profiles) and PISCES (which predicts changes over a larger beach area) were developed to represent physical processes occurring over wave and tidal periods. PISCES was used at Teignmouth as part of the COAST-3D project, where it was able to represent the main hydrodynamic and morphodynamic processes in this complex estuary (HR Wallingford, 2001). This European Commission project was co-funded by the EU and national sources, with Ministry for Agriculture, Fisheries and Food (MAFF) funding under contract FD0803. In addition to the modelling of hydraulic processes, a large amount of field data were measured and used to evaluate model predictions.

Other advances in modelling and coastal predictions include the Halcrow (1999) study into stochastic methods for long-term prediction of coastal sedimentary systems (under research contract FD1008), whereby processes are treated as random, possibly involving quasi-predictable trends or cycles.

Research has been carried out on the hydrodynamic regime using both field data and laboratory testing. HR Wallingford, under FD02 and FD07 (1998), used physical modelling to test the effect of bi-modal seas on wave overtopping, explore the cross-shore transport of shingle seas and investigate the effect of approach slope on breaking waves. Bender and Dean (2003) recently analysed wave transformation during changes in bathymetry and subsequent impacts on the shoreline, specifically where nearshore dredging was used in recharge schemes. Further impacts of wave processes are explained in Trim *et al.* (2002), who modelled the influence of combined wave and tidal action on sediment transport on a shingle beach.

The development of joint probability wave and water level methods has been the subject of a number of Defra-funded research projects, with FD1704 testing and disseminating the JOINSEA methods used by the industry in recent years. New two-variable applications developed under this project include waves and currents for seabed mobility and sediment transport applications, river flows and water levels for estuarine applications, and wind speed and water level. This research has been used to assess the performance of flood defences, and for flood risk assessments for proposed coastal developments in which the effects of beach level changes were also considered. These methods could thus be used to assess the condition and performance of beaches and hence devise suitable coastal defence management.

The Defra/Environment Agency research project FD2206, *Best practice in the forecasting of coastal floods*, aims to improve the accuracy of flood predictions, providing guidance for forecasting and reviewing current procedures; however, this research does not consider beach management itself.

The effects of climate change on sea levels and flooding has been investigated in a number of projects, including FD1204 (*Integrated effects of climate change on coastal extreme sea levels*) and FD0313 (*Climate change impacts for flood and coastal defence – effect of climate change on extreme surges*). Defra/Environment Agency research project FD2303, *Coastal defence vulnerability 2075*, considered the impacts of climate change on waves and water levels as simulated by a global climate model, and how these changes might affect coastal defences. Of particular relevance to beach management was the consideration of possible changes in longshore drift rates, with a chapter in the project report (Sutherland and Wolf, 2002) on simulating changes in beach levels and plan shapes. Five locations on the UK coastline, namely Lincolnshire, Dungeness, Lyme Bay, Swansea Bay and Fylde, were used to provide examples of the possible consequences of climate change on beach management, particularly beach recharge or recycling schemes likely to be affected by changes in mean annual drift rates and their statistical variability.

2.1.2 Beach morphological changes

The changing morphology of beaches and their response to changing physical processes has been widely researched since 1996.

Improvements in modelling were developed in the CAMELOT project (FD1001), including the investigation of non-linear methods for analysis of long-term beach and nearshore morphology which examined statistical techniques to predict long-term beach changes. The project also produced guidance on the numerical modelling of coastal morphology. Other research on beach morphological changes considered such topics as coastal steepening (HR Wallingford, 1999), and the influence of sandbanks on long-term coastal morphology. The former of these projects reviewed the evidence for the apparent long-term narrowing of the inter-tidal width of beaches around the UK coastline, a phenomenon that has yet to be explained. Research into the influence of sandbanks on coastal morphology produced a number of reports, including Posford Duvivier's (1997) and HR Wallingford's (1996).

Hearne (1996) developed a predictive N-line model of long-term coastline behaviour through analysis of coastal erosion/accretion and meteorological data.

A number of Defra-funded research projects under the Sustainable Asset Management Theme of the joint Environment Agency/Defra *Flood and coastal erosion management science programme* have sought to understand and predict beach morphological changes, the erosion of cohesive shore platforms (FD1926) and the impacts of permeability on beach performance (FD1923). These projects, completed in 2004-2007, aimed to collate current knowledge and improve our understanding of the different types of beaches and processes that alter their morphology.

Barrier beaches are important geomorphological features, yet the processes that maintain them are not widely understood. Further discussion of barrier beach breaching, with reference to the breach at Porlock, Somerset and subsequent management, was reviewed by Stevens (2001) five years after the initial breach in 1996. A recent scoping study was commissioned by Defra (*Understanding barrier beaches*, FD1924) and the final report is awaiting publication.

Two linked research projects (FD1304 and FD1901) reviewed current knowledge of mixed beach processes and developed predictive tools for these processes.

Backshore environments and their impacts on beach processes and the environment immediately inland have been considered, both for sand dunes (FD1302, 1998) and for soft cliffs (FD2403, 2002). The first study explored processes affecting sand dunes, their geomorphology and impact on the surrounding environment, with a computer database created to disseminate and analyse the results. A better understanding of cliff stability and recessions emerged from the soft cliffs project.

The SANDPIT project (FD1912) investigated the effects of offshore aggregate dredging on beach morphology, flood defence, erosion and ecology on adjacent coastlines; this could shed some light on possible impacts from dredging for beach recharge materials.

2.1.3 Effects of management schemes on processes and morphology

The effects of beach recharge schemes have been researched by a number of scientists, including Benedet *et al.* (2004) who examined nourishment as part of their assessment of cross-shore sediment variation in beach classification. They concluded that local wave conditions could be used to calculate likely consequences of beach nourishment on morphology, by calculating possible dimensionless fall velocity as a

function of changes in grain size. Kana and Mohan (1998) investigated the stability of nourished beaches, finding that the use of coarser recharge material than the existing beach sediment would cause the beach to adjust to a steeper profile, thus creating a wider dry beach.

With reference to beach control structures, such as groynes and breakwaters, there have been a number of studies on their impacts. The LEACOAST project funded by EPSRC (Engineering and Physical Sciences Research Council), now in its second phase, is studying large-scale long-term morphodynamic impacts of the Sea Palling shore-parallel breakwaters, to understand better how these structures interact with coastal processes during storms (LEACOAST, 2006). As part of this project, Bacon *et al.* (2003) examined the interaction of tidal currents with these breakwaters, and how this affected sediment transport in the region. Thomalla *et al.* (2001) also considered longshore sediment transport patterns at Sea Palling, and how they might be interrupted by the presence of the segmented breakwaters.

The Elmer breakwaters in West Sussex have been the focus of a number of studies. King *et al.* (2000) suggested that the breakwaters reduce shingle transport by a factor of two from transport at a comparable open beach. Ilic *et al.* (2005) used a physical model of the area to investigate the influence of the breakwaters on wave conditions and thus local hydrodynamics.

Finally, two research projects (FD1916 and FD1927, 2006) considered beach changes in front of coastal structures. A large part of this research concentrated on localised and often short-term "toe scour", this being a common effect of coastal structures such as seawalls or breakwaters. The studies showed how scour holes could form and fill in during the course of a tide and developed improved predictors for scour depths, along with information on measures used to mitigate this scour and its effects. The research placed toe-scour in the context of the longer-term phenomenon of "beach lowering".

2.1.4 Beach monitoring and data analysis

Methods to assess the success of management schemes and monitoring techniques have advanced since 1996. The need for long-term monitoring and data analysis is now accepted, with many shoreline management studies setting out requirements for monitoring and how to interpret them. The *Field measurements of coastal dynamics* project (FD0803, 2000) – linked to COAST-3D – involved the installation of continuous monitoring instruments at Teignmouth over 1.5 km of sea, and the organisation of a data management system for the storage and analysis of data. A workshop was held for project and external modellers to collaborate and run models simultaneously.

The UK's largest beach realignment scheme at Freiston has been extensively monitored by the Environment Agency (as FD1911, 2007) to improve our understanding of realignment processes, although this site is perhaps untypical of most UK beaches since it is deep within a major estuary (The Wash).

Hough and Peck (1997) identified ways to more effectively monitor schemes, using the beach recharges at Heacham to Snettisham and Mablethorpe to Skegness (Lincshore) as test cases. A data management system was created specifically for the Lincshore scheme, to store and analyse data to assess physical beach changes and environmental impacts (Zwiers and Dale, 1996). Benavente *et al.* (2005) championed the use of foraminifera in beach recharge materials as tracers, to enable the patterns of sediment transport of this material to be followed.

Cooper (1998) noted the lack of sufficient monitoring of schemes both prior to, and post, implementation. He assessed the performance of major sand replenishment

schemes at Poole Bay using a long-term beach monitoring record, which enabled post-replenishment volumetric decay trends to be calculated and used to predict when a new replenishment would be needed.

Browder and Dean (2000) also emphasised the importance of a long-term monitoring of beach replenishment, both to assess the performance of the scheme and to inform future designers of beach-fill schemes.

The recent increase in monitoring along the coastline from the Humber to the Thames, along with the establishment of the Channel Coastal Observatory and the monitoring of beaches from the Thames to Portland Bill (Bradbury, 2004), will greatly affect several sections of the current manual dealing with coastal data collection. Other monitoring programmes are beginning, for example in South-West England (Portland Bill to the Severn Estuary) and *Cell 11* which covers the Great Orme to the Solway. There appears to be very few publications on these initiatives, but this is likely to change during the period in which the manual is revised.

The Defra/Environment Agency research project (FD1927, 2006) on beach lowering has produced guidance on different types of beach level monitoring and the analysis of results to predict future changes.

2.1.5 Practical beach management schemes

The review of literature on beach management schemes is divided into two sections; the first deals with advances in the design of such schemes, and the second reviews the case histories found.

Design guidance

The assessment of beach management schemes and physical/numerical modelling enables advice and guidance on future schemes to be disseminated. Allison (1998) provides guidance based on the experience of the Environment Agency's Southern Region on the importance of strategic planning in beach management, to ensure that long-term planning and funding is effective.

On a broad design scale, reviews of the shoreline management plan (SMP) process funded by Defra aim to improve how an SMP is developed and used (FD1703), and to enable the development of high quality and consistent SMPs (FD2002).

The availability and suitability of dredged sediment for beach management schemes is a well explored subject. A number of Defra-funded projects have considered the marine aggregate industry, including the *Marine sand and gravel – development in North-West Europe* project (FD1011) and an assessment of marine aggregates in Carmarthen Bay (FD1301). Bellamy (2000) provides advice on the sourcing and obtaining of marine aggregates for use in coastal defence. French *et al.* (2000) advise the use of dredging to aid eroding estuarine foreshores, and list the uses and benefits of dredged material in these environments.

Guidance on the implementation of managed retreat policies is provided in project FD2008 (2002), which considers the logistics behind this option including the economics, institutional arrangements, policy, culture, funding, ownership and legislation. FD2413 (2004) provides guidance on the design and implementation of a managed realignment scheme.

Clarke and Brooks (2006) examine the experience of beach recycling schemes at Tankerton and Folkestone in Kent, and long monitoring programmes of beach morphology, sedimentology and groundwater conditions, to disseminate information on anticipating scheme life costs, long-term performance and the efficiency of recycling

schemes. Dean *et al.* (2006) review options for beach nourishment, and provide advice on the effect of such schemes on naturally occurring physical processes.

Guidance also exists on the use of structures in beach management. HR Wallingford, under FD2409 (2003), provides guidance on the design and assessment of low cost rock structures for coastal defence, to encourage their use. Submerged breakwaters were investigated using model facilities under FD0706, which drew up a preliminary design protocol for UK engineers intending to use such structures, to enable them to extract maximum efficiency. The use of linear defences was the subject of FD2318, which outlined approaches to assessing their reliability. The possibility of constructing rock armouring on unprepared foundations was investigated, as this would make such structures cheaper and easier to place. Some already exist, and many have performed acceptably. The study (FD2401) recommends further work and offers design guidance.

With regards to the planning and consulting phases of beach management schemes, in particular flood protection, the consultation and communication procedures used in England and Wales were reviewed (FD2007) by interviewing members of communities in case study areas. A list of methods was suggested to ensure that the public and stakeholder groups would be better able to understand the issues and risks involved.

Case study management schemes

A coastal defence strategy was prepared at Reculver, Kent, following the seawall collapse in 1996. A strategic approach encompassing the whole management unit was deemed necessary for successful management (McFarland and Edwards, 1998).

The Heacham to Snettisham beach management scheme was reviewed in 1998, with a combination of hard and soft defences proposed following the 1990 beach recharge scheme that was relatively successful, although a number of weaknesses were identified (Nunn and Beech, 1998).

Another coastal defence strategy is in place along the Rivers Arun to Adur frontage. This strategy was reviewed by Curtis *et al.* (2000) who discussed the issues arising during strategy development, and lessons learnt.

A £12.7 million sea defence scheme has been set up at Minehead, Somerset, which takes into account environmental issues and public concerns. Taberham *et al.* (1998) describe how the Environment Agency collaborated with consultants and contractors to ensure environmental sensitivity throughout.

The Pevensey Bay Sea Defences Contract was a pioneer as the first public-private partnership (PPP) flood defence scheme in the UK. Hardacre and Chester (2001) review the first years of the project and explain the background leading to its development.

An ECC (Engineering and Construction Contract) Design and Construct Contract was awarded to refurbish West Bay harbour, Dorset, following severe wave conditions after which the historic harbour entrance piers deteriorated close to collapse, with the beach to the west eroded and exposing seawalls. A scheme was completed in 2005 whose execution is described by Browning *et al*. (2005), explaining the use of the Latham Report to guide consultation, procurement and partnering.

A beach protection scheme at Corton, Suffolk, experienced a number of difficulties when the defences failed in 1999-2001. The implementation of a new scheme was hampered by low potential benefits, very limited access for construction plant, and the need to manage high public expectations. Patterson *et al.* (2004) reviewed the scheme and described how these complications were overcome.

Hamm *et al.* (2002) and Hanson *et al* (2002) provide summaries of nourishment experiences across Europe including amounts dredged, performance and so on. Further insight into the Netherlands is given by Van Duin *et al.* (2004), who report on a scheme implemented at Egmond aan Zee where both the shoreface of the outer bar and the beach behind it were nourished, with the beach nourishment seeming to function as a reef.

Nourishment schemes have been implemented at Hythe (Young *et al.*, 1997), Lee-on-the-Solent (Fowler, 1998) and Hurst Castle Spit (Bradbury and Kidd, 1998). A coast protection strategy was developed at Hythe for the whole seven-kilometre length of frontage – the nourishment contract formed the largest part of this scheme. At Lee-on-the-Solent, the Association of British Ports and Gosport Borough Council collaborated to enable the use of material dredged from Southampton Water to be used for coastal protection. The paper describes the practicalities of the project resulting from the need to coordinate both the dredging and recharge projects. The renourishment at Hurst Castle Spit was part of a scheme to stabilise the shingle spit that protects large areas of saltmarsh and the coastline further east. Shingle bypassing was used at Shoreham as part of a broader coastal management scheme involving rock groynes infilled with dredged shingle along Shoreham Port's frontage (Vaughan, 2001). Bypassing was instigated to protect the beaches downdrift of the port entrance breakwaters.

The sea defences at Jaywick and Clacton were reviewed by Posford Duvivier following concerns over their performance; the review concluded that the current structures (including fishtail groynes) were not sufficient to maintain satisfactory levels of defence, with further works planned (Sleigh *et al.*, 1997).

The performance of the fishtail groynes at Llandudno, North Wales, was reviewed by Bull *et al.* (1998), who considered their influence on the adjacent frontage. The authors found that beach levels had not increased as much as expected, and structures had promoted the accumulation of a large amount of fine sediment in their lee, which reduced their appeal to beach users.

Various reviews of the offshore breakwaters at Elmer, West Sussex and Sea Palling have been published, with King *et al.* (2000) describing beach plan-form change in the first few years after construction, using sediment tracing techniques. The Sea Palling structures have been considered by Thomalla *et al.* (2001) and Thomalla and Vincent (2003), with both local beach impacts and downdrift effects described.

2.1.6 Environmental, amenity and socio-economic aspects

The development of the new Minehead sea defences paid particular attention to environmental and amenity issues, with very large long groynes ruled out because they would extend far into the bay (Taberham *et al.,* 1998). An environmental report was produced and environmental constraints were placed on the design team and contractors involved in its construction. For example, the West Somerset railway was used to deliver (locally-sourced) material in 500 tonne loads, producing significantly lower carbon emissions than road haulage. Some construction material was also recovered from previous defences, reducing the need for landfill and for new materials.

At Corton, Suffolk, the environmental impacts of a new defence scheme were recognised at an early stage. Thanks to public consultation, no formal public complaints were issued over the 10-month construction period (Patterson *et al.*, 2004). Work had to be postponed to protect ornithological interests, as the initial timetable clashed with the Sand Martin breeding season. The most exposed soft cliffs were also covered for the duration of the works, to encourage the martins to move further away.

Considerations of flood defences at the community level were undertaken in research project FD2009, following concerns that some affluent areas were benefiting more from flood protection than poorer areas within a community. The project listed a number of criteria with which to evaluate the social and economic impacts of flood defences.

Guidance to develop better economic appraisal methods is available in the updated manuals for *Flood and coastal erosion risk management* (FD2014), including the use of better datasets on flood risk and damage to properties, and assessing the impacts of flood damage on different social classes.

Herrington *et al.* (2005) discuss the Hythe to Folkestone Harbour Coast Protection Scheme, which used Shepway District Council's new procurement strategy. The authors emphasise the importance of procurement drivers in cementing the client-contractor partnership.

The Defra/Environment Agency research project FD2324 developed a standard method for assessing and reporting the risk of erosion. It introduced a risk-based framework to aid policy, planning and implementation of coastal erosion risk management for local authorities. This project offers a consistent approach to risk assessment and management for flooding and erosion, as set out by FD2302 (*Risk, uncertainty and performance review*).

Two research initiatives currently underway should generate practical guidance on shingle beach management. The first, by Shepway District Council, is exploring the efficiency of recycling operations. Beach morphology and other data are being collected along the Hythe to Folkestone frontage in Kent, following the completion of a major beach recharge scheme in 1996. The project is monitoring the response of sections of beach to changes in beach recycling practices and making comparisons with other 'control' beaches. The principal aim of the research is to identify ways to optimise beach recycling by improving the existing beach structure, thereby generating long-term cost savings while improving beach performance.

The second project, also supported by Defra/Environment Agency funding, is being carried out by Canterbury City Council. At Tankerton, to the east of Whitstable, the shingle beach has been improved by a three-phase recharge scheme working from west to east. The first two phases were carried out in 1998/99 to improve beach levels along two-thirds of its length. The last third was recharged in 2004, using a mixture of different sizes of shingle and placement methods in different groyne bays. For economic reasons, the recharge material was considerably finer than the natural beach material, containing a greater proportion of sand. Recharging with a finer grading of sediment is now common practice in the UK, as economically viable sources that match the native beach are rarely available. When using finer material as recharge, it is necessary to either increase the quantity added or increase beach maintenance costs. Evidence from some schemes in the UK suggests that long-term beach maintenance costs are being consistently underestimated due to a lack of information on how mixed beaches react to being renourished with a dissimilar (finer) material.

The research underway at Tankerton is monitoring the response to variable waves and tides of both the newly recharged beach and an adjacent mature beach. The project is measuring beach profiles, beach plan shape, water-table variations and sediment size distributions. Crucially, since both the new and mature beach are subject to the same hydraulic forcing and geometric constraints, differences in their responses will be a result of sediment size distribution only. It will therefore be possible to compare erosion rates of the two beach types and determine the impact of enhanced erosion rates (if any) on whole life costs and hence economic justification of a beach management strategy. The project will also generate new data on mixed beach behaviour, the impact of tidal level variations on beach drainage and beach reorientation characteristics.

The new manual should take full account of these projects, to provide guidance to those considering similar schemes in the future. These two schemes should also provide valuable case histories for the new publication (see Section 4.4 below).

2.2 Consultation

As well as seeking literature on beach management schemes, this study aimed to consult with client organisations, designers, funders, contractors, conservation bodies and the like, to establish how the existing manual could be improved. In 2004, Professor Dominic Reeve (University of Plymouth) undertook a similar exercise, on behalf of CIRIA, by holding a workshop and canvassing opinions on the manual. The responses and outcomes were made available to this study, and a similar form to the feedback form used in 2004 was used here. The responses essentially requested updates or extensions to the information in the 1996 version of the manual and are discussed, together with other views on this publication, in Chapter 3 of this report.

In this scoping study, the consultation process was carried out in three stages. The first stage used an initial round of letters, emails and publicity to obtain views on updating the existing manual and extending it into new areas if thought useful. This was followed by informal contact, either by email or by telephone. Discussions were also held during project board and project team meetings. The issues raised are not formally reported, but are reflected in our recommendations outlined later in this report.

The final phase, which generated many ideas and comments, was a workshop held at CIRIA's offices in London on 5 February 2007. This workshop and its outcomes are described in Section 2.2.2 below.

2.2.1 Initial consultation process

In order to understand how the Beach Management Manual was being used by various organisations, and how this could be improved upon, the initial consultation process targeted UK practitioners, that is, those organisations and individuals most likely to be involved in managing beaches.

Since the emphasis of the original manual was on managing beaches as components of coastal defences against erosion and flooding, the main target groups for the consultation exercise were local authorities in England and Wales, and the various regions of the Environment Agency. To improve the likelihood of reaching the most relevant individuals in local authorities, a presentation was given at the meeting of the Regional Coastal Group Chairs at the Institution of Civil Engineers on 12 October 2006. A project description and consultation feedback form was sent out with the minutes of those meetings, and the various chairmen undertook to pass these on to the members of their groups. In addition, several councils in Scotland with known beach management schemes and problems were also contacted.

To seek suggestions and comments from within the Environment Agency, information about the project was sent by email to Jackie Banks (Flood Risk Management Technical Manager, Asset Systems Management and Enforcement) and Stephen Worrall (Policy Advisor, Flood Risk Planning), with a request to circulate it to the appropriate staff in regional offices.

In addition, other organisations were identified as potentially being interested in the manual, particularly consulting engineers and contractors (including dredging companies), those previously involved in producing the first edition of the manual and academic institutions with a known interest in coastal and beach processes.

Individuals in each of these organisations were contacted directly by post, with an explanatory letter and a feedback form.

In order to canvas views from a wider audience, both HR Wallingford and CIRIA included details of the project in their regular publications, that is, in the CIRIA News and HR's Research Focus. In addition, both organisations set up websites with information on the project and downloadable feedback forms for those wishing to comment, namely for CIRIA (http://www.ciria.org.uk/con142.htm) and for HR (http://www.hrwallingford.co.uk/projects/BMM2/).

In a further step to widely publicise the study, details of the project were circulated by email via two discussion/newsletter forums, namely "Coastal_List" and "COZONE". The former is international, reaching many coastal engineers and researchers around the world, particularly in the USA. The latter is mainly used by academic institutions within the UK to circulate information on research related to the coastal zone. As with other emailed requests for comments and ideas, these forums circulated information about the project on their websites.

Overall, the response from these initiatives was extremely disappointing. It was usually possible to identify the route by which those that did respond found out about the project. The following table (Table 2.1) summarises the number of responses received, without differentiating between those that made specific recommendations or provided ideas, those that offered assistance with the rewriting of the manual, and those that simply asked to be updated on progress.

Table 2.1: Responses from initial consultation exercise

Publicity method	Number of responses received
Defra research newsletter	2
Regional Coastal Group Chair meeting	4
HR website/Research Focus	1
CIRIA website/CIRIA News	0
CIRIA contacts list (letters/forms sent by post)	1
Coastal List (email forum)	7
COZONE (email forum)	2
Email circulation within Environment Agency	0

While most responses were generated through the Coastal_List email forum, these were largely offers either to assist in writing or reviewing the new manual (not necessarily unpaid!).

None of the responses criticised the contents of the 1996 version of the manual, but a few suggested potential extensions to it, for example expanding the sections dealing with dune management and introducing guidance on ensuring the safety of the public on managed beaches, for example where defence structures or schemes have been built or proposed.

2.2.2 Project workshop

The main aim of the consultation exercise was to engage with client organisations, designers, funders, contractors, conservation bodies and so on, to obtain information and ideas on updating the manual. As the third strand in this consultation process, HR Wallingford subcontracted CIRIA to run a workshop for these groups, to gauge the

need for an updated manual and ensure the requirements of the industry would be met. This workshop was held at CIRIA's offices in Old Street, London on 5 February 2007.

The need for such a workshop became apparent when analysing uptake of the previous manual. The project team was under the impression that the manual was widely circulated and used by beach managers, but this turned out not to be the case. For this reason, the workshop was more an open discussion on the necessary changes that a future manual should incorporate rather than, as initially conceived, a more restricted debate on how best to update the original publication. A review of the uptake of the 1996 manual, and the comments received on its contents, is presented in Chapter 3 of this report.

At the workshop, delegates were divided into two groups (see Appendix 1) who, in turn, discussed separate issues of beach management. These break-out sessions were led by staff from HR Wallingford and CIRIA, who facilitated discussion, recorded all delegates' comments on flipcharts and took minutes.

The workshop posed a number of questions on issues of beach management, rather than considering the content of the 1996 version of the manual as originally intended. In particular, it was felt that that publication was not well used, or even known about, by those engaged in routine beach management such as regular inspections, monitoring, maintenance of structures and occasional small-scale operations to alter beach plan shapes or profiles. Further, there was a clear interest on behalf of the Environment Agency for the new version to help implement new governance and research initiatives such as the Water Framework Directive, the Environment Agency's asset management strategy (supported in part by PAMS - *Performance-based Asset Management System*, see Defra/Environment Agency, 2004) and various risk-based approaches to managing defences against coastal flooding (such as FLOODsite).

In order to encourage discussions on these and other areas where the current manual was felt to be lacking, a number of questions were posed and debated in the break-out sessions. The main points arising from discussion of these six questions are summarised below. The final part of this section summarises the comments received about the format of a new manual.

Question 1: What are the environmental and public concerns relating to beaches and their management?

In general, it was felt that the present manual was rather brief on this subject area, treating these concerns as subsidiary issues to, for example, the design of a beach control structure or the delivery of beach sediments, rather than worthy of a chapter or section of the manual. The discussion of environmental attributes of beaches in the 1996 manual (less than five pages of text) might usefully be expanded in the new manual, particularly in the light of increased protection of sites of scientific importance and increased interest in the amenity and recreational importance of beaches.

It was not thought at the workshop, however, that the manual would need to cover beach management particularly for these interests; rather, the manual should concentrate on managing beaches for coastal defence while bearing these other interests in mind. It was pointed out, for example, that concerns about the costs, performance or longevity of a beach recharge scheme might or might not influence a decision about its implementation, but concerns about effects on the natural or human environment could prevent a scheme going forwards. If such concerns were only considered at a late stage, it would bring the possibility of much wasted effort.

Environmental concerns

Despite the lack of representatives from Natural England or CCW, who were unexpectedly unable to attend the workshop, a number of concerns regarding the impact of beach management schemes on the natural environment were raised. Guidance on assessing and minimising such effects is already available, and there are regulatory controls in existence, for example the Food and Environmental Protection Act, under which a licence needs to be obtained to place beach sediments or build structures below the high water mark. It was suggested that the new manual could contain:

- a checklist of environmental concerns that have been, or may be, encountered;
- information on the appropriate guidance for considering such concerns;
- information on the consents and licences that might be needed for any management operations, and the relevant legislation that has changed considerably since 1996.

Examples of specific concerns regarding wildlife or sites of geological/ geomorphological importance included:

- introduction of sediments of different size or mineralogy;
- possible chemical or biological contaminants in imported sediment;
- creation of turbidity during placing or dredging of sediments;
- impacts on the seabed by offshore dredging of sediment;
- disturbance to wildlife during operations, such as breeding/overwintering birds;
- damage to plants during operations, for example on shingle ridges and dunes;
- the need for “baseline” and possibly repeat ecological surveys.

Public concerns

It was considered of primary importance to discuss with the public any work/action to take place on beaches. People’s expectations are that their beach should remain the same and their concerns primarily relate to amenity/aesthetic issues, including untrammelled access. Beach managers are generally not renowned for their public engagement. A guide to increasing engagement, particularly with seasonal visitors who do not usually understand local politics/issues, was suggested for inclusion in the new manual. Positive signage explaining schemes proposed or underway was regarded as an important part of reaching the public, especially seasonal visitors. An example of the successful management of public engagement can be found in Davis and Cole (2005) at Lyme Regis, where foreshore and slope stabilisation works caused major disruption to this coastal resort, despite reducing landslide and erosion risk. Intensive public relations work resulted in much public participation and minimised conflicts, producing a sense of community ownership. A further example was the use of a “trust in community” approach by the Environment Agency during works at Teignmouth.

Typical areas of public concern identified during the study are listed below.

- the timing of major beach management works can cause problems, especially during the main holiday season in coastal resorts;

- noise and traffic created during construction and demolition operations can cause difficulties and resentment;
- consideration needs to be given to public safety, amenity and aesthetic issues, for example when designing beach control structures. This leads to the consideration of improvements to amenity being included in designs of coastal defence structures;
- arranging for safe public access to a beach during, for example, recharge or recycling operations can be a major difficulty, involving fencing and stewarding at certain times;
- the colour, size and shape of imported beach sediments are often seen as very important. Sharp edges on imported shingle or very large particles cause concern. Increasing the size of sand on a beach may improve the performance and longevity of a beach recharge scheme, but if this means children cannot make sand castles, this may deter holidaymakers;
- the short-term beach changes following recharge, in particular, can cause problems, for example the creation of very steep, even vertical ”scarps” in beaches or the deposition of fine-grained sediments that can form a quicksand. In either case, these can create a significant safety hazard, as well as hampering access to the beach and sea.

Question 2: *How best should I maintain, monitor, and assess the performance of my beach?*

Delegates began by discussing how the performance of a beach is judged, and it was agreed that this depends on its functionality. Different beaches will have different functions, for example as coastal defences, amenity areas, habitats and so on. The condition and performance of a beach will therefore be judged on how well it is fulfilling its function (or functions, since many beaches will be expected to have a number of these).

On the issues of maintenance and monitoring, it was agreed that these activities should not be separated, since monitoring should always guide beach maintenance activities. The conclusion reached was that monitoring should be the starting point, ideally comparing the results with some defined beach condition (or set of conditions) reflecting its required performance. The primary purpose of monitoring would be to assess whether the beach was meeting or deviating from that target (or targets).

While monitoring the physical condition of the beach − its levels, widths, gradients, grading and so on − it is clearly necessary to establish its condition (or state) and its likely performance in extreme conditions, in other words its functionality as a coastal defence, other types of monitoring may also be desirable or necessary. The workshop identified the benefits of environmental monitoring, and suggested that this topic should be included in the revised manual, covering aspects that beach managers should monitor both initially in a baseline survey, and subsequently. This type of monitoring might cover natural and/or human aspects, such as the numbers of plants or holidaymakers at different times of the year.

While such monitoring would be expected for a new beach management scheme, such as for new groynes or a beach recharge, it was pointed out that it would also be useful to carry out monitoring for de-commissioning activities such as the removal of structures or suspension of routine recycling. This would provide information on the

physical and environmental consequences of such decisions, which would be valuable for similar situations elsewhere.

The maintenance of beaches was defined as “when people interfere to try and keep a beach’s performance within a certain set of parameters”. Delegates believed that decisions regarding when to intervene were not always guided by reliable science and in many cases, activities were carried out because they had been done so historically. A need for trigger levels was identified, where these would indicate that a beach had reached a condition that meant that it was not achieving its required targets, and hence was not likely to perform adequately.

A further point made was that, although managers will have information on what maintenance should be carried out and what they are trying to achieve, they may not always be certain why a particular type of maintenance has been chosen or is necessary.

Question 3: *How do I plan and budget for maintaining my beach?*

Discussion on this question centred on three main topic areas as presented below.

Planning

Planning was considered a very important part of beach maintenance, although it was also necessary for a plan to be flexible in case any work close to the beach could be used for other benefits (for example, dredging of a port area might opportunistically provide extra beach sediments at modest cost). The inclusion of operations staff in the planning and budgeting for maintenance was seen as a simple and cost-effective way of improving beach management. Concern was also expressed about the potential for loss of focus in maintenance as a result of changes in beach managers, with information and objectives not being sufficiently well handed over.

Mention was also made of the need for contingency plans for unusual but severe events, for example in dealing with events such as the beach pollution, public safety and management concerns in Devon following the grounding of the MV Napoli in 2007.

Budgeting

The main issue identified as problematic with respect to budgeting was that maintenance money couldn’t be put aside for future years if the full allocation for the year wasn’t used; the funding for the next year would then be reduced. It was suggested the revised manual should guide managers on how to seek extra funding for their beach maintenance. An example was given for funding to be sought from regional development agencies if a beach’s function as an amenity would help bring tourists to a particular community/region. Guidance on how to reap this economic benefit of a beach should be provided in the manual, since this is a common requirement in the justification of beach management schemes.

Monitoring

Not surprisingly, delegates’ thoughts quickly turned to monitoring as it was already agreed that no beach management system could be implemented effectively without a monitoring programme and database.

The need to integrate data from consultants, environmental organisations and local authorities was highlighted, particularly with respect to maintenance. Historical data from previous maintenance is generally very sparse and it was suggested the manual could promote a standard way of monitoring and gathering data regarding the maintenance activities.

While some centralisation of monitoring information was regarded as valuable, a national database appeared likely to be unwieldy. Sediment cells were suggested as appropriate units to organise the storage and sharing of information and for managing data monitoring, since these form the basis of shoreline management plans and will have reasonably uniform geology, morphology, coastal processes and beach types.

Question 4: *How can I judge whether my beach management is successful and optimised?*

In retrospect, is it clear that this and Question 2 covered much of the same ground, and the discussions rather reflected this. The main points arising are outlined below.

Delegates felt that is was important to establish both the objectives of any beach management scheme and the criteria for judging outcomes before implementation, as well as initiating a monitoring and review programme to appraise it. The introduction of performance-based asset management was seen as one way of providing rapid feedback on beach management to both operational and design staff, as well as allowing the overall outcome to be assessed at a strategic level. Such strategic reviews should be carried out over a predefined time cycle, for example five years, and include a financial assessment as well as examining the defence standard achieved and the amenity or environmental performance.

In this context, it was seen as important that guidance should be provided in the new manual on how objectives for beaches should be set, not only for coastal defence but also for amenity and/or environmental objectives.

There was again considerable emphasis on communication between designers and operators regarding the aims and outcomes of beach management, and basic understanding of each other's roles, needs and difficulties. There have been considerable problems in the past in making the whole beach management process transparent and connected. The design of beach management needs to be linked to maintenance and budgetary requirements from the outset, and should consider the practicalities of implementing any operation. The possibility of alternative contractual arrangements, such as PPP schemes, was also mentioned.

Question 5: *How do I design a sustainable and environmentally - acceptable beach improvement scheme?*

The discussion of this question was wide-ranging but is presented here in three sections, namely considering a scheme in terms of:

- its effects on the natural environment, such as on plants and animals;
- its effects on the human environment, such as on amenity and safety;
- its sustainability, particularly in the light of uncertainties.

Effects on the natural environment

Few concerns about the effects of beach improvement schemes on the natural environment were mentioned at the workshop. However, there can be impacts on conservation when working next to areas of vegetated shingle or other protected habitats.

The chemical/biological composition of sediment used must be suitable for the particular site. This was a concern for the major recharge at Happisburgh/ Winterton, where the beach naturally fed the dunes and therefore the chemical content of the recharge needed to be suitable to support the dune vegetation.

Turbidity created either when dredging offshore for sediments or placing them on the beach, was not considered by delegates to be a great problem in terms of its effects on plants and animals on the seabed. However, it was pointed out that such operations would be subject to an assessment of their environmental effects, and subject to satisfying Defra/Centre for Environment, Fisheries & Aquaculture Science (CEFAS), for example, to obtain a licence under the Food and Environment Protection Act (FEPA).

Effects on the human environment

Amenity issues

More concerns were raised with respect to the effects of beach improvement schemes on the human environment. Where beaches are important for tourism, the recreational aspects are often very important. For example, there may be a requirement on the design of the new beach to be able to make sand castles. This can restrict the sediments considered suitable for recharge. In a similar vein, the colour of imported sediment may need to be considered, typically with a desire that it will match the existing beach.

Turbidity created during beach recharge or recycling operations is generally not considered to be a great problem with regard to effects on aesthetics or amenity usage.

Beach management schemes may also have impacts on commercial fishing interests. For example, the proposed borrow sites for the Mablethorpe to Skegness recharge scheme were regarded as likely to damage crab breeding grounds, and this forced alternative areas to be considered. It is possible for these issues to be “showstoppers” for recharge schemes. Conversely, restoring or widening an eroded beach may be helpful to inshore fishermen, such as at Hastings.

Health and safety issues

Delegates suggested a future BMM should address health and safety issues such as standardised signage on beaches.

The quality of imported sediments may also be a concern. For example, for the Mablethorpe to Skegness beach recharge scheme, there was a difficulty with contaminated sediments. Even though the existing beach sediments were slightly contaminated, the material used in the recharge was required to be of better quality.

Where beach management involves installing or maintaining structures such as groynes, breakwaters, reefs or revetments, public safety needs careful consideration. For example, rats often inhabit rock armouring where not entirely submerged by the sea from time to time, leading to concerns about public health. There have been reported incidents of accidents on rock armour; however, rock armouring has a high amenity value, especially for children.

Timber groynes also have associated safety issues and are often perceived to be present for amenity value rather than as beach control structures.

Sustainability

There was considerable discussion of the sustainability of beach management, with delegates feeling that this was interpreted in different ways at different locations. There is a problem in defining what is sustainable, since this does not necessarily correspond

with what is affordable or acceptable either environmentally or from an amenity viewpoint. An example was given of the Cley/Salthouse shingle barrier beach which is not reprofiled by bulldozers any more, as this is no longer considered a sustainable practice, although the decision not to continue caused considerable concerns about the effects on the environment. If the new manual could help to resolve the meaning of sustainable beach management, this would be valuable.

Uncertainty

A theme that received considerable attention in the context of sustainability was uncertainty, both initially at the design stage, and in future when present-day conditions might not longer prevail.

At the design stage, it was pointed out that the modelling of beach behaviour was not perfect. Modelling is unable to simulate everything correctly, such as beach response to storms. These difficulties are increased because it is often impossible or impractical to locate and deliver sediment that exactly matches that already present on the beach.

Public perception can also be a problem, since many people believe that sediment dredged offshore and placed on the beach will rapidly move offshore again. This can lead to difficulties for designers trying to overcome such preconceptions, even leading to hostility.

Looking to the future, a paper by Burgess and Townend (2004) was mentioned which suggested that hard sea defences such as vertical seawalls might be more sustainable than beach nourishment given increasing sea levels, due to suitable sediment resources running out. In a few decades time, such hard defences would still be capable of providing a satisfactory standard of protection against flooding, but would sufficient sediment still be available to provide the same level of defence? Ongoing recharge schemes might experience problems due to diminishing supplies and the fact that as sediment in nearshore areas was used up, resources would be more difficult and expensive to acquire and bring ashore. There might also be an increasing need to turn to sediment that was not as well matched as the existing beach material, which might also lead to recharge being required more frequently.

A similar concern arises because of the uncertainty of climate change following global warming. For example, changes in wave directions might increase longshore sediment transport rates to the extent that an alternative decision on how, or even whether, to manage a beach might be appropriate.

Despite these uncertainties, delegates felt that more emphasis on whole life costs was required for beach management. This type of analysis is often carried out, but more on an overall SMP basis than for specific schemes. However, developing a strategy for particular schemes on the basis of whole life costs is at the heart of performance-based asset management and will now be facilitated by the “block grant” arrangements being adopted for the funding of the Environment Agency’s role in coastal defence.

It was noted that local people often want the inclusion of revenue from tourism and amenity included in calculations of benefit/cost ratios, but this may not be practicable.

Question 6: *What are the problems in installing and maintaining a new or improved beach?*

Public safety and concerns

Initially, imported sediment may form near vertical “scarps” on the beach face, especially on shingle beaches. There may also be problems with areas of deposited soft sand or even finer-grained sediments, particularly where beach control structures such as breakwaters produce very sheltered conditions; these quicksand areas can be hazardous to people and vehicles alike.

The shape of imported sediments such as angular flints can be dangerous, although they provide a stable beach shape. When machinery breaks the shingle up, this can also result in sharp edges.

Dust can be problematic in dry weather where beach recharges have a high proportion of very fine-grained sediment, as can the noise of operations, especially as these often continue day and night. Typically the worst problems encountered are caused by moving equipment, such as vibrations from tracked vehicles, unloading of rock, and the beeping of reversing vehicles.

During beach operations public access needs to be controlled, to keep people at a safe distance from operations and maintain site security to reduce the risk of vandalism.

When trying to manage a long stretch of frontage, for example during a major recharge when pipelines extend along the frontage, it can be unpopular to close large sections of beach at once. This can also lead to problems with rights of way, if public footpaths need to be closed whilst work is carried out. Where beaches are privately owned, it may be difficult to gain permission/access to carry out works.

Unexploded ordnance is occasionally found in beach sediments/recharge material. Currently there is guidance for dredgers on how to deal with such ordnance when it is found on the dredger or at a wharf, but delegates felt nothing was available for beach managers and operators and it was suggested that this should be addressed in the manual. Such guidance was subsequently located in Cruickshank and Cork (2005).

There can be problems with the transport of plant/materials to beaches, particularly during holiday periods. It has sometimes been necessary for loads of large rocks to be covered with tarpaulins to hide them. The main public concerns are increased road congestion, the noise associated with large vehicles and potential risks to public safety that such traffic brings. There has been one well-publicised fatality at Llandudno caused by a lorry involved in a beach recharge scheme.

In conclusion, it was felt that public perception can be greatly influenced if the public are fully informed of planned works. Signage can make a positive difference and can make some works into an attraction. The more people see that they will directly benefit, the less likely they are to complain about any inconvenience caused.

Finance and construction issues

Problems can be encountered when scheduling and organising beach improvement schemes so as to work efficiently and make savings where possible.

Since such schemes are relatively unusual, and often require substantial quantities of construction materials and specialised equipment, there are always likely to be issues around scheduling. Where timber groynes are to be built, a considerable lead time is necessary to source suitable timber and even the large bolts needed; a cross-reference to the CIRIA Timber Manual was felt likely to be useful in this respect.

At certain times of year it can be relatively easy to obtain the large trucks, bulldozers and diggers needed for redistributing beach sediments, but this is not always the case.

There are often difficulties with fitting management schemes around various closed seasons, for example to avoid disruption to overwintering or breeding birds or to holidaymakers. Similarly, where materials are to be delivered by sea, there may be delays or damage to vessels during stormy periods, especially when unseasonably severe weather conditions occur (such as in late spring or early autumn).

All of these timing issues ideally need coordination with the availability of funding. Given enough financial flexibility, it is possible to make substantial savings, for example by taking advantage of the availability of materials such as beach recharge sediment from dredged channels, which may become available at short notice. Similar comments were made in respect of beach maintenance works, where delays and inflexibility in funding can lead to substantially greater costs or at worst, to greater risks of flooding or erosion before a beach can be restored to its desired condition.

Finally, it was felt that the new manual ought to provide more information on the practical problems associated with operating on beaches. Inexperienced contractors are likely to underestimate the problems of plant maintenance associated with enhanced 'wear and tear', especially on shingle beaches and by salt. Similarly, it is not uncommon to encounter problems with equipment being trapped by tides or in soft sand. The need to avoid pollution often means that machinery needs to use biodegradable oil when working on beaches.

It was suggested that new manual should include a section on 'plant operation on beaches' to provide advice and warning about these problems.

2.2.3 Implications for the revised version of the manual

The main points arising from the consultation and workshop can be summarised as follows:

- there was much praise and little criticism of the information in the 1996 version of the manual, although it was recognised that it needed updating in some areas, for example for changes in legislation;
- it was thought that it would be difficult to keep the manual up-to-date, even during the period when it was being published;
- the main feeling was that the manual lacked practical advice and guidance for those involved in routine beach monitoring and maintenance;
- it would be useful if the manual sought to disseminate 'best practice', and its title might be altered to reflect this goal;
- there is presently a lack of readily accessible information on the execution and performance of beach management schemes carried out in the UK, hampering the preparation of plans for similar schemes elsewhere. A larger number of case histories would be valuable to readers. One suggestion made was that a volume of the manual could be dedicated to a collection of case studies, reviewing their successes and failures;
- rather than focussing on major beach improvement schemes, it was felt that the manual should offer guidance on routine monitoring of the condition (or state) of beaches, assessing their performance and deciding whether and how to intervene most cost-effectively once some trigger level was reached. From an

economic viewpoint, this might lead to low-cost maintenance rather than substantial recharge schemes;

- providing checklists to guide readers through various stages of beach management was thought to be valuable, with cross-references to related issues at each stage, for example to required consents and licences, and guidance from other manuals dealing with specific issues (such as health and safety).

3 Review of existing manual

During the consultation stage of this project, the project team reviewed both the contents of the manual and to whom it had been sold. The latter revealed that the manual had not reached as wide a readership as initially believed. This, together with the consultation exercise, indicated that straightforward updating of the manual would be unlikely to significantly increase the readership, particularly among those involved in regular beach management. This resulted in a change of emphasis, with greater effort devoted to considering how best to alter and expand the manual to make it relevant to a wider range of organisations and individuals engaged in managing beaches.

The next section summarises the sales of the first edition of the manual, and is followed by a review of its contents, combining the views of the project board and the project team with those from the consultation exercise.

3.1 Assessment of use and sales of the 1996 edition

The initial distribution of the 1996 version of the manual was an estimated 275 copies to the CIRIA core membership, including organisations that funded it and/or were involved in writing, reviewing and publishing it. A significant number of copies would have reached local authorities and the Environment Agency (via its predecessor bodies) as part of the initial distribution to core members of CIRIA.

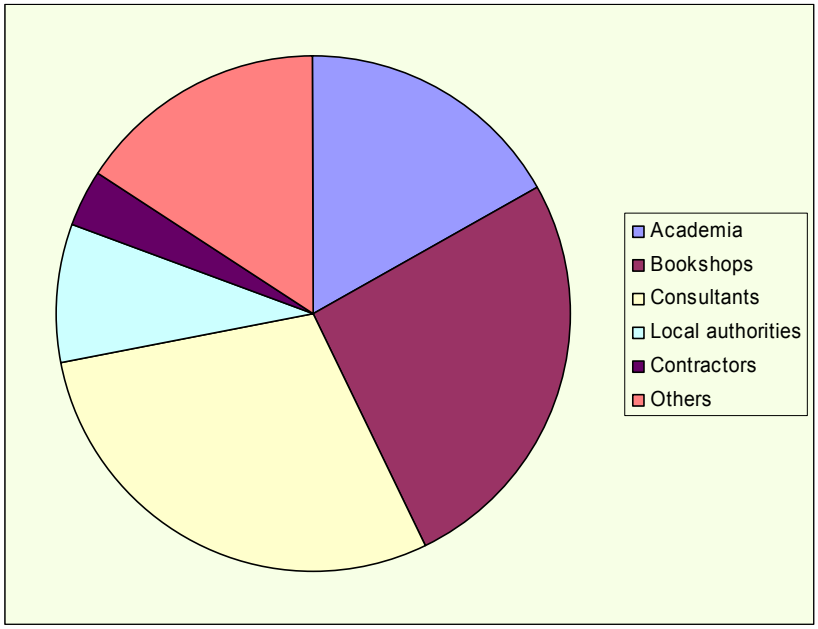

Figure 3.1: Distribution of 1996 version of the manual

Subsequently the manual was put on general sale, with some 110 copies sold prior to 1998, and 82 copies subsequently. In total, approximately 470 copies are in circulation. There is some information on the purchasers of copies sold after 1998, and this is summarised in Figure 3.1. This figure shows that about 30 per cent of copies went to consultants, about 20 per cent to universities and the like, but very few to local authorities (less than 10 per cent). A good proportion (more than 40 per cent) apparently went to overseas buyers, with some being purchased by organisations linked to governments (QUANGOs), so that while intended for use in the UK, its

contents were of interest to a wider audience. Because these were purchases some three years or more after the initial publication of the manual, however, this figure may not provide a typical breakdown of the manual's overall distribution, since those most in need of guidance in the UK are perhaps likely to have obtained a copy sooner.

Sales of the BMM can be compared to those of CIRIA's Rock Manual (CIRIA, 1991), where Table 3.1 shows the estimated circulation figures for the two publications. A large disparity is apparent, with the Rock Manual seemingly having sold approximately twice as many copies as the BMM. However, the Rock Manual is of greater interest to the global market, selling well in Europe, Asia and the Americas, whilst the BMM has traditionally been more centred on Britain. These figures serve to emphasise the need to ensure that the updated manual is better publicised and disseminated.

Table 3.1: Sales of the BMM and the rock manual

	Core project funders and book club	Sales pre-1998	Sales post-1998	Total
Beach Management Manual	275	99	110	484
The Rock Manual. The use of rock in hydraulic engineering	275	413	376	1,064

From this and discussions with various operating authorities and members of the project board, it was concluded that the 1996 version of the BMM was probably under-used in the context of routine beach management, although it was seen as valuable for designing major beach improvement schemes.

3.2 Comments on individual sections/ chapters

Whilst much of the consultation process concentrated on widening the scope of the 1996 manual, a number of more specific comments were received about its contents. These were added to the reviews carried out by the project team (and other staff) and the suggestions made by members of the project board. These are summarised below and presented in the order of contents, using the numbering of the original manual (reproduced in Appendix 1 for convenience).

3.2.1 Comments on Chapter 1 (Introduction)

This chapter presently reflects the original emphasis of the manual, which was the management of beaches for coastal defence. While this should remain the main thrust of the new edition, there may need to be more recognition of other reasons for beach management.

The chapter also sets out the 'road map' for the manual and this clearly needs to be revised, *a posteriori*, in line with the eventual layout of the new manual, reflecting any new chapters and perhaps the multi-volume and electronic publication style proposed.

It is recommended that the routine monitoring and maintenance of beaches be given greater consideration, and this introductory chapter will need to reflect this, perhaps more clearly identifying the various beach management stages that the manual is

seeking to help. It was suggested that the section on “Coastal defence and legislation” might be moved to an appendix, along with information on other legislation and required consents and licences, since this would allow a simpler updating of the manual as such legislation changed. This is one area where an online version of the report would have considerable advantages over a conventional book.

The format of the manual will determine how Chapter 1 is presented. The format is to be determined by the Project Steering Group. If the manual is to be produced as a single volume, then Chapter 1 will take its natural place at the beginning of the book. However, if it is felt that the appropriate style for publication is a multi-volume set, then Chapter 1 should sit as a stand-alone document, offering an overview of the subject of beach management with guidance on how to use the volumes, in a similar way as volume 0 of the PAGN series of guidance notes. This option would be the preferred option, as this preceding volume would draw out the issue of beach management being a whole-life process, highlighting the needs for design, construction, maintenance and decommissioning.

3.2.2 Comments on Chapter 2 (Beach attributes, morphology and processes)

This chapter considers the physical processes that have created and continue to modify beaches, particularly in the UK, and to a lesser extent the reasons and context for managing them.

It is the latter aspect of this chapter that may need expanding, to recognise and address the concerns of those interested in managing beaches for environmental reasons, whether that be the human environment (for amenity, archaeology, tourism, recreation, public safety, aesthetics and so on) or the natural environment (for their ecology or conservation or improvement).

In this vein, therefore, Section 2.2 (Beach attributes) and Section 2.7 (Implications for beach management) might need to form the basis of a more substantial section entitled (provisionally) “Beach management: Reasons and objectives”. This would go beyond simply mentioning the various environmental attributes of beaches as in the present manual, and discuss the importance, quantification and objectives of managing these.

For the natural environment, this suggested chapter could introduce the importance of national and international conservation designations (such as sites of special scientific interest or SSSIs) and the monitoring, reporting and management initiatives for these, including the Coastal Habitat Management Plans (CHaMPS) project. The publication, *A guide to managing coastal erosion in beach/dune systems*, published by Scottish Natural Heritage (see http://www.snh.org.uk/publications/on-line/heritagemanagement /erosion/sitemap.shtml) already provides a valuable background to this area. Such a section at an early stage in the new manual might also help set the scene for the environmental issues that are likely to be discussed in the different sections.

For the human environment, specifying the justification, objectives and methods of managing beaches might be less straightforward, but is still worth including given the considerable difficulties that may be encountered when proposing, for example, major beach improvement schemes in coastal resorts.

Finally this new chapter would allow a more thorough discussion of the main objective of the manual, to provide guidance on managing beaches for coastal defence, whether on a day-to-day basis or as part of a major scheme, to improve protection against flooding or erosion.

In terms of the physical processes acting on beaches, a few more changes and additions have been suggested, namely:

- inclusion of the interactions between beaches and the near-shore seabed (especially sediment transport) both now and in response to long-term sea level changes;
- updating of the section dealing with sediment transport processes, to reflect new research and methods;
- expansion of the section on climate change effects on beaches;
- inclusion of discussion on probabilistic methods used to analyse and predict coastal sediment transport processes and morphological changes, particularly in the context of risk assessments;
- expansion of the discussion on sediment supply by rivers, and its effects on beach morphology (presently very brief);
- review of the definition and importance of coastal cells presented in the 1996 manual.

3.2.3 Comments on Chapter 3 (Hydraulic conditions)

This chapter deals with tides and waves, and received very little comment from the practitioners consulted. In general, the main revision needed stems from advances in methods of predicting wave conditions, and to a lesser degree tidal propagation, and in measurements around the UK coastline since 1996, particularly the WaveNet project (see http://www.cefas.co.uk/wavenet/).

Individual comments on sections of this chapter are summarised below.

For Section 3.2 on tidal currents, the description of tides could be improved. Implications of beach and seabed morphology on currents should be more thoroughly addressed. For Section 3.3 on deep water wave conditions, a comment was made that the terminology used was confusing.

Section 3.5, entitled “Joint probability of water levels and wave conditions”, should be revised to cover new research and methods to predict such joint probabilities, such as the JOINSEA technique developed with Defra/ Environment Agency research funding.

Recent research, including the Stern report (2006) and the report produced by the IPCC (2007), has increased awareness and concern about the potential effects of climate change. Section 3.6 on climate variability thus needs to be expanded to cover such effects and offer guidance on predictions of future beach changes, involving sensitivity testing as recommended by Defra as part of a beach assessment and in the design of improvement schemes. A better description of effects of the North Atlantic Oscillation on wave conditions and tidal surges is also needed for this section.

Section 3.7 on hydraulic modelling is at present very short and tries to cover both numerical and physical modelling techniques. Computer modelling has not increased in use and the new manual should reflect this. It should also provide examples of typical modelling applications for beach management and design, and the reader should be directed to other sources for a more thorough description of such techniques, both later in the manual and elsewhere.

3.2.4 Comments on Chapter 4 (Data collection and monitoring)

Chapter 4 states that data collection and monitoring are aimed at understanding beach processes and changes, and helping in the design, assessment and performance of beach management schemes. The concept of assessing the performance of a beach as a coastal defence asset is notable by its lack of prominence in the manual. This aspect of beach management is now much more important and the new manual should reflect this. In brief, this might be summarised as monitoring to assess if beaches are reaching their desired targets, whether that be condition and performance targets appropriate for their role as flood defences, as natural habitats for plants and animals or as amenity and tourism resources.

Since 1996, the introduction of regional coastal monitoring schemes has greatly increased the amount of information gathered on beach changes and nearshore wave conditions, and the new version of the manual will need to reflect these schemes and their implications in terms of beach management.

In particular, it should be much easier in future to obtain good information on the outcomes of beach management schemes. A particular request was made during the consultation for more information before, during and after beach management schemes. Similarly, a view was expressed that accurate record-keeping and sharing of information would be of great importance.

A further change since 1996 has been the wider use of remote sensing methods to gather information on coastal processes and changes, and the new manual will need to consider this technology alongside more conventional methods of surveying. This technology includes fixed camera and CCTV systems, which can provide frequent information on beach changes and can be used in real-time for flood warning systems.

Daily or even more frequent records of beach level changes should allow us to follow, and hopefully one day to predict, short-term beach evolution. This is important in terms of probabilistic modelling of coastal defences. Archiving and sharing information on beach morphology changes is also regarded as important.

Comments were received about the need to provide advice on the frequency of beach monitoring and evaluation of schemes, reviewing their costs and value in terms of improving beach management and coastal defence standards.

One remaining comment related to Section 4.4 on nearshore seabed character, namely that understanding the possible offshore transfer of sediment from beaches to the seabed, or vice versa, is important to beach management.

3.2.5 Comments on Chapter 5 (Putting beach management principles into practice)

It is perhaps primarily this chapter that has failed to meet the needs of those involved in more routine management and maintenance of beaches, although it contains some information and guidance on such activities.

This chapter can, fairly, be criticised for its emphasis on the future of beaches rather than on their present condition and needs, with roughly two-thirds of the text devoted to predicting how beaches will change and what an improvement scheme should deliver.

For coastal defence structures such as seawalls and embankments, there is a need to continually review both their structural condition and associated risk of collapse and their geometry − crest levels, slopes and toe levels − which affects the hydraulic performance of the defence, especially overtopping. The former entails a requirement

to monitor the condition grade, in order to assess the risk of breaching, with this information used to assess the fragility of the defence. The geometry of the structure is measured by topographic surveys.

For beaches, the situation is rather different. Monitoring beach levels and the amount of sediment (the geometry of the beach) also provides information on its condition. If the performance of a beach of given geometry can be properly understood, in terms of its response to forcing conditions such as large waves and a high tidal level, this then makes it possible to assess subsequent deterioration in its performance as a result of changes in its condition. This assessment also needs to consider possible changes in the forcing conditions, such as a sea level rise and changes in the magnitude and direction of storms. Assessments of beach condition will need to improve in order to provide equivalent probabilistic information on their fragility as presently given for built coastal defence structures.

Comments were received on a number of aspects that should be included in a new version of the manual, such as:

- beach monitoring (physical and environmental);
- beach condition assessment (that is, whether it is reaching required standards or targets);
- routine maintenance including repairs (such as to groynes);
- health and safety inspections (arguably itself a condition assessment);
- cleaning and litter collection (including contingency plans for pollution incidents);
- public access, amenity and usage assessments;
- performance and risk assessments (for example, how the beach will perform as a flood defence under severe events).

In addition, it was suggested that the last two items should link to real-time flood warning and response activities. The assessment of the condition and performance of beaches, in common with that of other types of coastal defences, has been the subject of recent research projects (see Section 2.1 of this report), in particular the Defra/Environment Agency research studies *Performance and reliability of flood and coastal defences* (Defra/Environment Agency, 2005a and b) and *Performance-based asset management systems* (Defra/Environment Agency, 2004).

It was also suggested that the text on environmental requirements, presently covered in Section 5.4 as part of the design of an improvement scheme, should be updated.

Reflecting comments made on Chapter 3 (see Section 3.2.3 above), the need to consider the consequences of climate change on the future behaviour of the beach (presently Section 5.3 of the manual) was noted.

In conclusion, the redrafting and expansion of this chapter is perhaps the single most important improvement to the manual that could increase its usefulness and usage.

3.2.6 Comments on Chapter 6 (Elements of appraisal and design)

This chapter outlined the basic elements of the design and appraisal process common to all schemes. Comments received on individual sections in this chapter are summarised below.

The general approach presented in Section 6.1 would in the revised manual need to include other methods, such as designing for a greater standard of protection against climate change and whole life costing.

It should also emphasise the need to understand fully the processes at work in the area, and perhaps give weight to delaying decisions whilst field data is collected to calibrate and validate models upon which decisions are made.

In Section 6.2 on establishing design constraints and opportunities, the six key aspects of 'source of recharge material' in Section 6.2.4 should be extended to include 'assessing the cost of using recharge material outside of what is suitable for the site' (that is, higher maintenance costs) (see also Sections 7.1 and 7.2.3). Section 6.2.3 should include a section on 'amenity benefits' (also see Section 6.5.1).

The alternative options explored in Section 6.3 should include softer engineering options such as saltmarsh (re)creation.

Section 6.4, "Prediction of effectiveness and effects of beach management schemes", needs to examine recent schemes, older schemes that have worked and subsequently been forgotten and also beaches not managed by intervention but actively monitored. Table 6.2 should be updated to reflect current modelling techniques.

Section 6.5 on economic appraisal needs updating for current Defra project appraisal guidance and decision-making processes and should to be able to be further updated as necessary.

Section 6.6 needs a substantial rewrite and probably warrants a separate section due to the significance of environmental assessments in the whole scheme process. Examples of working within environmental legislation would be useful; however, due to changing legislation this may be difficult. It would be useful to demonstrate when works can be carried out to maintain the integrity of designated sites.

3.2.7 Comments on Chapter 7 (Beach recharge)

Chapter 7 describes beach recharge techniques and related issues in depth. However, it is evident that this section is now very out-of-date and requires a thorough update.

Individual section comments are summarised below.

For Section 7.1 on sourcing recharge material, the availability of sediment, principally from offshore sources, versus demand needs to be established in advance of the rewrite. A particular concern in recent years has been the sourcing of coarse gravel (larger than 30 mm) for use in recharging shingle beaches. Consideration of quarried rock that will be subject to abrasion and loss of weight under marine action would also be useful.

Section 7.2 on the selection of material size, grading and mineralogy needs to consider equations other than Kamphuis's for longshore drift. Planning considerations relating to the colour and grading of recharge sediment need to be included.

Worked examples would be helpful in Section 7.3 on “Determination of recharge volume”

Section 7.4 on the specification and testing of material requires a better understanding of the performance of graded and ungraded material. An understanding of the use of out-of-grade material and the cost implications would also be useful.

Section 7.5 , “Obtaining recharge material - UK procedures”, needs a clear description of the use of recycled/waste/secondary aggregates and materials.

This section needs updating for current licensing arrangements (Marine Consents and Environment Unit). However, legislation may change in the future and mechanisms for updating this section without wholesale changes to the whole manual should be considered.

For Section 7.6 on “Transportation to site and placing”, an update of delivery, dredging and recharging techniques is required in the light of developments in the last ten years.

It would be useful if guidance in Section 7.7 on measurement and cost could be updated to provide a definitive means of measuring beach volumes in particular. This would alleviate many contractual difficulties.

For Section 7.9 on environmental considerations, any discussion of the environmental effects of beach recharge needs to incorporate the wider aims of preserving and enhancing the environmental attributes of beaches, and as mentioned previously, this would merit a specific section in the revised manual. For beach recharge schemes, guidance will be needed on their effects on and around the source of imported sediments, on the beach itself and in its vicinity, that is, in nearshore waters and along adjacent sections of coastline. Consideration should be given to the human environment, such as landscape, recreation and amenity use as well as on the natural environment. Where possible, including relevant case histories would be valuable.

3.2.8 Comments on Chapter 8 (Beach control structures)

This chapter provides details on the design of the plan shape and profile of control structures. In general, it was felt that this section should include new and updated case studies to reflect recent experiences of beach control structures.

Individual section comments are summarised as follows.

Section 8.1 on initial considerations should incorporate an understanding of the combined effects of control structures, recycling and maintenance recharge, including terminal structures and their effects.

Section 8.2 on groynes should include examples of different types of groynes and their performance. The benefits of rock versus timber groynes should be discussed. Groyne decommissioning should be considered along with the re-use of materials. The implications on tidal currents around control structures and their impacts on amenity and public safety should also be discussed.

For Section 8.3 on detached breakwaters, there is considerable interest in multi-purpose reefs, that is, low-crested detached breakwaters that modify wave conditions and hence beach plan shapes, and provide other benefits such as breaking waves for surfing or habitats for marine plants and animals. A project is currently being carried out by CIRIA on the possible use of these in the UK. A number of papers have been written on the effects of detached breakwaters on beaches (see Section 2.1), for example at Sea Palling, Norfolk and Elmer, West Sussex. There may be an

opportunity to include any new design guidance emanating from LEACOAST2 project that is presently underway.

Section 8.4 on shore-connected breakwaters needs updating. Specifically, this section should further examine the accumulation of sediment in their lee over time, to establish an equilibrium state and avoid unwanted deposition of fine-grained sediments such silt and mud.

Section 8.5 on modified seawalls and revetments needs to be expanded to cover the impact of structures on the lower inter-tidal beach and on the foreshore platform on which the beach sediment lies. Beach lowering in front of coastal structures, its potential effects on beach amenity and public safety, and methods for mitigating these are topical issues that should be included, with reference to research such as the project FD1927, *Understanding the lowering of beaches in front of coastal defence structures* (see Section 2.1.4), and any subsequent guidance issued.

Examination of procurement frameworks and multi-functional assets could be incorporated into Section 8.7 on cost optimisation, while Section 8.8 needs to be expanded in light of recent emphasis placed on environmental considerations.

The revised manual should incorporate recent advances in beach drainage technology in Section 8.9 on construction, and there should be further discussion and guidance on health and safety procedures.

3.2.9 Comments on Chapter 9 (Further management methods)

The only substantial comment received on this chapter recommended expansion of Section 9.1 on dune management. The need to consider the potential effects of climate change and the potential conflicts and synergies between managing the environment and beaches was suggested. More specifically, the new manual should cover:

- monitoring of dunes (levels, volumes, vegetative cover and so on);
- use of natural processes to improve dunes;
- aeolian sand transport prediction methods;
- use of dunes as coastal defences (condition and performance assessments);
- possible conflicts with biological aims;
- methods for re-creating dunes.

It was also noted that this chapter mentions sediment bypassing in Section 9.5, which is rare in the UK, but not the recycling of sediment which is much more common. This topic is considered later (in Chapter 11 of the manual), but is presented as a “post beach improvement scheme” activity rather than one often carried out as routine maintenance.

3.2.10 Comments on Chapter 10 (Project implementation)

This chapter describes the practicalities of scheme implementation. In general, it was deemed useful to include flow charts of pathways through the legislation in the revised manual. The need for beach management plans should be emphasised along with ongoing monitoring and annual performance reports. Links back to data collation and management would be useful here.

There were no comments relating to specific sections of this chapter other than Section 10.6 on post-project monitoring, which should be updated to reflect new approaches. Evidence-based policy-making should be used in association with monitoring.

3.2.11 Comments on Chapter 11 (Ongoing management and beach recharge)

This chapter discusses ongoing management and beach maintenance, including recycling and reprofiling. The importance of monitoring should be reiterated, along with the need to record all management activities on a beach (such as recycling logs).

As with Chapter 10, there were no specific comments relating to sections other than Section 11.6 on managing the beach environment. Public beach safety and risk assessment before, during and after works needs detailed consideration here, including aspects such as cliffing. All-encompassing integrated coastal zone management (ICZM) could be incorporated within the guidance here.

3.3 Recommended new chapters/sections

Following the consultation and discussions between project team members, it became evident that a number of new sections would be worth including in the manual. These topics could either be included as extensions to existing chapters, where current information was found wanting or outdated, or become new stand-alone chapters to be determined by the project steering group. These sections should cover the following topics.

3.3.1 Legislation and consents

England is currently reviewing legislation and consent on coastal activities as part of the Marine Bill. Legislation is also changing within the EU following the introduction of a number of directives. The manual is in a good position to offer a reasoned interpretation of existing legislation in the context of beach management, and provide guidance on likely future requirements. As legislation will continue to change, it is suggested that the new chapter or appendix covering this area is created in such a way that it can be updated and reissued as appropriate.

The contents of this new section would include both UK and EU requirements for managing coastlines including the Water Framework Directive, the Habitats Directive, and the Marine Bill. In addition, it would be useful to include information on high level Defra and Environment Agency policies such as *Making Space for Water*.

Guidance on the licensing of offshore dredging areas, presented in Appendix A of the existing manual, should be updated in line with the new statutory process for assessing applications for aggregate extraction and the increasing need for such offshore dredging areas to provide for long-term beach recharge schemes.

3.3.2 Environmental considerations and sustainability

With reference to climate change and its impacts, guidance should be included on the management of environmental issues. Natural England, an organisation which is consulted on many beach management schemes, some of which it deems

inappropriate, believes that the manual could offer guidance to designers and managers on the conditions it would support. Natural England accepts that its knowledge of beach management schemes could be improved, believing the manual should offer guidance on the decision-making process behind proposed schemes.

There will also be a need to identify information for environmental impact assessments (EIAs) and other environmental aspects such as sediment sources, environmental designations, beach management consequences and impacts on conservation. Already, the requirement to protect beaches in designated conservation areas can be a significant factor in their routine management, particularly for shingle barrier beaches where both geomorphological and biological interests can be particularly strong.

Advice should be given on the consequences of contaminated beach/sediment testing and remediation throughout the construction process. With this process potentially contaminating the beach environment, good practice should be recommended including methods for treating for oil and other pollutants.

Sustainability is likely to become increasingly important, in common with all other coastal defence planning. Adopting a 'no regrets' attitude when deciding between alternative schemes is one practical way of making beach management more sustainable, but other issues need to be considered including the choice of materials used, delivery methods and the balance between infrequent major interventions and regular small-scale alternatives. This topic should be considered in the revised manual.

3.3.3 Beach safety and amenity

It is important to recognise that while a beach may have been designed and managed to a standard of defence that will save lives by reducing the risks of flooding or erosion, its primary importance to the local community may well be that of providing an economically valuable amenity. Thus, the manual should consider how engineering and amenity requirements can successfully interact. Often the best time for construction work is when the weather and tidal conditions are favourable, and this will frequently coincide with high demand for the beach as an amenity asset (from May through to September). Working outside this holiday period incurs a greater risk of delays due to bad weather, and hence greater costs.

Thus it is important, during the design of an improvement scheme or the planning of maintenance operations, that the desires and needs of local residents and recreational users are considered. Details on construction practices should be included in the manual, including health and safety aspects of working on a beach which may still be open to the public, for example managing the movement of plant through a populated beach area, or safe closure of the site at the end of the working day. Case studies could be included with details of accidents that occurred or were narrowly avoided, and advice on how to avoid them in the future.

3.3.4 Financial planning

There is scope within the manual to advise on how to obtain funding for a beach management scheme. Whilst such guidance exists in the original manual, funding mechanisms have changed and therefore the guidance needs to be updated, possibly with case histories. The issue of matching technological requirements with 'due process' for obtaining finance, securing supplies and implementing works should be included. It is not only the cost of the capital and routine maintenance works that should be covered, but all other related costs such as those associated with monitoring and analysis of the condition and performance of beaches, the effort involved in

organising maintenance operations, or issuing and acting on flood warnings. These costs can be easily neglected but can become substantial, especially where a beach forms a major part of the coastal flood defences for low-lying areas.

To assess the sustainability of a beach, consideration needs to be given to whole life costing, arriving at 'optimal option choices' and intra- and inter-generational options and costs. Guidance should include the provision of funding for major works that have an undefined trigger point. For example, a beach recharge scheme may be designed to allow for supplementary recharge in year twelve; however, during an extreme storm in year ten, the requirement could be brought forward, placing an unexpected financial burden on the beach manager. Recognising that a beach has several uses, such as for flood and erosion protection as well as tourism, the manual should offer guidance on seeking alternative funding for projected work. The manual should recognise that beaches are often an important 'economic engine' for some communities, who will be very sensitive to the management of the beach not only as a coastal defence but also as an amenity and economic asset. Issues such as the timing of works and quality of the beach sediment will become much more important at such locations.

3.3.5 Guidance on routine management

Those involved in routine maintenance of beach profiles or coastal structures often face considerable practical difficulties. The manual should emphasise the importance of regular beach monitoring to provide information on the condition or state of the beach as a coastal defence, and advise on appropriate programmes and timescales for such monitoring.

Condition standards for beach levels, widths and so on may be specified as part of individual asset management plans, so that the likely performance of that beach in severe conditions can be assessed. Currently, there is little guidance on this issue.

Such guidance could usefully include checklists, decision trees and procedures for carrying out monitoring and maintenance. These could be inserted as appendices, to be reproduced and used in the field. If appropriately designed, they could be used by inexperienced operatives for data recording, and provide enough information for beach managers to undertake a detailed data analysis. The manual should also explain and give examples of trigger levels for action along with suitable responses, whilst still recognising the individual circumstances pertaining to every beach and therefore the need to manage each beach individually. The PAMS research project has made a start by producing flow charts indicating how the condition grade of a beach should be determined, based on visually assessed 'performance features' (Defra/Environment Agency, 2004). This approach forms part of the Environment Agency's *Condition Management Manual*.

When new management schemes are designed, there is often a lack of integration between the designers and operators. By working together at all phases of the project, and discussing the practicalities of beach maintenance during the initial planning phase, it would be possible to optimise the details, targets and requirements for subsequent monitoring and management.

Finally, evaluation of the beach as a coastal defence asset will alter over time, particularly in the light of climate change, so the manual should include guidance on reviewing beach management plans.

Section 6.1 of this report outlines a framework for the regular assessment of the condition and performance of coastal defences, including beaches. The framework also shows the next stage of making decisions about possible interventions.

3.3.6 Real-time monitoring and beach imagery software

There has been a significant growth in recent years of real-time monitoring of beaches, for example using CCTV and fixed cameras (Argus and Cam-Era systems), that is not mentioned in the manual. Accompanying these advances is a corresponding increase in software which allows 3-D mapping of the beach surface. Together, these new capabilities can be used to continuously assess and report on the state or condition of a beach, which may be crucial in situations where there is risk of flooding of hinterland.

Similar real-time monitoring has been carried out, for example, of groundwater levels within Chesil Beach at Chiswell. This may well be extended to other sites and techniques in the future, principally to assist in flood warnings but also to provide useful information on beach responses for designers as well as operational staff.

As this technology continues to develop, the new version of the manual should review the state of play at the time of production, and provide further information and examples (perhaps case histories) of the use of such methods.

3.3.7 Recording of storm events

Real-time monitoring is useful not only to follow the development of a storm event, but also as an aid to flood warnings and associated short-term and emergency responses.

In addition to predictive modelling, recording the dates and times of events that caused flooding, erosion or substantial changes in beach morphology would provide valuable information both for assessing the performance of an existing beach and to evaluate its likely performance in future and potentially more severe events. Although this would be a simple diary-keeping exercise, no centrally supported attempt has been made to initiate such a system, thus missing opportunities to assess coastal defences and design improvements. This is a vital element for improved communication between designers and operators of beach management schemes.

It is suggested that the new manual should provide guidance on the monitoring of beaches and their performance during severe events, and on recording the actions taken before, during and after them to reduce their impacts on people and property.

3.3.8 Incident management

The revised manual could provide more information on incident management, and contingency planning, such as planning how to react and recover from unexpected events such as oil spills and wreckage, including staff training and deployment, handling public relations and so on. This issue has become more prominent following the wreck of the container ship MSC Napoli at Seaton, Devon in early 2007 and the difficulties in clean-up because of a lack of guidance. Eventually the beach had to be closed, and there was considerable difficulty organising a clean-up operation. Similarly polluting events are likely to occur in future, requiring action from Environment Agency (and local authority staff. Guidance on this subject could be included, along with links to further published information on incident and emergency planning.

3.3.9 Beach/seawall or esplanade interactions

Maintaining adequate beach levels against the toe of structures such as seawalls can be crucially important, to prevent undermining and collapse of the structure and to limit

the frequency and intensity of wave overtopping and impact forces. The process of scour immediately in front of the structure, often occurring rapidly during severe events, is well recognised as a major hazard to coastal defences.

The existing manual draws attention to this problem (in Section 8.5) but in a rather academic manner, assuming that it can be mitigated by appropriate design of a seawall. It offers no other general advice on mitigation in front of existing structures, for example by monitoring the beaches and structure to give early warnings, or taking localised and modest measures to reduce the risk and extent of scour or solve associated problems when they have arisen.

A link will therefore need to be forged between the revised manual and the Defra/Environment Agency research project (FD1927, 2006) on beach lowering in front of coastal structures, which has already investigated this issue and reviewed mitigation measures used in the UK. This research may also lead on to a short-term project to provide a guide on scour mitigation methods, which would be a useful starting point for advice on managing beach/seawall or esplanade interactions.

3.3.10 Decommissioning beach management schemes

There is currently little information for beach managers on decommissioning a scheme at the end of its useful life. This extra guidance could cover:

- the implications of removing structures such as groynes and breakwaters, such as what happens to longshore drift, erosion rates and the resulting impacts on the environment;
- what to do with old structures such as groynes − cut-off, cap or excavate;
- re-use of materials, for example the feasibility of removing and re-using rock structures;
- contamination issues and other related topics.

These considerations would ideally have been taken into account at the design stage of a scheme, not least because this aspect is expensive and unlikely to yield any defence benefits, and hence is unlikely to warrant grant aid. This section should be emphasised early on in the manual during discussion of scheme design.

4 Beach recharge inventory

4.1 Introduction

One of the aims of this project was to compile a catalogue of major UK beach management schemes (those involving recharge and/or recycling), and to extract useful information for the updated manual (see Section 1.2). Such schemes, carried out to improve the standards of protection provided by beaches, have formed a significant proportion of UK expenditure on coastal defences over the last 10 years; providing advice on these was one of the main purposes of the original manual.

This section summarises work undertaken to compile a list of beach recharge and recycling schemes in England and Wales over the past 30 to 40 years. The result is a Beach Recharge Inventory, referred to as BRI throughout this section. Producing a list of such schemes, and establishing even the basic details of them, was far from straightforward. Changes in central and local government and in organisations dealing with flood defence (regional water authorities, the National Rivers Authority and the Environment Agency) have led to a lack of continuity in records of such schemes.

For the most part, the catalogue of schemes was compiled from the previous manual and its companion report (CIRIA, 1996b), using the knowledge of the project team, the literature review and information from the Crown Estate. Figure 4.1 summarises tonnages of sediment used in UK beach recharge schemes, where these have been supplied from offshore aggregate dredging areas. This reveals that over the period 1995-2005, the average amount of sand and shingle dredged for beach recharge each year was almost 2.5 million tonnes, of which about 70 per cent was sand and about 30 per cent shingle. This figure also reveals the considerable variability in the amount of recharge carried out each year, ranging from over six million tonnes in 1996 to less than 0.25 million tonnes in 2001.

This analysis, however, only gives an indication of the scale of major beach recharge schemes, which are usually supported by grants from central government. A few of the major beach recycling schemes have also been reasonably well documented.

It is much more difficult to find details of smaller beach management schemes, although these may be particularly effective and economical. Such schemes might involve monitoring and minor works such as dune stabilisation, maintenance and repair of beach control structures such as groynes and minor beach reshaping, where small-scale redistribution of sand or shingle produces a desired beach profile or plan shape. Some of theses schemes are carried out under revenue budgets, without grant aid, or may be undertaken by private organisations or individuals rather then pubic bodies.

Further examples of such schemes would be useful for providing guidance in the new version of the manual.

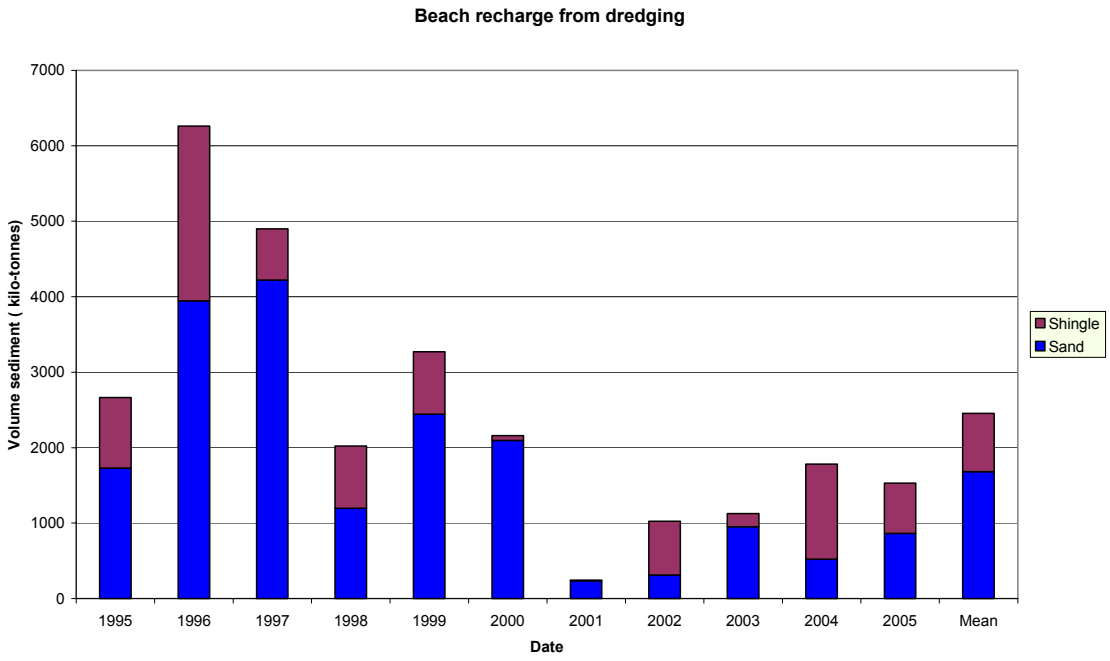

Figure 4.1: Annual tonnages of dredged aggregate for beach recharge

4.2 Initial research

The first steps in developing the BRI were to (a) define a list of parameters for which information about each scheme would be required, and (b) to identify schemes around England and Wales about which to collect this information. The list of parameters about which information is required for each scheme is shown in Table 4.1 below.

The initial list of beach recharge and recycling schemes was developed by Halcrow and HR Wallingford, drawing upon knowledge from within both companies, as well as other sources such as the current CIRIA *Beach Management Manual* (1996a) and published papers.

The initial list of sites included 126 schemes about which further information was required (although some schemes were for the same location but with different event dates). Figure 4.2 shows the location of schemes initially identified.

Table 4.1: Information required for the BRI

ITEM	DESCRIPTION
Location	Reflects scheme location/name.
X	X co-ordinate of scheme National Grid (OSGB)
Y	Y co-ordinate of scheme National Grid (OSGB).
Date(s)	Start/end dates (years) of scheme.
(Approximate) Length of coast (km)	Extent of scheme.
Frequency	One-off event, occasional or annual works, and so on.
Volume (m^3)	Volume of recharge placed.
Maintenance/recycling (m^3 pa)	Volume of material recycled or maintenance recharge placed per year.
Sediment type	Sand/shingle.
Sediment grading	Range of sediment size placed.
Sediment source	Land or offshore (licensed area?).
Delivery type (sea/land)	Method of delivery to site.
Presence/use of control structures	Details of any shore control structures involved.
Cost	Cost of recharge (if possible); total scheme cost as well.
Operation (recycling/recharge/reprofiling/trickle charge)	Nature of works as described.
Monitoring practices	Is monitoring undertaken? If so, how often and how is it recorded?
Beach management plan	Is there one for this location?
Practical dune management	Is dune management involved?
Land type (flood defence/resort)	Type of land use the scheme protects, such as urban (number of properties), rural and so on.
Environmental/amenity aspects	Such as SSSI, tourist beach, and so on.
Problems/successes	Any key learning aspects (positive and negative).
Client (EA/LA/private/other)	Main client.
Reference(s)	Sources of information.
Additional notes/comments	Anything else you feel should be noted not covered in the other fields.
Contact info	Contact details for further follow-up.

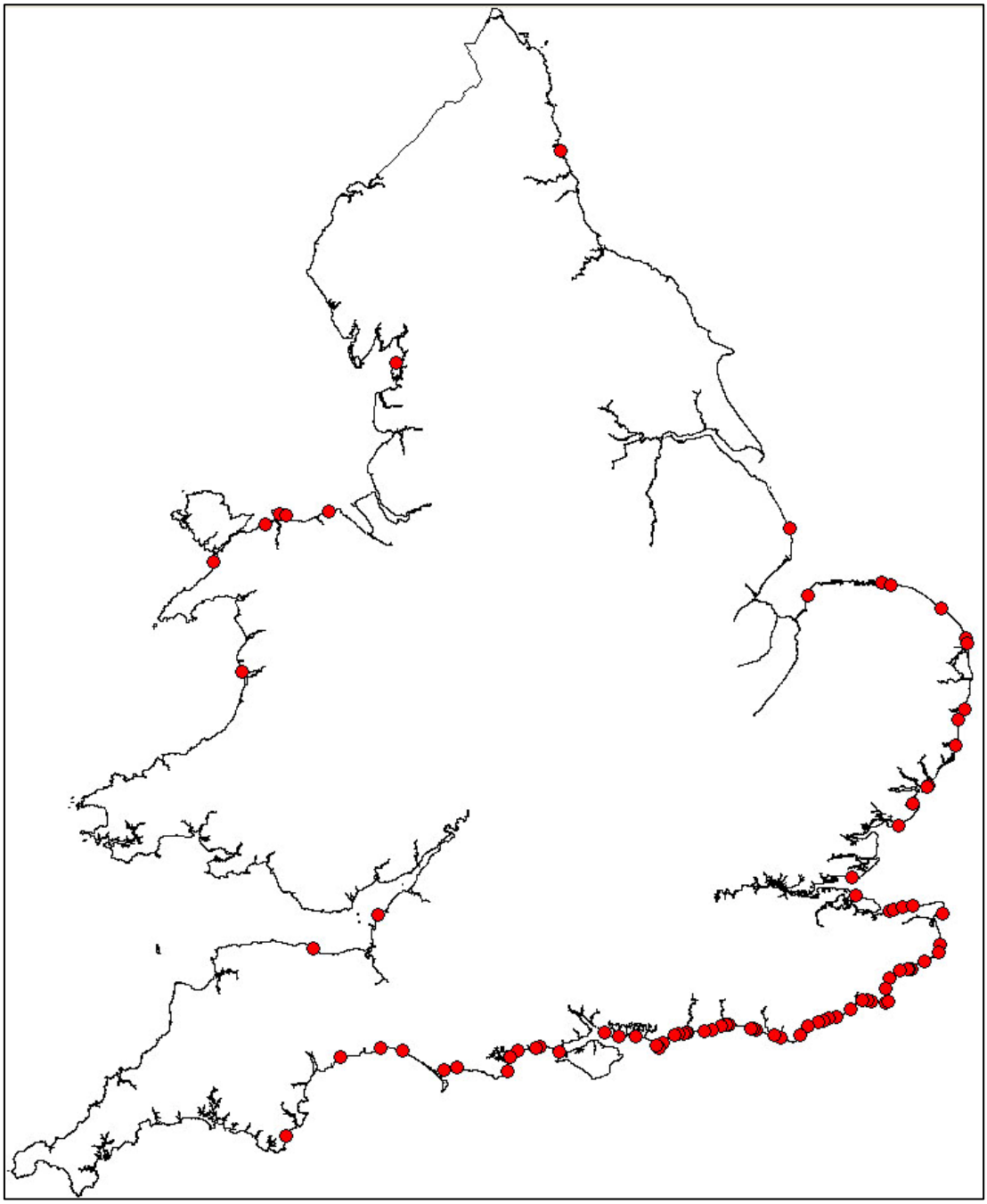

Figure 4.2: Location of beach recharge schemes identified as part of the initial research (plot produced on 1 February 2007)

Using the initial list of schemes and parameters, the first phase of populating the BRI was undertaken by HR Wallingford and Halcrow by the following means:

- review of reports prepared by both HR Wallingford and Halcrow for schemes with which each has been involved;
- review of third party reports (such as CIRIA and published papers);
- Internet searches (Google).

As a result of this process, six of the initial schemes identified were found not to have been schemes at all, and so the list was reduced to 120.

4.3 Consultation

The outcome of the first phase of populating the BRI showed that some of the information required was not readily available, and so it was decided to carry out a consultation exercise. This consultation was coordinated by Halcrow and involved writing to a number of people within the Environment Agency and local authorities to request as much of the required information as possible. Halcrow personnel involved in some of the schemes were also contacted at this time.

A response date of 9 March 2007 was set for the information to be provided. To date, feedback has only been received for 40 per cent of schemes. However, contact has been made by a number of other consultees and as a result, feedback is anticipated with regards to a further 24 per cent of schemes. No contact has been made with Halcrow regarding the remaining schemes and so it is not known if any information will be forthcoming from these at this time.

The feedback received to date has been variable in its quality and quantity. Some responses have provided only approximate or incomplete information. Others have provided much more detail, and one or two have even supplied grading curves, beach management plans and detailed volume/cost breakdowns. The full BRI is available as an EXCEL spreadsheet.

Some of the responses received have identified additional schemes not included in the BRI, which has resulted in an increase in the number of schemes to 145.

The process of collating information for the BRI is ongoing, and is anticipated to contain information on about 60 per cent of identified schemes in the near future.

It is not known if details will be forthcoming about the remaining 36 per cent of schemes that information has been sought for, though contact will be made with the relevant people about these, in due course, to prompt them for responses.

4.4 Case studies

A further objective of this project was to provide, for a selection of five to ten such schemes, a review of their outcomes including any problems encountered, lessons learnt and views on overall success, such as their performance, value for money and environmental effects (see Section 1.2). To ensure consistency in the presentation of these case histories, a template for their description was devised as follows:

- site name, location, owner (such as the local authority), designer, cost and beach type;
- background to scheme (why was it needed?);
- constraints on scheme design/execution (such as site designations, public concerns);
- description of capital works (such as volumes, structures built and so on) and start/finish dates;
- problems encountered during capital works;
- description of any supplementary works (such as new/adjusted groynes, reprofiling of beach);
- description of monitoring programme (surveys, analysis, outputs);

- routine maintenance operations (such as annual recycling, reprofiling);
- photographs of before/after scheme if available;
- lessons learnt (such as problems encountered/overcome);
- views on overall success of scheme (from owner initially);
- references/reports available on scheme.

A number of case studies were then chosen from the full catalogue, concentrating on those for which there was readily available information and a reasonable number of years had elapsed since the initial works were carried out, so that the long-term performance and maintenance requirements would be apparent. For the most part, these schemes comprised an initial beach recharge (of sand or shingle) followed by some degree of routine maintenance. The initial compilation of case studies was carried out by the project team; draft versions were then sent to scheme owners for comment. At the time of writing this final report, seven such case histories had been completed and are presented in the appendix to this report for the following locations:

- Dungeness (shingle recycling);
- Eastoke, Hayling Island (shingle recharge, groynes and recycling);
- Herne Bay (shingle recharge and breakwaters);
- Hurst Spit, Hampshire (shingle recharge, groyne and recycling);
- Mablethorpe-Skegness (sand recharge);
- Sand Bay (sand recharge);
- Whitstable (shingle recharge and groynes).

Time constraints prevented the completion of further case histories, although a further good sites were identified for which this would be both possible and useful, including:

- Bournemouth (sand recharge, groyne improvements and top-up operations);
- Heacham-Snettisham, Norfolk (shingle recharge, recycling and top-ups);
- Pevensey Bay (shingle beach recharge, top-ups, recycling and groyne improvement);
- Preston Parade, Weymouth Bay (shingle recharge, single groyne, seawall and recycling);
- Seaford, Sussex (shingle recharge, terminal groyne(s) and recycling).

Each case study can provide valuable practical experience in terms of understanding the physical processes involved in beach evolution, assessing impacts on the natural and human environments, identifying and overcoming problems and/or providing information on the whole life costs and performance of beaches as coastal defence assets. It is recommended that the electronic version of the new manual host these case histories online. The host site used for accessing the manual could act as a portal for such case histories, and these could be updated over time to form a valuable source of information for academics, designers and operational staff alike.

5 Justification for revised version of the manual

5.1 Overview

Justification for updating the *Beach Management Manual* is primarily based on information obtained in the consultation and scoping exercises conducted by HR Wallingford, Halcrow and CIRIA under contract from the Environment Agency, although the knowledge of the project team and project board also contributed significantly.

5.2 Benefits to be achieved from rewrite

The main benefit of an updated publication would be improved advice and guidance for beach managers and their consulting engineers and contractors, which should result in improved beaches that provide appropriate standards of coastal defence in a cost-efficient and environmentally acceptable manner.

Assessing the economic benefits of improving guidance is always problematical, but the costs of beach recharge schemes alone in the UK are about £10 million per annum. If use of the manual helped save one per cent of this cost, this would mean that, in five years time, the savings promoted by the manual would be twice its production cost. In reality, the cost of major recharge schemes is probably only a modest proportion of the expenditure on beach management around the UK. As well as the expenditure on routine monitoring and maintenance, such as regular surveys of beach cross-sections and repairs on groynes, there are significant costs in staff time spent analysing information on beach condition and performance, in issuing flood warnings and in attending and clearing up after severe events. This would, if evaluated, lead to an even greater benefit-cost ratio for the proposed revision of the manual.

The previous manual is highly regarded by those practitioners (primarily designers) who have used it, although it is also fair to say that its use has not been as widespread as would have been desired. This is particularly true for operational staff, maintenance managers and the like who have not found the manual of help in their work.

With this fact in mind, much of the project workshop was dedicated to understanding why delegates believed this was the case and what could change in an updated version to promote awareness and uptake of the new manual.

In particular, there was a perceived need to rearrange and expand the new manual to provide more practical guidance on routine beach management, rather than focussing on major beach improvement schemes, which was the emphasis of the 1996 version.

The inclusion of advice on compliance with the WFD and initiatives such as PAMS and the preparation of the second round of Shoreline Management Plans would benefit beach managers attempting to fit their objectives into a broader framework.

In addition to increasing the appeal and usefulness of the manual to those engaged in routine management of beaches for coastal defences, it was thought that extra sections on management for amenity and tourism purposes would increase the appeal for planning officers and developers. Guidance for those communities where a beach is a major contributor to the local economy, thus requiring particularly sensitive

management, could also be included. The extent to which this would be possible depends on support from interested organisations, particularly in providing case histories and advice on problems encountered and overcome.

A detailed list of areas worthy of inclusion in the manual is given in Section 3.3. However, this should not detract from the need to improve guidance on the design of major beach improvement schemes. This guidance would also benefit from the inclusion of case studies and the results of recent research projects.

5.2.1 Risks associated

The risks associated with production of this updated manual are negligible. The manual will not be attempting to innovate or research new methods of beach management, but will act as a guide to managers by collating examples and methods of good practice.

Risks to the level of uptake of the new manual will hopefully be addressed by the feedback given at the scoping workshop and a future publication will be geared towards being as practical as possible for practitioners, without affecting its weight.

Risks associated specifically to the Environment Agency from production and implementation of the document can also be considered negligible.

5.3 Project management

5.3.1 Schedule

The project is planned to last 24 months that will roughly be broken down as follows:

- Information collation and production of first draft: eight months;
- Consultation and comments: six months;
- Production of second draft: four months;
- Final comments and final draft: four months;
- Editing and publication: two months;
- **Total project time = 24 months.**

5.3.2 Organisational structure

It is envisaged that management of the production of a new manual will be led by a carefully selected project steering group (PSG) organised by CIRIA. This PSG will include representatives of all professions and organisations associated with beach management, including project funders. CIRIA will be responsible for the organisation and running of all PSG meetings, and for ensuring all suggestions and concerns emanating from them are accounted for by the project team. Two main options were considered for the organisation of the team to carry out the rewrite of the manual, as set out below.

Option 1: *Multiple contractors*

CIRIA suggests that the best way to contract out production of the document will be through subcontracting different sections. These subcontractors will be leaders in beach management and coastal processes, with a good understanding of the practicalities of ground work associated with maintenance and public consultation (HR Wallingford, Halcrow, Black and Veatch and Royal Haskoning have already shown interest).

These subcontractors will report to a lead author who will be the point of contact for all research contractors and CIRIA. The lead author will also collate outputs produced by subcontractors assigned to work on individual sections. The lead author will be an expert in the field, ideally with experience of working on CIRIA projects with a project steering group.

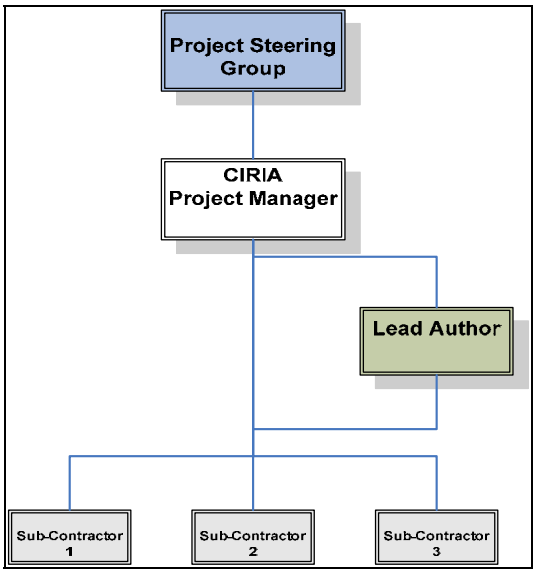

Figure 5.1: Option 1 – Organisational structure

Option 2 – *Sole contractor*

This option will function in a very similar way to Option 1, but will see all sections of the publication written by a single research contractor. This option would remove the need for a lead author and would thus reduce costs. The downside would be the limited involvement by other research contractors, unless they agreed to be a part of the PSG, and the potential lack of knowledge of the lead organisation on specific topics for which another research contractor might be better suited.

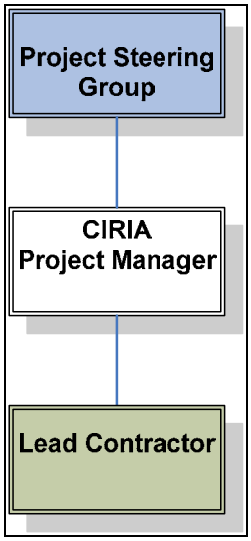

Figure 5.2: Option 2 – Organisational structure

5.3.3 Project costs

The costs associated with updating the *Beach Management Manual* to the final draft stage, and the different publication costs depending on the option selected, have been calculated by CIRIA and are summarised below:

Option 1

- CIRIA project manager staff time: £84,000;
- Subcontractor costs: around £120,000 (depending on the number of extra chapters);
- **Total cost: £204,000.**

Option 2

The reduction in costs associated with Option 2 compared to Option 1 is around £20,000, mostly associated with elimination of the lead author's costs.

- CIRIA project manager staff time: £80,000;
- Subcontractor costs: around £100,000;
- **Total cost: £180,000.**

5.3.4 Publication costs

The type of publication used for the 1996 edition, as a single large volume, has not been ruled out as a possibility for the revised manual. However, the general impression given by the project board and delegates at the scoping workshop, supported by the project team, was that the structure and content of a new manual on beach management should be significantly different, published in some type of modular

format. It was felt that this would not only promote uptake, but would also make the future document as user-friendly as possible. It would also allow the future revision, updating and republication of parts of the manual, though it would increase initial publication costs.

The costs associated with different forms of publication and dissemination can vary significantly. The editing costs of a multiple volume approach and a single publication will be similar, but if an electronic hyperlinked version is deemed the most appropriate, the costs would escalate. E-publication, for example in the form of a hyperlinked pdf document, will be a condition of funding from the Environment Agency for the rewrite of the manual. However, the need for a more modular publication has been emphasised, to allow easier reference to or downloading of sections of particular interest.

CIRIA's editing and publishing costs of the new manual (omitting the hyperlinked pdf version) would be assumed to be recovered through sales of hard copies and are thus not accounted for in the overall costs shown previously.

The publication costs of different forms of publication for a 350-strong order are shown in Table 5.1 below.

Table 5.1: Publication costs for different styles of manual

Type of publication	Cost estimate (£)
Single publication of 600 pages	9,500
Multiple publications in box set of seven volumes (84 pages each)	15,000
Hyperlinked pdf	3,600

Prices would be in accordance with the usual CIRIA prices for a ten-colour version and would offer a discount to CIRIA members as is usual practice.

Publication price range – £150-£180 for non-members, £75-£90 for members.

If an internet version was preferred, the ideal candidate sites to host it would be the Environment Agency and/or CIRIA website, with maintenance being undertaken in-house or alternatively subcontracted out. The cost of maintenance would depend on the amount of links to other websites, or information that could expire and therefore require regular updating in the document.

5.4 Dissemination of the new manual

In order to maximise uptake and hence the benefits of an improved version of the previous *Beach Management Manual*, it will be important to plan for its dissemination at an early stage.

An important target group will be those engaged in the routine monitoring, assessment and maintenance of beaches as part of a wider coastal defence management project. This would include those involved, for example, in the coast defence asset management initiative being introduced by the Environment Agency. Potential links between the revised manual and this type of coast defence management would need to be designed carefully, so that the manual provided appropriate explanations, guidance and detailed procedures and checklists.

The greater relevance of the manual to these professionals would need to be publicised not only by traditional methods of dissemination (advertisements, targeted emails and so on) but also by direct contact with those working in local authorities and Environment Agency regional/area offices. One way to achieved this is by giving presentations to the various coastal groups and regional coastal monitoring organisations such as the Channel Coastal Observatory around England and Wales.

The relevance of the manual should also be maintained, for example through a web portal, which needs to be discussed further by the proposed project steering group. This could take a number of different formats from a fully managed site to a wiki-style, self-managed website. The site would be accessed and modified by individuals who had purchased a copy of the manual and subsequently subscribed to the website. The contents would include:

- updates to case studies;
- updates of new projects;
- potential database of coastal schemes;
- links to the second round of SMPs;
- database of individuals involved in beach management, ranging from contractors and consultants to coastal groups;
- updates on how the Marine Bill is affecting beach management.

As well as increasing the usefulness of the manual by incorporating such links, the revised edition would need to be publicised to a wider group of potential users, including consulting engineers, contractors, conservation and environmental organisations, planners within local government and academic institutions.

6 Structure and contents for a revised manual

6.1 A new emphasis

From the consultation undertaken in this study, it is evident that the structure and content of any new manual for beach management is likely to be significantly different from the existing publication.

The general consensus amongst those involved in beach management was that practical management guidance was required. The project team suggested that there was merit in maintaining the connection between the old and new versions of the manual, but to improve usage of the new version, the following titles were suggested.

- *Beach Management Manual*: *Best practice guide*
- *Beach Management Manual: A practical guide*

These suggested titles may appeal to those engaged in the operational aspect of beach management, and may encourage the sharing of experience around the UK.

The new manual's main objective should be to provide guidance on maintaining beaches cost-effectively as vital elements of secure coastal defences against flooding and erosion, while preserving or enhancing their other attributes, such as natural habitats or amenity and recreational areas. In many cases, this may simply involve routine monitoring and assessment, to check that the beach is in a condition to fulfil its roles or functions, of which providing an appropriate standard of defence is one. On occasion, however, its likely performance, for example in severe storms, will be judged likely to be sub-standard. It then will be necessary to consider, and if justifiable to plan and execute, more substantial beach improvement schemes and the revised manual will need to provide guidance on such schemes. Figure 6.1 shows a management cycle summarising this overall context of beach management, which could be used as a basis for the structure the new manual.

Interventions that might be necessary will more often be minor maintenance, such as adjusting groynes or moving modest quantities of beach sediments, rather than embarking on a major beach improvement scheme. The revised edition of the manual should provide advice on such interventions as well as guidance on larger schemes.

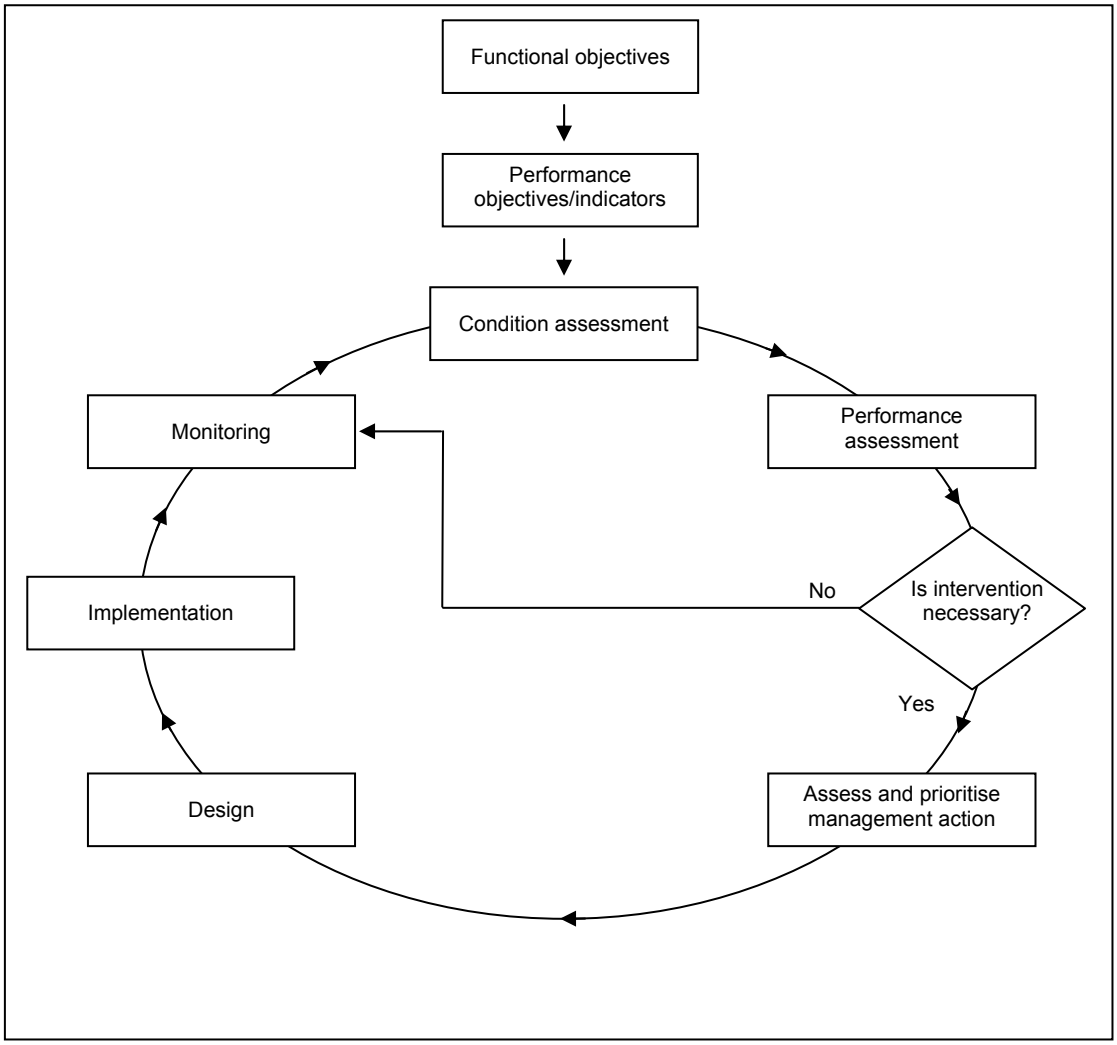

Figure 6.1: Beach management cycle

While a shift in emphasis is needed, there is agreement that much of the existing manual is of high quality and serves its intended purpose well, for example in explaining the processes that alter beaches, providing guidance on hydrodynamic loadings and on the design of beach improvement schemes. These sections are in need of updating with new information and references to further research, but there is no evidence that a major overhaul is required (see comments in Section 3.2 above).

6.2 Media

There are several options with regard to the format including electronic, hard copy or a combination of the two. Beach managers appear to prefer off-the-shelf reports to electronic versions, and it is therefore proposed that the new version should be available in conventional book form, although as discussed later the idea of providing a series of volumes covering different aspects was regarded as worthwhile.

It was recognized, however, that e-publication of the manual would bring added benefits, particularly in relation to adding to or updating the manual in coming years, which a straightforward book or series of books could not offer.

For example, the sharing of best practice, regarded as important by the Environment Agency, could be improved by establishing an online portal for new or updated case histories or research projects. Similarly, if new legislation was introduced or changes were made to the need for consents/licences for beach management activities, the electronic version of the manual could be updated more easily than the conventionally published edition. No firm conclusions were reached on the appropriate host for online access to the manual, or who should maintain and update the e-publication. This is an issue presently under discussion within the Environment Agency with respect to a number of previous and ongoing research projects (Mitchell, *personal communication,* 2007). It is therefore not immediately obvious that the host should be Defra, CIRIA or the Environment Agency, and this issue will need to be referred on to the team writing the revised version of the manual.

6.3 Structure and contents

There are various options available for the structure of the new manual. The existing manual has been criticised as being fragmented and difficult to dip into without prior knowledge of the whole publication's content. Establishing a user-friendly structure to the new publication, whether as a single book, multiple volumes or an e-publication, is therefore seen as an important objective.

From the consultation and discussions within the project team, a number of options were suggested for the structure of the new manual. These could be, for example:

- subject categorised (such as processes, data, environment, financial);
- scheme life cycle based (such as monitoring, appraisal, design, construction);
- reader-type based (such as academic, designer, operational staff, contractors, asset managers, environmentalists).

We would recommend implementing the second of the three options, as a beach manager is more likely to be interested in the subject categories at a particular stage of a project than the subject matter over the whole lifetime of a project.

The initial chapters of the revised manual would probably be similar to those in the 1996 edition, covering the following areas.

- introduction (expanded to cover management for amenity and environment);
- beach attributes, morphology and processes;
- hydraulic processes;
- the context and objectives of beach management.

The last of these topics would provide a bridge between practical beach management for coastal defence and the overall theme of sustainable asset management that has substantially advanced since 1996. In particular, this section would emphasise the links between beach monitoring and maintenance and the overall concepts of performance-based asset management systems, and evaluating the condition and likely performance of beaches during severe events in particular. In addition, this section would consider the links between beach management for coastal defence and the aims of environmental conservation or enhancement, whether for the natural or the human environment.

Based on the consultations undertaken, the subsequent organisation of the manual, in the view of the project team, would ideally reflect the life cycle of the beach management process.

Our initial thoughts are that it would be useful to develop the guidance as series of stand-alone volumes spread over the life cycle of the beach management process, supported by an introductory volume covering general issues and coastal processes outlined above. For example:

- **Volume 1: Introduction** – including beach attributes, morphology and processes; hydraulic processes; the context and objectives of beach management;
- **Volume 2: Management** – including routine beach management methods (expanded Chapters 9 and 11) and issues relating to decommissioning;
- **Volume 3: Monitoring** – including methods of monitoring, assessment and interpretation and post-scheme appraisal methods;
- **Volume 4: Intervention** – description of beach improvement schemes including identification, design and planning;
- **Volume 5: Implementation** – detailing project implementation, including construction.

This, in essence, would provide a circular set of documents with no defined start or end point. This would enable any user to dip into the guidance at any appropriate time, and would also offer flexible opportunity for web-based publication.

Each of these sections would then need to cover, within the specific context of that part of the management cycle, the following topics:

- process issues;
- data collection;
- climate change impacts;
- planning;
- economics;
- environment;
- amenity;
- health and safety;
- public engagement;
- legislation/procedure.

These topics would perhaps be emphasised by colour-tabbed sections.

As stated previously, this would enable the user to dip into the guide at the appropriate stage of the project and understand the issues relating to beach management at that particular phase of the process. There might be some repetition between stages, but the benefits of presenting time-dependent issues in one volume would appear to outweigh the need for switching between volumes.

7 Recommendations for short-term research

As part of this study, it was requested that any further research needed to improve the contents and/or uptake of the new manual should be identified. The emphasis was on work that could be undertaken in the short period between completion of this report and rewriting of the revised manual − approximately six months to one year − since it was intended that rewriting would probably start in late 2007.

This section outlines two suggested short-term research topics that would be of direct benefit to the new manual based on the views of the project team.

7.1 Expansion and review of beach management case histories

As concluded in Section 4.4 above, the compilation of case histories for past beach management schemes is seen as a worthwhile objective in its own right as well as complementing a revised manual. Within the time constraints of this study, it has not been possible to compile basic information on more than a few of the schemes or to consult with all parties that might have a view on the advantages and disadvantages of the schemes carried out. It would be useful, for example, for those carrying out an environmental impact assessment for a proposed new beach scheme to understand how a similar scheme elsewhere had affected the surrounding areas and habitats, and whether any unanticipated effects, either beneficial or detrimental, had occurred.

Similarly, it would be interesting to review the public perception of a beach recharge scheme at various stages of its lifetime, prior to, during and after its installation. Opinions could be sought from elected councillors, representatives of tourism and commercial businesses in the area, holidaymakers and locally-based beach users as well as those whose property was directly protected by the scheme. This is an area with very little in the way of published information for those contemplating beach management schemes to consult, making it more difficult to engage with the public during the planning of such schemes.

In the immediate future, it is suggested that one or two pilot studies of this type are carried out, perhaps as academic projects, to establish how to collect and analyse information in a way that helps to improve future beach management schemes.

It has not been possible within this study to gather information on the many routine beach management activities undertaken around the coastline. These are perhaps more interesting for many potential readers of the revised manual than the major improvement schemes for which case histories have been drawn up. If beaches can be maintained in a condition that achieves the desired performance, be that for coastal defence, amenity or environmental reasons, by monitoring and minor works such as maintaining groynes, dune management or minor recycling/reprofiling works, then this is likely to be more cost-effective and sustainable than major schemes.

Extending the review of beach management schemes to include information on more routine maintenance operations would provide useful examples for the revised manual. In this respect, attention should also be paid to beaches that are managed for amenity and environmental reasons, for example in coastal resorts or in nature reserves. Such

examples may fall outside the normal boundaries of coastal engineering, but will still be relevant to those managing beaches primarily as coastal defences.

7.2 Evaluation of beach management scheme performance

An important emphasis in the revised version of the manual should be the use of monitoring data to periodically assess the condition and performance of beach management schemes, as part of the asset management systems being introduced by the Environment Agency. This, in turn, would clearly relate to the economic evaluation and whole life costs of beach management schemes.

In this light, there would be value in appraising past beach management schemes and their outcomes against what was predicted in the actual cost profiles at the scheme appraisal stage. This would determine whether (a) proactive beach management was or was not being undertaken as planned at the appraisal stage and (b) whether the actual costs were correspondingly rather different when looked at over a long period.

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Bibliography

The literature review presented earlier in this report concentrated on recent research and case histories regarded as particularly relevant to the BMM, thus focusing largely on the UK. The perceived weakness of the manual was in providing guidance on best practice for routine beach management for the UK. It provided better guidance on improving the design of specific management schemes such as beach recharge.

Clearly, undertaking a comprehensive review of international research on beach management is a major open-ended task requiring many months of effort and correspondingly large resources. In many cases, it would not yield information relevant to the particular characteristics of physical or natural conditions, or to the funding and management of such schemes, in the UK.

This bibliography presents some examples of beach management research and practice around the world that might be of use to those compiling a new version of the manual.

Selection of manuals from around the world:

- *Coastal Engineering Manual*, US Army Corps of Engineers. See http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ARTICLES;104 (Part 5 – Coastal Project Planning and Design (Chapters 1, 2, 3, 4 and 7) and Part 6 – Design of Coastal Project Elements)
- *Coastal Engineering – Shore Nourishment in Europe* (Elsevier, December 2002)
- *Design Manual for Coastal Facilities 2000*, Japan Society of Civil Engineers. See http://www.jsce.or.jp/publication/contents/c_p474.html or http://www.jsce-int.org
- *Manual on Artificial Beach Nourishment*, CUR (Netherlands, 1987)
- *Beach Nourishment and Protection*, Marine Board Commission on Engineering and Technical Systems (US, 1995). See http://www.nap.edu/books/0309052904/html
- *Beach Nourishment with Emphasis on Geological Characteristics Affecting Project Performance* by Robert Dean, Richard Davis and Karyn Erickson. NOAA Coastal Services Center. See http://www.csc.noaa.gov/beachnourishment/html/geo/scitech.htm
- *Beach Nourishment: A Review of the Biological and Physical Impacts*, Atlantic States Marine Fisheries Commission. See www.asmfc.org/publications/habitat/beachNourishment.pdf

Florida Database on Monitoring of Beach Nourishment Projects

A comprehensive review of beach nourishment project monitoring data is being conducted for the Florida Department of Environmental Protection (FDEP). A total of 37 projects are being monitored by FDEP, covering about 158 miles (254 km) along the Gulf of Mexico and Atlantic Ocean shoreline. A comprehensive database of monitoring data parameters and information is being developed in web-based format.

Evaluation of these monitoring data and reports will provide valuable information for the FDEP beach management programme with regard to design optimization, performance and cost-effectiveness of beach nourishment in Florida.

A comparison of predicted versus measured beach nourishment performance will assist the FDEP and project designers in assessing the effectiveness of current predictive methods. Beach nourishment projects in South West Florida including Longboat Key, Lido Key, Venice and others have been reviewed and evaluated in the initial phase of this effort.

Further information can be found at
http://www.floridadep.org/beaches/publications/pdf/cosed03.pdf.

The Good Beach Guide, UK, Beach Database

(The following information is taken from http://www.goodbeachguide.co.uk/index.php)

The Good Beach Guide website, produced by the Marine Conservation Society, has a database of beaches around the UK and Republic of Ireland.

The database can be searched via a 'Beach Search' screen that allows regions or specific locations be searched, or by a quick search from the map on the front screen. Information on the website is concerned with beach safety and quality, including facilities, access, lifeguard provision and bathing water quality. There is a secure area for registered users to upload information and 'submit new beach'.

The database contains details of over 1,200 beaches.

Surf Life Saving Australia (SLSA) Beach Management and Safety Programme

Surf Life Saving Australia are developing, as an update to a system first developed in 2004, a comprehensive database on all Australian beaches as part of their *Australian Beach Safety and Management Programme* (ABSAMP, see http://www.slsa.asn.au/default.aspx?s=beachmgmtandsafetyprog).

ABSAMP was established in 1990 as a joint programme between SLSA and the Coastal Studies Unit, University of Sydney. ABSAMP aims to be the most comprehensive study ever undertaken on beaches of any part of the world's coast. Detailed information on every beach in Australia, all 11,011 of them, has been amassed.

The main aims of the programme are to:

- develop a comprehensive, standardised and scientific information base on all Australian beaches with regard to their location, physical characteristics, access, facilities, usage, rescues, physical and biological hazards (see beach hazards section below), and level of public risk under various wave, tide and weather conditions;
- improve the management and safety services of all Australian beaches, and help other countries to develop similar programmes.

The database is currently maintained in two software packages: MapInfo is a Geographical Information Systems package that is used for geographical analysis of every beach, while Microsoft Access is used for data entry, management and analysis.

A new version of the database is now in development, using MySQL, and will be accessible through the web to authorised users.

Data on each beach is acquired from a range of interrelated sources: topographic maps and aerial photographs, aerial and ground site inspections, beach conditions (produced on a daily basis by patrolling surf lifesavers filling in beach maps) and published data. All information is filed as hard copies, and all appropriate information then extracted for entry into the database.

In order to address public risk on beaches, there is a need to know both the nature of hazards and the type and level of usage. The ABSAMP database provides accurate information on the nature and level of beach hazards, as well as categorising each beach into one of fifteen general types.

The level of public usage can be assessed using daily beach patrol reports, and an assessment of the location and level of access, parking, accommodation and facilities, all contained in the database, to gauge likely seasonal usage.

Beach hazards are elements of the beach environment that expose the public to danger or harm, such as surf zone topography, water depth, waves and rip currents. Every beach in the ABSAMP database is given a beach hazard rating, which refers to the scaling of a beach according to its associated hazards. The rating ranges from a low rating of one (least hazardous) to a high rating of 10 (extremely hazardous), and is based on a combination of beach type and wave height. The beach hazard rating was developed to provide a simple, yet effective method of scientifically rating both the average and prevailing hazards on each beach, for the range of conditions that each beach may experience. Public beach risk is a product of the beach hazard rating and the level of beach usage.

ABSAMP is based on integration of a scientific understanding of beaches, their hazards and usage, together with the expertise in beach safety management and resources of SLSA, using the latest technology for data management and analysis. The programme has already had wide application and impact on the management of Australian beach systems, and will play an increasing role in their management into the next century, particularly as growing coastal development, population and tourism all demand accessible, yet safe, beaches for public recreation and tourism.

Appendix 1 Case histories

Dungeness Power Station

National Grid coordinates: E 608340, N 116560
Beach material: Shingle **Scheme type:** Recycling
Scheme owner: British Energy (formerly Nuclear Electric plc/CEGB)
Scheme designer: Halcrow
Cost of scheme: Approximately £100,000 per annum

Background to works:
The Dungeness Nuclear Power Stations were built on a naturally eroding coastline at the southernmost tip of Kent. The coastline has been changing continuously over many centuries due to the littoral movement of shingle from west to east, caused primarily by waves from the south-west. Shingle is eroded from the southern shore and it is deposited on the eastern side of the Ness.

Prior to the construction of the first power station and adoption of coastal protection measures in 1965 and 1966, the southern shoreline was receding at an average rate of 1.1 metres per year, increasing to 1.5 m per year over the easternmost 600 m. In order to provide long-term security to the power stations, five main possible protection schemes were originally considered.

Of these five options, it was recommended that the most appropriate choice was beach feeding and this was adopted. No serious disadvantages were foreseen at that time and none appear to have arisen in practice since the scheme was adopted. The policy of beach replenishment is, however, regularly reviewed.

Constraints:
Borrow area is designated as a special area of conservation (SAC).

Start date: 1966 **Completion date:** Ongoing

Description of capital works:
Annual surveys are carried out each May using RTK GPS and robotic total station equipment and difference plots between successive surveys generated to locate areas of erosion and accretion. From these surveys, recommendations are made for maintaining the beach in front of the nuclear power stations. During the winter months, additional monthly inspection and monitoring is undertaken.

Studies and reports have also been completed on the effect of extensive gravel pits on the stability of the Ness and the feasibility of landing very heavy single unit loads directly onto the beach. The present beach feeding scheme maintains a totally un-groyned beach by means of shingle recirculation. Recent years have seen managed realignment of part of the frontage.

Problems during capital scheme:
None reported.

Description of supplementary works:
Periodically, further studies are undertaken to confirm that the system of beach recycling continues to be the most cost-effective. These have involved the use of mathematical models to study possible alternative engineering structures and estimate costs. In the last decade, this has resulted in the implementation of a policy for allowing managed retreat to develop at the western end of the frontage.

Description of monitoring programme:
Refer to ‘Description of capital works’.

Annual efforts:
Refer to ‘Description of capital works’.

Picture(s):
Ongoing shingle recycling

Lessons learnt:
Long-term sustainable beach management in an environmentally sensitive area to provide flood defence for nuclear power stations.

Views on overall success:
Very cost-effective and sustainable beach recycling programme that has been ongoing since the 1960s.

References/Reports on scheme:
Halcrow Annual Beach Management Reports.

Eastoke, Hayling Island, Hampshire

National Grid coordinates: E473000, N98400
Beach material: Shingle **Scheme type:** Recharge/recycling
Scheme owner: Havant Borough Council (Mr Lyall Cairns)
Scheme designer: Havant Borough Council
Cost of scheme: £6.1 million

Background to works:
Hayling Island is a low barrier island that separates Langstone and Chichester harbours, except for a narrow link at its northern end. While historically it may have been able to retreat landwards naturally, that process has been disrupted. At its eastern end, along the Eastoke peninsula frontage, the narrow shingle barrier beach has been prevented from rolling back by the presence of seawalls, and this has resulted in the lower foreshore levels falling. This frontage also has a "drift divide", with the drift westward from Eastoke about 20,000 m³ per year and an eastward drift of about 10,000 m³ per year. While this net loss is partly balanced by onshore transport of about 20,000 m³ per year, this still left (Clare, 1988) a net deficit of some 10,000 m³ per year. This deficit had been much larger prior to the mid-1980s, leading to the beach erosion problems along the Eastoke peninsula frontage.

Major works were required to prevent further overtopping. Following extensive studies, a scheme was adopted which tackled the fundamental problem of the reduced shingle 'sediment budget'. The beach nourishment scheme that was initiated was one of the first of its kind in the UK.

Constraints:
Eastoke Point, a shingle barrier beach at the eastern end of the frontage, encompasses a nature reserve (LNR). Both lie within the Chichester Harbour AONB, SSSI and SPA. The whole frontage also borders the Solent SAC. These conservation designations constrain both the type and timing of any coastal defence scheme works that can be carried out. While the overall defence policy of 'hold the line' is justified by the large number of people and properties at risk from coastal flooding, especially if the narrow barrier beach was to be breached, this does restrict the natural development of that beach, which would otherwise retreat landward in response to sea level rise. Avoiding 'coastal squeeze', the narrowing of the inter-tidal zone between a seawall and the gradually landward moving low-water mark, is a concern of conservation bodies.

The need to preserve safe navigation into Chichester Harbour, and the desire to maintain public access and amenity also influence the choice of a defence scheme.

Start date: 1985 **Completion date:** Ongoing

Description of capital works:
In December 1985, some 500,000 cubic metres of sand and shingle were brought on from offshore and then spread by bulldozers and dumper-trucks over a frontage of some 1.5 km. The nourishment material was won from the nearby Owers Bank dredging licence area, which at that time had ample reserves of suitably coarse material. The material was landed by barge on the lower foreshore and was then bulldozed to form a 35 m wide berm, with a crest of approximately 5.5 m OD and a seaward slope of one in five.

Problems during capital scheme:
Erosion along this frontage during previous decades had removed all of the original shingle, leaving behind a sandy inter-tidal beach that was covered at high tide. There was considerable local opposition to the use of coarse shingle to recharge the beach, including protests and direct interference with operations being undertaken to sort the sediment delivered (in order to place the largest diameter particles on the beach face). The higher beach was also alleged to have reduced tourist visits to local retail outlets at high tide, when the previous beach was underwater. Restrictions had to be introduced because of fouling by dogs.

During stormy periods, the recharged beach developed steep scarps in the well-compacted sediments, in places up to 2 m high, causing some concern about beach safety and access from its crest to the water's edge. Small scarps still occasionally form more than 20 years later, as the beach width dwindles and the original recharge material at the rear of the beach becomes exposed.

In the first few years after nourishment, an unusually high frequency of storms occurred; between 24 March

1986 and 6 January 1988, wave heights in excess of 1.5 m were observed on nine occasions, and on two of these the wave height was as large as 2.5 m. On four occasions the wave period exceeded 12 seconds and on one occasion the mean wave period was 17 seconds. This frontage was particularly vulnerable to overtopping by long period waves and during any of these events serious overtopping of the seawall would have occurred had the beach nourishment scheme not been in place (Clare, 1988). Because of these storms, and a delay in installing new groynes after the recharge, the imported material was dispersed quite rapidly alongshore.

Description of supplementary works:
A new timber groyne system was installed two years after the beach nourishment scheme, and the beach was topped up with a further 46,000 cubic metres of shingle. A year later, the beach was topped up with a further 25,000 cubic metres of shingle.

In the late 1980s, rapid easterly transport of beach sediment led to massive accretion at Eastoke Point, at the eastern end of the peninsula. The accumulation of recharge sediment formed a 'ness' at Eastoke Point, which impinged on and affected the deep-water channel into Chichester Harbour. The rapid ebb flows off the point swept some of this sediment into deep water and transported it offshore, leading to losses in the overall beach sediment budget. A groyne was built in 1990 to help prevent further material reaching the ness. However, erosion then occurred east (downdrift) of this groyne, threatening to create a breach further north, in the shingle ridge around Sandy Point Nature Reserve. Soon afterwards, a rock revetment and short groynes were constructed east of the 1990 groyne to reduce this threat. This scheme, in combination with routine recycling operations, has successfully protected this frontage since that time.

Description of monitoring programme:
The beach is regularly monitored and changes in volume calculated, providing guidance for the regular recycling operations (see below). Havant District Council has also developed an asset management database, and periodically review the condition of the groynes, seawalls and so on.

Annual efforts:
Since 1991, annual recycling has been undertaken to maintain an adequate standard of flood defence. However, the overall beach volume at the eastern end of Hayling Island continues to diminish, as some beach material is lost into Chichester Harbour. On average, 27,000 m^3 per year moves off the Eastoke frontage, with around 22,000 m^3 per year placed back on the beach through recycling, hence a net loss of around 5,000 m^3 per year which has been identified as 'leakage' and which should be replaced through periodic recharge on a five-yearly cycle.

The annual loss of sediment from the Eastoke frontage is therefore about 22,000 cubic metres, despite the groyne system along the frontage that substantially reduces the longshore transport. Periodically, shingle lost offshore is dredged from the entrance channel to Chichester Harbour and used to restore beach volumes, but the main recycling is undertaken by trucks transporting it from areas where shingle has accreted during the year, producing a wider beach than required to provide a satisfactory standard of defence.

Pictures (before/after):

Lessons learnt:
The annual recycling operations cannot recover sediment from some areas north of Eastoke Point, because this has accumulated at the beach crest and been colonised by unusual plants, extending the conservation value of the Sandy Point Nature Reserve. Routes taken by the trucks undertaking the recycling operations have to be carefully defined and controlled to prevent damage to this vegetation.

From time to time, sediment swept off Eastoke Point that settles in the channel into Chichester Harbour is dredged to avoid forming a hazard to navigation. This sediment is made available to Havant District Council to use (again) for beach recharge, rather than being taken to an offshore disposal area. To take advantage of this, the council requires flexibility in the timing and amount of funds available for beach management from year to year, since the timing of such dredging operations is affected by the occurrence of storm events and is thus rather unpredictable. A request for funding at short notice for such events can conflict with national plans for coastal defence spending, especially when budgets are very restricted.

While using dredged sediments from the navigation channel is a very economic way of maintaining the beaches at Eastoke, some difficulties have been experienced with the quality of the dredged material, which has increasing percentages of sand as time goes by.

Views on overall success:
The recharged beach at Eastoke has greatly reduced the incidence and severity of flooding of the low-lying residential area just landward. In addition, it has allowed the preservation of the character of the Sandy Point LNR, and shingle lost from the main frontage has resulted in gains in the areas of vegetated shingle around its periphery.

The amenity value of the frontage has changed, but the beaches still seem to be acceptable and widely enjoyed by the public.

References/Reports on scheme:
Clare MJ, 1988. The performance of the Hayling Island beach replenishment scheme. *MAFF Conference of River and Coastal Engineers*, Loughborough University, 5-7 July 1988.

WS Atkins, 2006. *Eastoke Sectoral Strategy Study: Project Appraisal Report*.

Herne Bay, Kent

National Grid coordinates: E 617740, N 168415
Beach material: Shingle and sand **Scheme type:** Recharge
Scheme owner: Canterbury City Council
Scheme designer: Delft Hydraulics / Canterbury City Council
Cost of scheme: £5 million

Background to works:
Central Parade, in the Herne Bay Central Area, was constructed between the 1920s and the 1960s and was in a poor condition. This, along with the low-lying land behind the seawall forming a natural basin for flooding, meant that significant works were required, becoming a priority in the early 1990s.

The coastline, orientated on an approximate east-west bearing, is vulnerable to wave attack from the North Sea under northerly winds. The pre-existing wall had been built of low quality blocks, and it had been predicted that a 20-year return period storm would be sufficient to cause breaching, and thus flooding of the hinterland. The back seawall was only founded on shingle and therefore if breaching did occur, this wall could be easily undermined. Beach levels were low, increasing the intensity of the waves reaching the wall.

It was decided to design a scheme to the 100-year return period storm, which approximately matched the 1953 storm event.

Constraints:
Tourism (existing and potential). Because of the poor state of the beach and the high level of overtopping experienced on a regular basis, both the beach and the space on the landward side of the seawall were unattractive for amenity purposes. Local people demonstrated through responses to a public exhibition that the most acceptable coastal defence would be that which enhanced the seafront and general amenity value. There was a strong public desire for a sand beach, but this was deemed impractical due to the length of the beach (which would have a more gentle gradient of one in 30) and the cost of maintenance. Nevertheless, an aggregate with a higher percentage of sand was used and has been stable.

Disruption to fisheries during the delivery of rock and beach aggregate required mitigation.

Start date: 1991 **Completion date:** 1992

Description of capital works:
A recharge of 70,000 m³ sand and shingle was placed on the beach in 1991-2, dredged from The Sunk, off Harwich in the North Sea. In addition, a 400m long breakwater was constructed 80-200m offshore from the seawall, connected to the shore by the new sediment. The breakwater was constructed of 80,000 tonnes of quarried granite. At the western end of the recharged area, a 180m long rock berm was constructed to retain the material, with a concrete wave return wall on top.

The new beach had a gradient of one in 10, with the crest at five metres AOD, just below the level of the new promenade. The dredged sediment was supplied to a specified grading envelope consisting of 50mm shingle, decreasing to sand.

Problems during capital scheme:
None with the beach recharge. Minor issues with the rock placement on the breakwater.

Description of supplementary works:
Culverts in breakwater arm closed to reduce ingress of sediment into basin; downdrift groynes improved and western terminal rock groyne raised by around 1.5 to 1.8 metres. Minor breakwater repairs following storm of approximately 10 year return period in 1996.

Description of monitoring programme:
Tide and wave gauge approximately 1.2 km NNW of site since 1995, beach profile data 1978 to 2003, annual beach plan surveys (summer) plus spring and autumn profiles as part of the *Strategic regional coastal monitoring programme* (since 2003), nearshore bathymetry in 2004 and 2007.

Annual efforts:
Annual sediment recycling operations have been carried out since 1992, moving approximately 5,000 cubic metres per year from the central area to the west end a distance of about 250m at a cost of around £1 per cubic metre. Annual dredge (using injection dredging) to remove build up of silt from the basin (approximately £20,000 - £25,000 per annum).

Pictures (before/after):

Before

After

Lessons learnt:
Design of rock breakwater, management of siltation and wider beneficial impacts of coastal defence schemes.

Views on overall success:
The scheme has had major amenity and economic effects, with the breakwater creating a sheltered area immediately behind the seawall. Here, regeneration funding was used to create new landscaped gardens which can now be maintained to a higher standard than was previously possible (due to reduced salt spray). This, in turn, led to the generation of private finance to refurbish the Edwardian bandstand and the development of a number of previously derelict/underused seafront properties. The scheme also enabled the creation of a public performance space adjacent to the clock tower; which, during summer months, has hosted open-air concerts and activities attracting crowds of up to 10,000 people. The breakwater itself has its own amenity value as a means of being able to stroll out to sea and as an excellent launch site for fireworks (meeting health and safety and relevant codes of practice for public displays).

The sheltered area of water produced by the breakwater allowed for the creation of a limited number of watercraft moorings and a boat launching facility. The construction of the launching ramp coincided with a rapid growth in the use of personal watercraft (PWCs) and now has considerable use due to it being the closest launching facility of its kind to London on the Kent coast. The stabilised beach has also meant that concessions such as crazy golf can operate and a national model boat racing competition has been attracted to Herne Bay as a result of the sheltered area of water behind the breakwater.

The sheltering effect of the breakwater has affected the habitat behind the breakwater, with the previous clay foreshore with a thin layer of sand becoming muddy. This has meant that the area at the base of the beach slope is unsuitable for bathing.

There has been no loss of beach from the frontage and no recharges are anticipated in the near future. The beach has easily withstood a 10-year return storm and apart from the need to

recycle annually to correct a tendency to realign to face a WNW direction at the open end of the breakwater structure, the beach has required little maintenance. However, the success of the breakwater in creating a sheltered area in its lee has provided the conditions for silt to collect. This needs annual dredging to maintain access to the boat-launching ramp.

In conclusion, the scheme itself has been the catalyst for increased investment in Herne Bay, especially in the seafront area, and has benefited the town by revitalising the tourism industry.

References/Reports on Scheme:
Canterbury City Council online (http://www.canterbury.gov.uk/cgi-bin/buildpage.pl?mysql=155)
Delft Hydraulics, Defra Conference, BMPs, ICE paper

Hurst Castle Spit, Christchurch Bay, Hampshire

National Grid co-ordinates: E430400, N90300
Beach material: Shingle **Scheme type:** Recharge and recycling
Scheme owner: New Forest District Council (Professor Andrew Bradbury)
Scheme designer: New Forest District Council
Cost of scheme: The capital cost was £5.2 million, of which around £1.2 million was for beach recharge.

Background to works:
Human activity has drastically changed the natural coastal processes around Poole and Christchurch Bays since the late eighteenth century. In particular, the construction of coast protection and flood defence structures over the last 70 years has stopped the erosion of sand and gravel from the soft cliffs along much of this stretch of coastline. Consequently, the volume of shingle moving by littoral drift onto Hurst Castle Spit, a shingle barrier beach at the eastern and downdrift end of Christchurch Bay, declined and as a result the spit decreased in size. This decrease has accelerated markedly since the 1940s when large scale groyne construction began at Bournemouth and Christchurch. In addition, this reduction in the size of the barrier beach was accompanied by an acceleration of its long-term movement. The spit is a transgressive barrier beach, gradually moving landwards due to the processes of overtopping and overwashing. The rate of transgression has increased from approximately 1.5 m per year (1867-1968) to 3.5 m per year (1968-1982) (Nicholls, 1986).

The crest of Hurst Castle Spit was breached many times from 1954 onwards, notably in January 1962 when recently constructed timber groynes were outflanked as the Spit rolled back during storms, leading to widespread flooding in Milford and Keyhaven. An increase in storm activity in the 1970s further weakened and lowered the spit, and maintenance costs increased substantially. Storms in October and December 1989 caused dramatic crest lowering and roll back across the saltmarshes behind it, and outflanking of rock armouring that had been used to strengthen the root of the spit. Landward recession of 10-25 m took place over a length of 2,300 m on 29 October 1989. Crest lowering in excess of 2.5 metres, roll back of the seaward toe by up to 60 metres, and roll back of the lee toe by up to 80 metres resulted in displacement of more than 100,000 tonnes of shingle overnight in December 1989. For the first time, tidal breaches through the spit were created by the December 1989 event, allowing the sea to flow through at all states of the tide and resulting in rapid erosion of the saltmarsh in its lee. This recession exposed some 600 m² of foreshore to erosion and exposed underlying saltmarsh deposits on the foreshore.

A major storm was experienced on 1 April 1994, causing overwashing, elevation lowering, crest cut-back and fans extending up to 26 m across the back-barrier slope (Bradbury, 1998). This event emphasised the urgent need for a comprehensive scheme of barrier management.

Constraints:
Hurst Spit is of national and international importance for geomorphological features. It is designated as a SSSI for its morphological importance and is also within an SAC and Ramsar site. Vegetated shingle is associated with the 'fossil' recurves of the distal part of Hurst Spit.

The maintenance of Hurst Spit is crucial to the continuing survival of the rich variety of habitats in the North West Solent SAC (Keyhaven and Pennington marshes) that lie landward of the barrier beach; this is one of several objectives justifying the Hurst Spit beach management scheme. There will, however, be some loss of both intertidal and terrestrial habitats if this barrier structure continues to evolve by transgressing landwards.

This SAC is part of the Solent estuary cluster site. The Solent and its inlets are unique in Britain and Europe for their hydrographic regime of four tides each day, and for the complexity of the marine and estuarine habitats present within the area. Sediment habitats within the estuaries include extensive estuarine flats, often with intertidal areas supporting eelgrass, algae, shingle spits, and natural shoreline transitions. Solent Maritime is the only site for smooth cord-grass *Spartina alterniflora* in the UK and is one of only two sites where significant amounts of small cord-grass *S. maritima* are found. It is also one of the few remaining sites for Townsend's cord-grass *S. x townsendii* and holds extensive areas of common cord-grass *Spartina anglica*, Other features of significance fall in to the categories of annual vegetation of

drift lines and perennial vegetation of stony banks.

Start date: August 1996 **Completion date:** January 1997

Description of capital works:
The main measures that were implemented by 1996 (New Forest District Council, 1996; Bradbury and Kidd, 1998; Bradbury, 1998) were:

- recharge with 300,000 m³ of gravel obtained from the Shingles Bank immediately offshore; this closely matched the indigenous sediment. The effect of this recharge was to almost double the previous volume of the spit;
- the barrier beach crest level and width were both increased, declining eastwards in conformity to the reduction in wave climate severity from proximal to distal ends. The finished profile was to a crest elevation of 7 m OD at the western end, reducing to 5 m OD at Hurst Castle; this was designed to resist overwashing under surge conditions occurring up to a one in 200-year return frequency;
- recharge allowed for ground settlement due to compaction and possible shearing affecting the basement sediments;
- construction of a short, obliquely-aligned, detached and armoured rock breakwater, with a crest height of 2 m OD at the proximal end of the spit. The purpose was to act as a headland structure and to smooth the former transport discontinuity between the terminal point of a rock armoured sector to the west and the adjacent unprotected beach. The breakwater creates localised wave diffraction and promotes realignment of the beach by sand and gravel deposition in its lee, rapidly producing a tombolo.

Problems during capital scheme:
Localised difficulties were experienced with loading of partially consolidated muddy channel deposits on which the capital recharge was placed. Adjustments were made to the loading (layering and reduction in thickness) in order to prevent the sediments from shearing.

Recharge material quality was consistently of very high quality. Samples taken during discharges were analysed in context with the dredger track plots and minor changes instructed to the dredging patterns when the sediment became smaller than desirable. As the dredging licence was under the control of the client, and contractual arrangements made provision for such changes in dredging patterns, this was a straightforward task. Although the licence made provision for screening of the gravel, the dredged material was of such good quality that this was not required.

A major storm event caused some serious loss and damage to segments of the discharge pipeline during the project.

Fired ordnance was found regularly within the discharged material, and dealt with by Ministry of Defence personnel. Subsequently, a specialist ordnance disposal team was commissioned to sweep the site on completion of the works.

Description of supplementary works:
The original project made provision for overbuilding of the crest of the barrier in order to allow for compaction of the subsoil. A maximum expected loss of about one metre in height was anticipated during the first ten years. In actual fact, a maximum displacement of 0.7 m has occurred, with most areas settling by less than 0.3 m; these observations have been confirmed by regular monitoring of settlement beacons installed at the time of recharge. Trimming of the crest elevation has subsequently been conducted to ensure that the crest is not too high, and to reduce the incidence of cliffing.

Description of monitoring programme:
Routine monitoring and analysis leading to routine management. Monitoring comprises biannual profiling of the beach at 100 m profile centres and a detailed annual spot height survey that is able to describe the plan shape and beach volume (see Figure 1). Post-storm surveys are conducted following events with a return period of about 1:1 year; these are identified at a local directional wave buoy. Wave climate data is updated annually and all storm events are reviewed. Survey data is used in combination with beach management information, which includes details of recycling volumes and locations. Cross sections are checked against defined critical conditions using an empirical model, which identifies the conditions that are likely to result in overwashing of the beach crest.

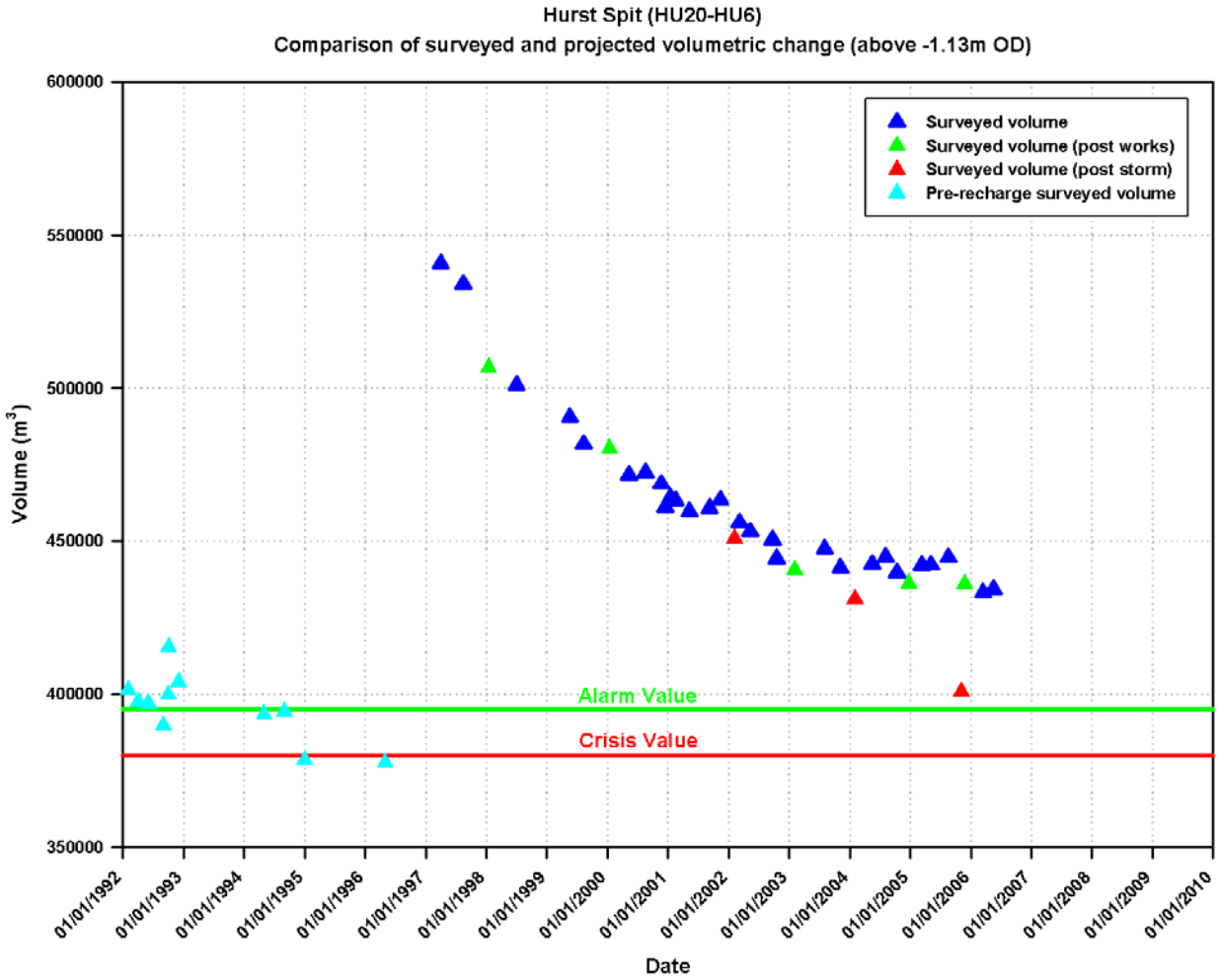

Figure 1: Beach volume changes above mean low water springs

Annual efforts:
The maintenance activities include the following:

- recycling of beach material from the active recurve at North Point to areas of the main body of the spit that are thinning;
- trimming of the beach crest elevation that changes due to local variations in compression of the underlying saltmarsh deposits, to maintain an even crest elevation that will permit some overtopping;
- bypassing shingle around the headland breakwater near the root of the spit;
- recycling from the lee slope of zones of the main body of the spit where accretion is the predominant process.

The first planned interim recharge is now scheduled for 2008/09 when an estimated 100,000 m³ of shingle will be required. This will be followed by recharges of 100,000 m³ at 15-year intervals until 2036. The volumes are based upon historical rates of loss and have been reassessed using the results of the first ten years of the beach management plan. The beach management plan is reviewed annually and minor revisions are made to the maintenance and monitoring programmes to reflect changes to beach performance. The expenditure profile has also been reviewed and modified to reflect the changes required. The results of the monitoring programme have been tested against new developments in best practice for design and management methods.

Problems during annual works:
Recycling from the distal tip of the recurved spit is conducted over low water spring tide periods. Recycling

activities are carried out away from environmentally sensitive areas (tern nesting). Nesting season is avoided during such activities. Haul routes are confined to the intertidal swathe in order to avoid environmental damage to the vegetated shingle. The site remains open to the public during the recycling programme, with localised diversions in place, in order to maintain appropriate safety.

Views on overall success:
Since scheme completion in 1996, Hurst Spit has successfully resisted over 20 storms that would otherwise have caused overtopping or overwashing. However, crest cut-back has occurred, with crest cliffing also a feature before fine sediment in recharge material was winnowed out or moved down-profile (Bradbury, 1998). Accretion behind the breakwater has occurred as predicted. Overall, the morphodynamic behaviour of the spit has been close to model predictions. Although the beach response has been largely as predicted in most storm events (Bradbury, 2000), a number of events have resulted in much more damage than predicted.

Data collected to date indicates that the beach recharge scheme is performing as predicted, and that no major changes to the 50-year strategy are required, at this stage, provided that the capital recharge is maintained. Emergency action should not be necessary although a contingency plan has been outlined.

The beach management scheme (Bradbury, 1998; Bradbury and Kidd, 1998) has maintained much of Hurst Spit's morphodynamic character as a barrier structure. The historical recession of the back-barrier slope of the western and central sectors of the barrier beach has historically inhibited the establishment of vegetation, but this has begun to develop at some locations since the beach recharge in 1996.

References/Reports on scheme:

- Clare, M.J., 1988. The performance of the Hayling Island beach replenishment scheme, *MAFF Conference of River and Coastal Engineers*, Loughborough University, 5-7 July 1988.
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- Bradbury, A.P., 1998. *Response of shingle barrier beaches to extreme hydrodynamic conditions*. Unpublished PhD thesis, School of Ocean and Earth Science, University of Southampton.
- Bradbury, A.P. and Kidd, R., 1998. Hurst Spit stabilisation scheme. Design and construction of beach recharge. *Papers and Proceedings of the Thirty-third MAFF Conference of River and Coastal Engineers*, 1.1.1 to 1.1.14.
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- Nicholls, R.J.,1987. Evolution of the upper reaches of the Solent River and the formation of Poole and Christchurch Bays. In: K.E. Barber (ed), *Wessex and the Isle of Wight: Field Guide*, Quaternary Research Association, 99-114.
- Nicholls, R.J. and Webber, N.B., 1987a. The past, present and future evolution of Hurst Castle Spit, Hampshire. *Progress in Oceanography*, 18, 119-137.

Mablethorpe to Skegness, Lincolnshire (Lincshore)

National Grid coordinates: E 556200, N 374680
Beach material: Sand **Scheme type:** Recharge
Scheme owner: Environment Agency (Anglian)
Scheme designer: Halcrow
Cost of scheme: Capital cost = £78.8 million (to date)

Background to works:
The 25 km length of coastline between Mablethorpe to Skegness in Lincolnshire is totally exposed to the North Sea and has a long history of beach volatility, where flooding events are recorded as far back as the thirteenth century. In more recent times, there was a major breach of the defences on the night of 31 January 1953, when a surge tide broke through in numerous places, with 41 people killed as a result of the flooding. Many defences were rebuilt in the aftermath and have required maintenance, repair and upgrading ever since.

The sea defences here protect some 20,000 ha of low-lying land which extends inland for about eight kilometres before higher ground is reached. The average land level is two to three metres below high tide level. There are 35,000 permanent residents within this protected area, which also contains an extensive holiday industry (around 18,000 static caravans), other businesses and the Theddlethorpe North Sea Gas terminal. There is no natural or artificial compartmentalisation of the protected area. The potential 'do nothing' damage to permanent dwellings alone amounts to over £900 million.

In 1991, the National Rivers Authority, now the Environment Agency, initiated a strategy review to develop a sea defence strategy for the frontage from Donna Nook in the north, to Gibraltar Point in the south. The study concentrated on the Mablethorpe to Skegness area because the beaches to the north and south were accreting. The strategy concluded that nourishment of the beaches, along with subsequent renourishment to replace losses, represented the best technical, environmental and economic solution to secure these defences and to provide a one in 200 year standard of protection.

Constraints:
- Consideration of material moving onto Gibraltar Point Bird Reserve;
- High amenity value for tourism;
- Densely populated with caravans.

Start date: 1994 **Completion date:** Ongoing

Description of capital works:
Between 1994 and 1998, approximately 7.5 million cubic metres of sand similar (in size and colour) to that on the beaches at the time, was dredged from an offshore source and placed on the beaches along the frontage, making this project the largest beach recharge scheme undertaken in the UK. The existing sea outfalls were buried and extended to match the new beach profile.

The works continued on an *ad hoc* basis until 2004, when a review of the 1991 strategy was carried out in order to deal with the potential flooding of the hinterland behind the Mablethorpe to Skegness frontage. This was undertaken in the context of historical flooding in the area, and the past studies and works undertaken along the frontage. The strategy review carried out a comprehensive investigation into coastal processes, a geomorphology assessment and addressed environmental, structural and economic appraisal aspects. The outcome of this was a long-term sea defence strategy, which included justification for works over the next five years.

To date, a total of 10,583,232 m³ of sand has been pumped ashore and placed on the beaches.

Problems during capital scheme:

Budgets have only recently been made available to gradually build the beach profile to a consistent defence standard along the full frontage. In previous years, the more piecemeal approach to recharge may have left some frontages more vulnerable to losses (where recharged beaches were not always tied into neighbouring profiles effectively).

Description of supplementary works:
Subsequent renourishment to make up natural losses, estimated to be approximately 200,000 cubic metres per year, is carried out annually.

Description of monitoring programme:
Prior to each recharge campaign, a beach monitoring survey covering approximately 113 survey lines is undertaken, to identify recharge locations and inform recharge volumes required for each campaign.

Annual efforts:
Annual recharge to replace natural losses estimated to be approximately 200,000 cubic metres per year.

Part of the study frontage c.2002

Lessons learnt:
To be effective, beach nourishment needs a long-term commitment to renourishment as and when losses of sand occur. Suitable material may be available (at least in the short term) from elsewhere, but in order to guarantee both long-term availability of supply and economic price, it would be desirable for the Environment Agency to have its own source. The only viable source was to dredge from well offshore for which a licence (administered by the Crown Estate) was required.

Views on overall success:

References/Reports on scheme:

- Halcrow, 2004. *Lincshore Sea Defence Strategy*.
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- Hough, A. and Peck, S., 1997. Effective environmental monitoring of beach recharge schemes. In: *Thirty-second MAFF Conference of River and Coastal Engineers, July 1997.*
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- Zwiers, M., Dales, D. and Hunt, H., 1996. Mablethorpe to Skegness beach nourishment: is it working? In: *Partnership in Coastal Zone Management*. Taussik, J. and Mitchell, J. (eds), Samara Publishing Ltd. Cardigan, 631-637.

Sand Bay, Gloucestershire (or North Somerset)

National Grid coordinates: E 333100, N 164500
Beach material: Sand (some gravel) **Scheme type:** Recharge
Scheme owner: Environment Agency (South West/Wessex)
Scheme designer:
Cost of scheme:

Background to works:
Sand Bay is a small, partly enclosed sandy embayment, situated near the upstream limit of the Bristol Channel, just to the north of Weston-Super-Mare. At this location the bay is partly sheltered by the alignment of the shores of the Bristol Channel, thus having a relatively small wave 'window' to the west from which Atlantic waves can approach directly. The bay is well sheltered from other wave directions by the large limestone headlands to the north and south. At the northern end of the frontage, the shelter is so pronounced that a saltmarsh has developed in the immediate shelter of the Middle Hope headland. However, the central and southern parts of the frontage are more exposed and the sand beach had become quite narrow there by the early 1980s.

Before the 1980s, the bay had a low shrub-covered ridge that separated caravan parks, low-density housing, and low-lying former marshland from the inter-tidal zone. The ridge was backed by a wall of relatively low crest height, in turn backed by a coastal road running parallel to the wall. Seaward of the ridge was a sandy beach and below this a wide, muddy lower foreshore (the beach width has substantially increased since nourishment in 1983 and the backshore is now dune-covered).

Being located between two limestone headlands, Sand Bay experiences no losses of sediment in a longshore direction. The lower foreshore is muddy, so offshore sand transport would result in material being permanently lost from the beach. Also, when beach levels are high, there can be some slight losses due to onshore sand transport by wind action.

The low beach levels in the central and southern part of Sand Bay made the seawall in that area vulnerable to wave overtopping. In the early 1980s Sand Bay experienced several severe storms, which caused flooding on at least two occasions. This occurred when high tidal levels, elevated by surges, coincided with severe westerly gales. On 13 December 1981, the storm surge elevated the high water level by 1.4 m. This, in combination with significant inshore wave heights of about two metres, caused serious overtopping, structural damage to the wall and the flooding of 82 properties (Bown, 1987). The sea defences protect some 250 properties, a holiday camp, and some 400 ha of land against flooding.

Constraints:

Start date: 1983 **Completion date:** 1984

Description of capital works:
Around 300,000 cubic metres of sand and gravel were extracted from a specifically licensed offshore dredging area between June 1983 and March 1984. The material had a minimum particle size of 0.2 mm, thereby minimising likely offshore losses. The maximum particle size was 30 mm, still small enough to be pumped the considerable distance from beyond the low water line to the upper beach. This sediment was brought onshore over a frontage of some 2,200 m, to form a berm some 0.5 m higher than the crest of the seawall to the rear. The material was first formed into a bund into which the dredgings were pumped. Bulldozers were then used to create the 20 m wide berm, with a crest some 15.3 m above Chart Datum, about 1.5 m above the high water of spring tides. The sand was graded to a relatively steep slope of one in 10, thus avoiding displacing the material onto the muddy lower foreshore.

Problems during capital scheme:

Bown (1987) reported problems experienced in trying to dredge and place material onshore during October 1983, caused by stormy weather. This resulted in a change in the delivery method and an increase in the costs of the scheme. Following the recharge, problems were experienced with sand blowing inland over the coastal road and into houses and gardens further landward.

Description of supplementary works:
Dune management, in the form of installing fencing and encouraging establishment and growth of dune-binding grasses, was undertaken to reduce the problems of sand blowing inland. The fencing has also reduced potential problems of pedestrians damaging the dunes.

Description of monitoring programme:
Six-monthly beach cross-sectional surveys.

Annual efforts:

Sand Bay in 2005

Lessons learnt:

Views on overall success:
Despite the scheme design assuming further recharge to replace a potential loss of 30 per cent of placed volume within 10 years, no further recharge has been necessary. The initial scheme cost was significantly less than for a seawall, so the continuing good performance of the scheme as a flood defence can be judged to be very satisfactory.

No adverse criticism of environmental effects has been reported.

The beach now adds to the amenity and aesthetic attributes of Sand Bay.

References/Reports on scheme:
Bown C. J., 1987. Sand Bay beach nourishment: A review of performance. *MAFF Conference of River and Coastal Engineers,* Loughborough, July 1987.

Whitstable, Kent

National Grid coordinates: E 610130, N 166240
Beach material: Shingle and sand **Scheme type:** Recharge
Scheme owner: Canterbury City Council
Scheme designer: Canterbury City Council
Cost of scheme: £5.1 million

Background to works:
Prior to the works, the Seasalter to Whitstable frontage was protected by a combination of seawalls, groynes and mixed sand/shingle beaches. Most of these defences dated from the 1950s to the 1970s, with later additions constructed at the Whitstable Central Area in 1989.

These defences protected both graded London Clay coastal slopes, which range in height from three to 15 metres, and the low-lying Whitstable flood plain. Within the flood plain, which has an area of about 110 ha, there are 2,380 houses and commercial and cultural assets.

Some parts of the Seasalter frontage, where the defences protected the London Clay coastal slopes, had deteriorated over time to the point where the standard of service had reduced to as low as 20 years.

At Whitstable, although the defences were generally in a good condition, there were two sections of the defences at either end of the Whitstable Central Area where the standard of service had reduced to 10-20 years. At both these locations there was a long-term beach erosion trend, with old low groynes and the seawall itself founded on the beach at a relatively high level.

The preferred solution was the construction of a 'small beach' along the coastal cliff frontage, to bring the standard of service to 100 years throughout, and the construction of a 'big beach' at Whitstable to provide a 200-year standard of service. Hardwood timber groynes would be used as beach control structures.

Constraints:
All of the foreshore and intertidal area fronting the works area is designated as SPA/Ramsar and SSSI.

As a result, English Nature imposed working hour restrictions around the high water period, to reduce the disturbance to overwintering birds.

In addition, to protect the foreshore and vegetation established on some parts of the upper beach, an agreement was reached with English Nature to restrict plant movements on the foreshore to a minimum and keep vehicle and plant movements to specific marked routes along the beach.

Restrictions were also imposed on the route taken by vessels bringing beach material to the beach transfer point, due to nearby oyster beds.

All works were carried out in close proximity to private houses and businesses and on beaches that are heavily used by the public throughout the year. Vibration monitoring was undertaken throughout the construction phase, as were detailed pre-and post-construction structural surveys of all properties.

Start date: 2005 **Completion date:** 2006

Description of capital works:
Forty-nine new groynes of average length 47 m were constructed using hardwood imported from Guyana. Beach replenishment using 73,000 m³ of shingle was then carried out. This material was imported from licensed dredging sites in the English Channel located off the Isle of Wight and Hastings.

The dredged beach replenishment material was supplied to a specific grading envelope consisting of 75 mm shingle down to sand. PSD analysis was undertaken on over 100 samples of the delivered material to ensure that the specification was met.

Along the London Clay coastal slopes frontage, the new beach had a gradient of one in eight, with a crest level of 4.0 m AOD at the Railway Wall, 4.35 m AOD. at Admiralty Walk and 4.7 m AOD at Preston Parade. Along the Whitstable flood plain frontage, the new beach had a gradient of one in eight and a crest level of 4.7 m AOD.

Problems during capital scheme:
Site access was a major problem due a relatively high foreshore. As the quantity of beach material required could not be brought in by road via narrow roads with weight restrictions from nearby Whitstable Harbour, flat bottom barges were used to deliver the beach material. These barges brought the beach material to a point approximately 150 m offshore where an unloading/ transfer point was established. The beach material was then loaded into dump trucks at low water and driven along a temporary haul road to the beach and on to the desired tipping point.

As the beach is widely used as a leisure amenity, the nature of the beach material caused quite a bit of controversy with beach hut owners and other members of the public. Although the overall grading of the beach material was maintained within the grading envelope, the material dredged from one of the dredging sites was fairly sharp and angular. This caused numerous complaints from the public, but the problem was overcome by overlaying the beach with a final layer of more rounded beach material sourced from the other dredging site. It is likely that the more angular material will gradually move to the surface in time; however, previous experience suggests that initial abrasion of the sharp edges happens quickly and gradual exposure of this angular material should not present a significant problem in the future.

Plant access to the site was via a new access point, which had to be cut through the existing seawall. All the groyne timber was also brought onto site via this route.

Description of supplementary works:
No alterations or additions have been made to the scheme to date.

Description of monitoring programme:
Beach profiles and beach level grid surveys are carried out as part of the ongoing strategic coastal monitoring programme. Post-survey analysis will indicate if, where and at what rate any beach movement is taking place.

Annual efforts:
It is envisaged that some recycling of beach material will be required after 10 years. Further beach recharge may be required in front of the Golf Club Wall over a similar timescale.

Pictures (before/after):

Before

After

Lessons learnt:
The importance of undertaking considerable public relations effort, both in advance of the contract by the council and during the contract works, when the contractor helped to reduce the impact of the works on the local community.

This started with extensive public consultation and a public exhibition about the proposed scheme. During the course of the works, regular newsletters were sent to local residents and other interested parties and a further public exhibition was produced which was updated as the works progressed. The newsletters were also available on the council's website.

Views on overall success:
In addition to the increased standard of service for the Seasalter to Whitstable frontage, the scheme has had some amenity benefits, mainly for beach users and walkers through the creation of an enhanced promenade in front of the seawall. It is, however, too early to judge the hydraulic performance of the scheme.

References/Reports on scheme:
Canterbury City Council online at Whitstable Coastal Strategy Study

We are The Environment Agency. It's our job to look after your environment and make it **a better place** – for you, and for future generations.

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