Shoreham Harbour

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Abstract

The Beach Management Plan (BMP) topographic surveys have been analysed to examine beach changes that have occurred since the last BMP report between May 2011 and May 2012. The analysis takes into account natural change as well as human induced change.

Shoreham Port Authority carried out shingle bypassing works on two separate occasions within the timeframe of this report; from 24/10/2011 to 02/11/2011 and from 23/04/2012 to 03/05/2012.

The waverider buoy at Seaford recorded five storms above the storm threshold of 3.5 m Hs during this reporting period, (13/12/2011, 03/01/2012, 06/09/2011, 05/01/2012 and 08/12/11) and two of the same events (13/12/2011 & 03/01/2012) were recorded at Rustington.

The highest storm event was on the 13/12/2011 from the SSW with an Hs of 5.21 m and occurred 3 hours after high water. This event was followed, three weeks later by a less intense storm on the 03/01/2012 from the south-west. No post storm surveys were carried out during the reporting period.

The reported volumes of material bypassed were converted from tonnages using a conversion factor of 1.8 m$^3$/tonne. Approximately 7,144 m$^3$ was extracted from 4dSU15 during the October 2011 bypassing operation, with approx. 7,488 m$^3$ being bypassed in April 2012. In both cases, approx. 50% of the material was placed along a 100 m stretch in the western most groyne bay of the 4dSU14 BMP area, with the other 50% being placed along a 50 m stretch in the eastern most groyne bay of the 4dSU14 BMP area.

The profile charts show that between recharge events the western sides of the groyne bays of 4dSU14 deplete significantly. Also, without the artificial removal of material adjacent to the eastern harbour breakwater in 4dSU15, large amounts of shingle would accrete against the breakwater eventually becoming unavailable to the active sediment system. If left unmanaged, the build-up of material in this location could affect the functionality of the port.
1 Introduction

This Beach Management Plan (BMP) report provides an overview of beach changes, beach management events, wave and tidal measurements since the commencement of the Strategic Regional Coastal Monitoring Programme (SRCMP).

Boundaries for the extent of this report are survey units 4dSU14 (Southwick) & 4dSU15 (Shoreham Beach) either side of Shoreham Harbour.

Survey Unit 4dSU15 is managed by the Environment Agency and Survey Unit 4dSU14 by the Shoreham Port Authority. A ‘hold the line’ policy option is in operation for both Units in order to protect the commercial and residential property that lies landward of the frontage.

The beach has been surveyed using aerial survey techniques for the SRCMP since the spring of 2003. For phase 2 of the programme from summer 2007, all topographic surveys between 4dSU24 (Selsey Bill) and 4dSU13 (Brighton) plus 4dSU06 (Seaford) have been undertaken twice a year in spring and autumn using RTK GPS survey equipment. Survey Unit 4dSU23 (Pagham Harbour) has been surveyed using LiDAR since 2009 for operational reasons.

From Phase 3 of the programme that commenced in April 2012, an ATV mounted laser scanner, linked to GPS has been employed for all of our surveys. This has allowed us to collect the data much more quickly and to a much higher resolution than before.

In addition to this, bathymetric surveys of the adjacent seabed were conducted in 2004, 2006 and a multi-beam survey has been undertaken during 2011, this will be reported on in the 2013 BMP report. A network of tide and wave gauges has been established. The location of the frontage is shown in Figure 1.1 and also includes the nearest wave buoy and tide gauge.

![Figure 1.1 Location of Shoreham Harbour, Wave Buoy and Tide Gauge](image)

1.1 4dSU15 – Shoreham Beach

Shoreham Beach is characterised by a broad, relatively flat area of vegetated shingle approximately 50m wide, from the berm crest to the houses that demarcate the back of the beach. The beach is a designated ‘Local Nature Reserve’ due to the presence of vegetated shingle, recognised as a nationally rare habitat. The site has also been identified and designated as a ‘Site of Nature Conservation Importance’.
1.2 4dSU14 – Southwick Beach

Southwick Beach is located on the seaward side of Shoreham Port. The beach has four large and widely spaced rock groynes within the BMP study area, with a series of timber groynes placed immediately after the fourth rock groyne, a concrete outfall pipe and four further rock groynes are placed along the eastern half of the management unit. The beach within the BMP study area is backed by a concrete revetment at the western end which then gives way to a concrete sea wall further to the east.
2 Beach Management Plan Design Conditions

There are no design conditions or alarm and crisis values available for this BMP site at the moment.

Tide Levels for 4dSU14 & 4dSU15 from the UK Hydrographic Office (UKHO) are given in Table 2.1 below.

<table>
<thead>
<tr>
<th>Tide Level</th>
<th>Tide Height Shoreham Port (mODN) 4dSU14 &amp; 4dSU15</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHWS</td>
<td>3.03</td>
</tr>
<tr>
<td>MHW</td>
<td>2.28</td>
</tr>
<tr>
<td>MHWN</td>
<td>1.53</td>
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<tr>
<td>MSL</td>
<td>0.13</td>
</tr>
<tr>
<td>MLWN</td>
<td>-1.37</td>
</tr>
<tr>
<td>MLW</td>
<td>-2.02</td>
</tr>
<tr>
<td>MLWS</td>
<td>-2.67</td>
</tr>
<tr>
<td>Spring Tidal Range (m)</td>
<td>5.70</td>
</tr>
<tr>
<td>Neap Tidal Range (m)</td>
<td>2.90</td>
</tr>
</tbody>
</table>

Table 2.1. UK Hydrographic Office Tide Levels for Shoreham Harbour.
3 Surveys

Since the inception of the SRCMP numerous different survey methods have been used for data collection on this frontage. For the analysis undertaken in this report, the 2012 survey was undertaken using an ATV mounted laser scanner. The 2011 survey was undertaken using Real Time Kinematic (RTK) GPS receivers mounted on All Terrain Vehicles (ATV’s). The November 2007 LIDAR survey was used as the baseline survey.

All surveys cover the over the whole 4dSU15 frontage and the 4 western most groyne bays of 4dSU14, fronting Shoreham Port. From the 2013 BMP report onwards the whole of 4dSU15 & 4dSU14 will be analysed.

The surveys completed on 29 November 2007, 18 & 23 May 2011 and the 09 & 24 May 2012 are used for the comparisons in this report.

Explanatory notes of the survey methodology are given in Annex A. The schedule of surveys completed since the start of the SRCMP is given in Table 3.1 below.
### Table 3.1. Completed surveys

<table>
<thead>
<tr>
<th>4dSU15</th>
<th>4dSU14</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile</td>
<td>Baseline</td>
<td>Bathymetric</td>
</tr>
<tr>
<td>10/03/03</td>
<td></td>
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<td>09/07/09</td>
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<td>24/11/2010</td>
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<td>07/03/12</td>
<td>12/03/12</td>
<td></td>
</tr>
<tr>
<td>24/05/12</td>
<td>09/05/12</td>
<td></td>
</tr>
</tbody>
</table>

#### 4 Beach Management Operations

##### 4.1 Extraction

Shoreham Port Authority bypass shingle biannually (spring and autumn) around the harbour entrance structures in order to maintain beaches on the eastern side of the harbour. Material is extracted from the shingle bank immediately adjacent to the western harbour wall in 4dSU15, as shown in Figure 4.1 below.
For the purpose of data presentation, 4dSU15 has been split into 48 areas labelled on the maps as 4dSU15_1, through to 4dSU15_48, based on either groyne bays or interim profile locations. Material extraction is limited to areas 4dSU15_46 and 4dSU15_47, as shown above in Figure 4.1.

Additional material was sourced in May 2010 from the vicinity of the Southern Water outfall at Black Rock, immediately west of Brighton Marina in 4d-SU13 (Figure 4.2). This extraction was intended to prevent the blockage of the outfall pipe by shingle accretion, whilst providing extra nourishment material for 4d-SU14.

There was no additional material sourced from this area during the spring 2011 or spring 2012 recycling works although this location may be used as a source of material again in the future.
4.2 Deposition

Material is deposited to the east of the harbour structure in the western groyne bays of 4d-SU14, replenishing areas immediately seaward of the sea wall.

For the purpose of data presentation, 4dSU14 has been split into four areas labelled on the maps as 4dSU14_1, 4dSU14_2, 4dSU14_3 and 4dSU14_4, based on the four groyne bays. Deposition of material is limited to areas 4dSU14_2 and 4dSU14_4, as shown below in Figure 4.3. In general, two-thirds of the material is deposited in 4dSU14_2 and one-third in 4dSU14_4.

Figure 4.3 4d-SU14 Deposition Areas

The recycling works relating to this report were undertaken from 24/10/2011 to 02/11/2011 and from 23/04/2012 to 03/05/2012.

It should be noted that the stated volumes of material bypassed and imported in the table below are based on tonnages moved, as reported by Shoreham Port Authority. The volumes stated below have been converted to volumes from tonnes using a conversion factor of 1.8m$^3$ per tonne. Due to the problems associated with tonnage estimation and inaccuracy inherent in the volume conversion, the figures for the resulting net volume change should be considered tentative.
### Table 4.1 Recycling Volumes

*4dSU13 Black Rock Outfall, extraction occurred on 24 May 2010.*
5 Digital Terrain Models (DTM)

Digital Terrain Models of the November 2007 LiDAR baseline survey and the repeat baseline surveys for May 2011 and May 2012 are shown in Figures 5.1 and 5.2 in Annex C. The maps are displayed overlying the 2008 ortho-rectified aerial photography.

Volumes analysed are based on the Digital Terrain Models for each survey, calculated as the amount of material above MLWN (-1.37m ODN).

A summary of all surveyed volumes is given in Table 5.1, with the surveys used for difference modelling in this report shown in bold text below.

<table>
<thead>
<tr>
<th>Survey Date</th>
<th>Survey Type</th>
<th>SU15</th>
<th>4dSU14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>SU14_1</td>
</tr>
<tr>
<td>29/11/2007</td>
<td>LiDAR</td>
<td>2,678,987</td>
<td>13,184</td>
</tr>
<tr>
<td>18/05/2011</td>
<td>ATV BMP Survey</td>
<td>2,656,324</td>
<td>15,375</td>
</tr>
<tr>
<td>09/05/2013</td>
<td>ATV Laser Scan Survey</td>
<td>2,715,764</td>
<td>16,625</td>
</tr>
</tbody>
</table>

Table 5.1 Summary of All Surveyed Volumes (m³)

Note: Values shown are based on calculated volumes derived from generalisations of surface topography measurements, each of which is subject to the accuracy limitations discussed fully in 12.1 Glossary of Data Application.

6 Difference Models

The maps shown in Annex D indicate areas of net erosion or accretion, in terms of the difference between the Digital Terrain Models for each survey. It should be noted that ±0.25m difference in elevation is considered as “no change”, for the purpose of presentation.

Difference calculations analysed within this report are based on volumes obtained from the Digital Terrain Models (DTM’s) for each survey. Volume figures are calculated as the amount of material within a defined area, above MLWN (-1.37m ODN).

It is anticipated that as monitoring continues and further data points are added, projected graph trends will indicate, for example, how much material will be needed for beach recharge and when.

6.1 4dSU15 – Shoreham Beach

Figure 6.1 in Annex D shows the difference between the most recent survey, May 2012, and the previous year’s survey, May 2011, for Survey Unit 4dSU15. Figure 6.2 shows the difference between the May 2012 survey and the November 2007 baseline survey for Survey Unit 4dSU15.
Since November 2007, the BMP area for 4dSU15 has seen a measured gain of 36,777m$^3$ of material. In the most recent year, between May 2011 and May 2012 a gain of 59,443m$^3$ has been recorded across the BMP area.

### 6.2 4dSU14 – Southwick Beach

Figure 6.3 in Annex D shows the difference between May 2012 and May 2011 for 4dSU14, and Figure 6.4 shows the difference between May 2011 and November 2007 for 4dSU14.

Since November 2007, the BMP area for 4dSU14 has seen a measured gain of 13,898m$^3$ of material. Accretion occurred across all groyne bays, particularly in the groyne bay 4dSU14_3, where an increase of 4713m$^3$ has been recorded. Erosion during this period was concentrated in areas towards the back of the beach, particularly towards the NE corners of the groyne bays.

One factor that must be considered is that the 2007 LIDAR survey was undertaken approx. 2 months after the Autumn 2007 bypass operation, with the 2012 Laser Scan Survey being undertaken only 1 month after the bypassing operation.

Between May 2011 and May 2012 a measured loss of 5,681m$^3$ has been recorded.

### 6.3 Summary of Measured Volume Change

Tables 6.1 and 6.2 below summarise the measured changes in volume in each area for both the May 2011 to May 2012 difference model and the November 2007 to May 2012 difference model. The percentage change for each difference is also included to illustrate the significance of the recorded changes.

<table>
<thead>
<tr>
<th>Area</th>
<th>Measured Change (m$^3$) (May 2011 to May 2012)*</th>
<th>% Change</th>
<th>Measured Change (m$^3$) (November 2007 to May 2012)*</th>
<th>% Change</th>
</tr>
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<tbody>
<tr>
<td>4dSU15-1</td>
<td>-825</td>
<td>-1.8</td>
<td>866</td>
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<td>4dSU15-2</td>
<td>-938</td>
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</tr>
<tr>
<td>Area</td>
<td>Measured Change (m³) (May 2011 to May 2012)*</td>
<td>% Change</td>
<td>Measured Change (m³) (November 2007 to May 2012)*</td>
<td>% Change</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------------------------</td>
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<td>--------------------------------------------------</td>
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<td>4dSU15-40</td>
<td>3,486</td>
<td>3.8</td>
<td>9,892</td>
<td>11.6</td>
</tr>
<tr>
<td>4dSU15-41</td>
<td>10,834</td>
<td>9.6</td>
<td>11,538</td>
<td>10.3</td>
</tr>
<tr>
<td>4dSU15-42</td>
<td>2,898</td>
<td>3.5</td>
<td>9,569</td>
<td>12.5</td>
</tr>
<tr>
<td>4dSU15-43</td>
<td>2,449</td>
<td>2.1</td>
<td>12,076</td>
<td>11.1</td>
</tr>
<tr>
<td>4dSU15-44</td>
<td>3,408</td>
<td>2.7</td>
<td>13,854</td>
<td>12.0</td>
</tr>
<tr>
<td>4dSU15-45</td>
<td>7,390</td>
<td>5.7</td>
<td>12,108</td>
<td>9.7</td>
</tr>
<tr>
<td>4dSU15-46</td>
<td>11,599</td>
<td>11.2</td>
<td>4,476</td>
<td>4.1</td>
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<tr>
<td>4dSU15-47</td>
<td>3,849</td>
<td>15.0</td>
<td>298</td>
<td>1.0</td>
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<tr>
<td>4dSU15-48</td>
<td>3,042</td>
<td>20.6</td>
<td>581</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59,443</strong></td>
<td><strong>2.2</strong></td>
<td><strong>36,777</strong></td>
<td><strong>1.4</strong></td>
</tr>
</tbody>
</table>

Table 6.1 4d-SU15 Summary of Material Gain and Loss
### Table 6.2 4d-SU14 Summary of Material Gain and Loss

<table>
<thead>
<tr>
<th>Area</th>
<th>Measured Change (m³) (May 2011 to May 2012)*</th>
<th>% Change</th>
<th>Measured Change (m³) (November 2007 to May 2012)*</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>4dSU14_1</td>
<td>1,250</td>
<td>8.1</td>
<td>3,441</td>
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<tr>
<td>4dSU14_2</td>
<td>-6,796</td>
<td>-15.0</td>
<td>2,470</td>
<td>6.9</td>
</tr>
<tr>
<td>4dSU14_3</td>
<td>-213</td>
<td>-0.4</td>
<td>4,714</td>
<td>10.3</td>
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<tr>
<td>4dSU14_4</td>
<td>79</td>
<td>0.3</td>
<td>3,274</td>
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</tr>
<tr>
<td><strong>4dSU14</strong></td>
<td><strong>Total</strong></td>
<td><strong>-5,681</strong></td>
<td><strong>13,898</strong></td>
<td><strong>11.3</strong></td>
</tr>
</tbody>
</table>

*Negative figures represent erosion and positive figures accretion of beach material.

### 6.4 Summary of Recycling and Net Change

<table>
<thead>
<tr>
<th>Area</th>
<th>Measured Change (m³) (May 2011 to May 2012)</th>
<th>Volume Bypassed (m³)*</th>
<th>Net Sediment Change (m³) (May 2011 to May 2012)</th>
<th>% Net Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>4dSU15</td>
<td>59,443</td>
<td>-14,632</td>
<td>74,075</td>
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<tr>
<td>4dSU14</td>
<td>-5,681</td>
<td>14,632</td>
<td>-20,313</td>
<td></td>
</tr>
</tbody>
</table>

*Table 6.3 Measured and Net Changes – May 2011 to May 2012

<table>
<thead>
<tr>
<th>Area</th>
<th>Measured Change (m³) (November 2007 to May 2012)</th>
<th>Volume Bypassed (m³)*</th>
<th>Net Sediment Change (m³) (November 2007 to May 2012)</th>
<th>% Net Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>4dSU15</td>
<td>36,777</td>
<td>-78,559</td>
<td>115,336</td>
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<tr>
<td>4dSU14</td>
<td>13,898</td>
<td>86,070</td>
<td>-72,172</td>
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</tr>
</tbody>
</table>

*Table 6.4 Measured and Net Changes – November 2007 to May 2012

*Negative figures represent extraction and positive figures deposition of recycled material.

Tables 6.3 and 6.4 above compare the amounts of shingle bypassed and imported with the measured change for the reporting period to establish a net change in beach volume for each area.

The ‘Volume Bypassed (m³)’ column in table 6.3 (column 3) states the total volume of shingle bypassed during the reporting period and includes the total volume of shingle extracted during the winter bypassing operation in October 2011 and the total volume of shingle extracted during the April 2012 bypassing works.

The difference between the figures of measured change (based on BMP topographical survey data) and the volume bypassed for 4dSU15 is 74,075m³. The difference between the measured and bypassed figures for 4dSU14 is 20,313m³.
These following points should be noted when considering these figures:

- **Survey Timing** – Surveys either side of Shoreham Harbour aren’t undertaken on the same day, so losses / gains will occur during the period between each sites survey. Plus if any given survey is undertaken before a bypass and the previous or following survey were undertaken after a bypass, results would be skewed. It is therefore important that the net change figures are used.

- **Unquantified Recycling** – over the period this report covers there have been two cases where material has been recycled or placed where the exact quantities moved remains unknown. These are as follows:

  - January 2012 – Emergency Recycling Works were undertaken by the Environment Agency in the region of Lancing Green, between areas 4dSU15_1 & 4dSU15_8 on the 4dSU15 frontage. An OUT Survey and the February 2012 Lancing Recycling report comparing the collected data against the Shoreham to Lancing schemes design profile was undertaken by the Worthing BC Coastal Survey Team and is included in Annex H

  - May 2012 – Material was placed in the eastern most bay of 4dSU14 (4dSU14_1) following concerns by Shoreham Port following stormy conditions. Further details are provided in Annex H

- The stated volumes of material bypassed and imported in the table below are based on tonnages moved, as reported by Shoreham Port Authority. The volumes stated below have been converted to volumes from tonnes using a conversion factor of 1.8m$^3$ per tonne. Due to the problems associated with tonnage estimation and inaccuracy inherent in the volume conversion, the figures for the resulting net volume change should be considered tentative.

Consequently, the amounts stated in the tables above are intended to be representative of the proportion of measured change that can be considered to be due to natural sediment transport, the net sediment change.

The ‘Volume Bypassed (m$^3$)’ figures between 4dSU15 and 4dSU14 in table 6.4 above, differ due to an additional 7,512m$^3$ of shingle imported from 4dSU13 during May 2010 and deposited in the BMP area of 4dSU14, as described in section 4.2.

Figures 6.1 and 6.2 below, show a graphical representation of the volumetric changes over time, above MLWN (-1.37mODN).
7 Profile Change Analysis

A cross-sectional area (CSA) has been calculated for all beach profiles. This is calculated as the area of profile above a Master Profile. For the Shoreham Beach frontage, the lower boundary of the Master Profile is Mean Low Water Neaps (MLWN) (-1.37mODN) and the landward boundary is the back of the active beach. The Master Profile is held constant for a given profile line and therefore the changes in CSA through time can be compared.

Further information about the method of calculation for the change in CSA can be found in the Explanatory Notes in Annex A.

Analysis of the profiles has been carried out using the November 2007, May 2011 and May 2012 surveys. All profile change Figures are shown in Annex E.

Blue text below highlights areas of accretion, whilst red text highlights areas of erosion.

7.1 4dSU15 – Shoreham Beach

Figure 7.1 in Annex E shows the change in CSA between the May 2012 and the May 2011 survey for 4dSU15. Figure 7.2 shows the change in CSA between May 2012 and the baseline survey in November 2007 for 4dSU15.

Between May 2011 and May 2012 the BMP area remained stable with a small gain in beach cross sectional area of 1.2%, equating to 7.7m$^2$. The greatest individual loss was 8.5% which equates to 56m$^2$ at profile 4d00693A. The greatest individual gain was 14.5% which equates to 98.1m$^2$ at profile 4d00650, just west of the extraction area. Figure 7.5 & 7.6 below, illustrate the profile changes described above, between the 2007, 2011 and 2012 BMP surveys.

Profiles 4d00647 and 4d00648 (Figures 7.7 and 7.8 respectively, below) also show profile changes within the shingle bypassing extraction area.
Figure 7.5 – Profile Envelope Chart – Profile 4d000693A

Figure 7.6 – Profile Envelope Chart – Profile 4d000650
Between November 2007 and May 2012 the BMP area was stable with a small gain in beach cross sectional area of 1%, equating to 13.9m$^2$. The greatest gain was an increase of 18.3% or 77.2m$^2$ at profile 4d00683. The greatest loss was a decrease of 24.6% or 85.9m$^2$ at profile 4d00741A.

The majority of losses on the 4dSU15 frontage are at the western (groyned) half of the frontage, whereas all the gains are along the open beach stretch in the east.
7.2 4dSU14 – Southwick Beach

Figure 7.3 (Annex E) shows the change in CSA between the May 2012 and May 2011 survey for 4dSU14. Figure 7.4 (Annex E) shows the change in CSA between May 2012 and the baseline survey in November 2011 for 4dSU14.

Between May 2011 and May 2012 the BMP area was stable with a small loss in beach cross sectional area of 2.6%, equating to 6.5m². The greatest gains were an increase of 24.8% or 26.6m² at profile 4d00637 which lies towards the western end of area 4dSU14_1. 23.1% or 26.7m² at profile 4d00630 and 5.1% equating to 6.5m² at profile 4d00629. These latter two profiles lie just down-drift of the eastern most deposition area. The greatest loss was a decrease of 19.8% or 35.1m² at profile 4d0642 (see figure 7.8 below), which is the second profile east of the eastern harbour arm, within the western most deposition area.

![Figure 7.8 – Profile Envelope Chart – Profile 4d000642](image)

Between November 2007 and May 2012 the BMP area showed overall accretion, with a net gain in beach cross sectional area of 13.3%, equating to 17m². The most significant gains were increases of 49.6% or 35.8m² and 30.6% or 31.4m² occurring at profiles 4d00644 and 4d00637 respectively. No Profiles recorded losses over this period.

8 Changes in Mean High Water Position

The varying shape of the beach (illustrated in the beach profile plots) affects the position of the Mean High Water (MHW) line. Figures 8.1 and 8.2 in Annex F show the positions of the MHW line for November 2007, May 2011 and May 2012 for 4dSU15 and 4dSU14 respectively, based on contours of the survey data.

The maps show that since 2007, the MHW position in 4dSU15 has uniformly extended seawards by approximately 10-12m east of the rock groynes at the western end of the

---

1 Mean High Water level at Shoreham Harbour is 2.28m ODN
frontage. Within the rock groyne bays the MHW position has moved landwards between 2 and 15m since 2007, with the largest shift in the vicinity west of Lancing Sailing Club.

The MHW position in 4dSU14 is less uniform, although generally the MHW position has moved seaward by varying degrees since 2007.

9 Bathymetric Data Analysis

The results of the 2006 – 2007 hydrographic survey are presented in Annex C as Digital Terrain Models (Figures 9.1 and 9.2). The survey data is taken from a single beam survey. A multi-beam survey of this area was undertaken during 2011 and should be available for analysis in the 2013 report.

10 Wave Climate

Annex G presents a detailed analysis of the wave climate and storm events between July 2011 and June 2012 based on Wave Buoy data from Rustington and a separate analysis of the wave buoy data from Seaford. Both wave reports have been included as Shoreham harbour lays at the centre of the frontage between the two wave buoys.

11 Storm event performance

No post storm surveys were conducted at Shoreham after the storm events.

12 Additional Analysis

There is no additional analysis.

13 Particle Size Analysis

No particle size data have been collected for this BMP site.

14 Assessment of Beach Performance against Critical Levels.

No critical levels have been assigned to this Management unit at this time.

15 Report Update

This report will be updated in autumn 2013 / Spring 2014 and is expected to include details from the autumn 2012 and spring 2013 shingle bypassing operation and the 2011 multi-beam bathymetric survey – the data of which has been delayed due to the contractor going into administration.
Annex A
Explanatory Notes
EXPLANATORY NOTES

1. Summary of method of conducting topographic and hydrographic surveys (based on the Environment Agency’s National Specification Sections XIII and XII)

Topographic cross-shore (profile) measurements are made at the intercept of the beach and a hard structure, at all changes of beach slope, at changes in surface sediment and at maximum defined intervals (every 5 metres). At some sites (those with long, low-tide terraces), the maximum interval is relaxed to 10 metres seawards of 50 metres from the beach toe. Each measurement is feature-coded with the sediment type. Profiles are 100-500m apart, depending on management status. The seaward limit is Mean Low Water Neaps.

Topographic baseline (spot height) surveys are carried out annually at Beach Management Plan sites. Cross-shore profiles are measured at 50 m intervals (in the same manner as for beach profiles) with the addition of spot heights at the crest and toe of hard structures, the beach surface surrounding structures, all beach ridge crests, all other changes in slope and sediment changes. All measurements are feature-coded with sediment type. Sufficient data points must be measured to generate a reliable Digital Terrain Model.

Hydrographic surveys are conducted with a single beam echo-sounder, with the position fixing requirement relaxed to DGPS. Soundings are taken along cross-shore profile lines 50m apart and extend 1km offshore. A minimum of 4 shore parallel tie lines are required (including one near each of the landward and seaward boundaries). The landward limit varies slightly across the region, due to the variation in tidal range, but in general is landward of Mean Sea Level, thus providing overlap with the topographic surveys. Tidal control may be by RTK GPS or by correction from tide gauges which are tied to the survey control network.

2. Change in Cross-sectional Area (CSA)

The annual change in cross-sectional area is calculated as the difference in CSA between two surveys, expressed as a percentage change compared to the earlier CSA.

\[
\frac{CSA_1 - CSA_2}{CSA_2} \times 100
\]

Eqn (1)

where CSA_1 = most recent springtime survey and CSA_2 = spring survey previous year. Therefore an annual change of –14% represents erosion during the last year of 14% of the area of last year’s survey.

3. Method of derivation of Digital Terrain and difference models

The Digital Terrain Model is created by interpolating the points of a topographic baseline survey collected by using RTK GPS system. The interpolation method used to create the SCOPAC DTM is specified as Natural Neighbour and is applied in ArcGIS to create a 1 metre resolution grid. The Natural Neighbours interpolation creates a Delauney Triangulation of the input points and selects the closest nodes that form a convex hull around the interpolation point, then weights their values by proportionate area. A Natural Neighbours interpolation combines TIN functionality with the raster interpolation process.
To visualise the resulting grid, the same colour scheme is applied, thus enabling comparison between grids of different geographic origin. The colour bands cover a elevation range between -4 to +12 metres OD with elevations lying between -2 and + 5 metres OD are shown in 0.5 metres intervals, the remaining elevation bands shown in 1 metre intervals.

The difference models are created by using a grid calculator within the GIS system. For example the difference model of two baseline surveys is created by subtracting the earlier baseline grid from the most recent baseline grid:

\[ \text{Grid}_1 - \text{Grid}_2 \quad \text{Eqn (2)} \]

where \( \text{Grid}_1 \) = most recent baseline grid and \( \text{Grid}_2 \) = previous baseline grid. Therefore an annual change of \(-14m^2\) represents erosion during the last year of \(14m^2\), whilst positive values represent accretion over the period.

Within the SDCG, the Digital Terrain Model is created by interpolating the points of a topographic baseline survey collected using aerial photography and photogrammetry techniques. The interpolation method used to create the SDCG DTMs is specified as Triangular Irregular Network (TIN) and is applied in Vertical Mapper to create a 1 metre resolution grid. The TIN interpolation connects points based on the nearest neighbour relationship (the Delaunay criterion) which states that a circumcircle drawn around any triangle will not enclose the vertices of any other triangle.
Annex B
Glossary
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Glossary

Data Application

This section aims to provide guidance on the accuracy and limitations of the Strategic Regional Coastal Monitoring Programme data, in order to inform its use and application. It must be appreciated that the accuracies of each measurement system must be taken into account when drawing conclusions from the data, particularly when interpreting difference models.

Topographic survey data

Topographic data points collected with RTK GPS can be considered accurate to ±0.03m for the baseline (spot height) surveys, which are used to generate both DTM's and difference models. Accordingly, differences of ±0.06m can generally be considered as ‘real’, whilst smaller changes may be an artefact of the measuring system, and should be considered as ‘no change’. In practice, Regional Monitoring Programme analysis considers only differences in excess of ±0.25m, as indicative of genuinely measurable change. Smaller changes may also be present but these are filtered from the analysis to provide clarity. Nevertheless, even where detailed analysis of difference models suggests that the changes are real, the user should approach the results as indicative, unless reinforced over time or with other information.

LIDAR data

LIDAR (‘Light Detection and Ranging’) is an aeroplane-mounted optical remote sensing technology. Modelling using LIDAR as the source the data set is less precise than RTK GPS. Each LIDAR cell value has a plan position representative of a 1m² grid (pre-2007 data is 2m² resolution). Changes with positional accuracy of better than 1-2m, therefore, cannot be observed. Profiles across steep slopes may suggest that the changes ‘bounce’ back and forth. This is an artefact of the accuracy of the source data. LIDAR is particularly ineffective at identifying sharp edges or steep slopes e.g. seawalls and cliffs where an affect known as ‘shadowing’ can occur. Despite these limitations in accuracy, the changes will indicate an overview of change, but to a lower precision than the RTK data. Users should compare the differences with the adjacent topographic profiles to confirm how representative lidar difference models are of real change.

Ortho-photography

All ortho-photography since 2002 uses a common ground control network, but care must be taken when comparing results with earlier photography. It is not unknown for instances of swimming pools to have ‘moved’ up to 2m, due to a different control network.
Coastal Terms

**Beach Backstop**
This maybe defined as a seawall, promenade or any other structure at the back of a beach. If no backstop structure exists, for the purposes of master profile analysis this is the perceived landward boundary of any given active beach.

**Coastal Process Cell**
The coast of the UK has been divided into a series of Major Coastal Cells, many with sub-cells. These sub-cells represent a practical subdivision of the coastline into lengths that follow sediment cell principles while enabling suitably sized groups to be formed to consider coastal defence issues at the strategic level. This provides the necessary framework for Operating Authorities to prepare Shoreline Management Plans (SMP’s).

Coastal Process Cells of Southeast UK

**Cross-Sectional Area**
The cross-sectional area is the area between the survey profile and the master profile.

**Management Unit**
A Management Unit is a length of shoreline with coherent characteristics in terms of natural coastal processes, land use and coastal defence.

**Master Profile**
The Master Profile is the boundary or datum, which any given profile is measured against. Each profile has a unique Master Profile, with a lower boundary of Mean Low Water Neaps (MLWN), which allows only the active beach cross-section of each survey to be measured and compared against other surveys.

**Mean High Water Contour**
The Mean High Water (MHW) contour is the line at which the beach intersects the average High Water elevation for a particular region. This implies that beach erosion (and subsequent encroachment of the sea) can be highlighted as a landward shift of the MHW contour. As shown below, the amount by which the MHW position will shift for a given change in volume is directly related to the steepness of beach.
Specifically, loss of material on a low gradient (gently sloping) beach will result in a more significant landward movement of the MHW position than the same volume loss on a steeper beach:

![Beach steepness affecting shift in Mean High Water Position](image)

Similarly, cases where erosion itself has caused beach steepening would be reflected in the narrowing of the distance between the MHW and Mean Low Water (MLW) contours over the same time period. Thus, the changing shape of the beach can be inferred from the changing contour positions.

![Beach steepening](image)

**Profile**

A profile is cross-section through a beach; normal to the shoreline, where repeatable topographic, hydrographic and LIDAR surveys can be undertaken in order for changes in beach level to be observed. In the 4d coastal sub cell, nearly 1500 profiles 1km in length exist at an average longshore spacing of 50m. Different types of profiles are surveyed at different times - interim profiles (those spaced at 200m) are surveyed in every survey, with baseline profiles (those spaced at 50m) surveyed only when a Beach Management Plan or repeat baseline survey is undertaken.

*Note: Profile lines displayed in the Profile Change Summary maps are intended to indicate Profile locations and may be longer or shorter than the actual width of frontage covered.*
**South Downs Coastal Group**

The former Coastal Group that was concerned with matters relating to the frontage between Beachy Head and Selsey Bill, or coastal sub-cell 4d. The SDCG has now been amalgamated with the South-East Coastal Group, and now covers coastal cell 4 between the Thames Estuary and Selsey Bill.

All Coastal Groups are made up of Local Authority, County Council and other coastal stakeholders. For further information about the South Downs and South East Coastal Groups, please visit [http://www.sdcg.org.uk/](http://www.sdcg.org.uk/) and [http://www.se-coastalgroup.org.uk/](http://www.se-coastalgroup.org.uk/)
Annex C

Digital Terrain Models
Hydrographic Digital Terrain Models
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Figure 5.1 - 4dSU15 Digital Terrain Model Comparison (1 of 8)

Shoreham Beach

November 2007

May 2011

May 2012
Figure 6.1 - 4dSU15 Digital Terrain Model Comparison (6 of 6)
Figure 9.2 - 4d-SU14 2006 - 2007 Hydrographic Survey (Single Beam)
Annex D
Difference Models
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Figure 6.2 - 4dSU15 Difference Model (2 of 9)

Volume (m³)
8,514

Red = Material Lost
Blue = Material Gained

Model Extent

Change in Elevation (m) between November 2007 and May 2012

- >= 3
- 2.5 to 3
- 2 to 2.5
- 1.5 to 2
- 1 to 1.5
- 0.5 to 1
- 0.25 to 0.5
- 0.25 to 0.25
- 0.5 to -0.25
- 1 to 0.5
- 1.5 to -1
- 2 to -1.5
- 2.5 to -2
- 3 to -2.5
- <= -3
Figure 6.2 - 4dSU15 Difference Model (5 of 9)
Southeast Strategic Regional Coastal Monitoring Programme

BMP Site Report 2012

Change in Elevation (m) between November 2007 and May 2012

Volume (m3) 8,514

Red = Material Lost
Blue = Material Gained

Model Extent

(2008 Aerial Photography)
Annex E

Profile Change Summary
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Figure 7.1 - Condition of Survey Unit 4d-SU15 - Beach Change (1 of 9)

SDCG - Shoreham Beach

% Change in X-Sectional Area
(May 2011 to May 2012)

- Accretion
  - > 30% (0)
  - 15 - 30% (1)
  - 5 - 15% (7)
- No Change
  - Less than 5% (94)
  - 5 - 15% (5)
  - 15 - 30% (0)
  - > 30% (0)

SU Boundary
Actual m2 Change in Cross-Sectional Area

(2008 Aerial Photography)
Figure 7.1 - Condition of Survey Unit 44-SU15 - Beach Change (4 of 9)
Figure 7.1 - Condition of Survey Unit 44-SU15 - Beach Change (8 of 9)
Figure 7.2 - Condition of Survey Unit 4d-SU15 – Beach Change (2 of 5)
Figure 7.2 - Condition of Survey Unit 4d-SU15 - Beach Change (3 of 3)
Figure 7.2 - Condition of Survey Unit 4d-SU-H - Beach Change (9 of 9)

Southeast Strategic Regional Coastal Monitoring Programme

BMP Site Report 2012

(2008 Aerial Photography)
Figure 7.3 - Condition of Survey Unit 4d-SU14 - Beach Change

SDCG - Shoreham Harbour (West)

% Change in X-Sectional Area
(May 2011 to May 2012)
- Accretion
  - 15 - 30% (2)
  - 5 - 15% (1)
- No Change
  - Less than 5% (5)
  - 5 - 15% (6)
- Erosion
  - 15 - 30% (3)
  - > 30% (0)
Figure 7.4 - Condition of Survey Unit 4d-SU14 - Beach Change

SDCG - Shoreham Harbour (West)
Annex F

Mean High Water Position
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Figure 8.1 - 4d-SU15 Mean High Water Position (6 of 9)
Figure 8.2 - 4d-SU14 Mean High Water Position

MHW Position
+ 2.28 m OD

- November 2007
- May 2011
- May 2012

(2008 Aerial Photography)
Annex G

Rustington Wave Buoy Report
Seaford Wave Buoy Report
Rustington Waverider Buoy - July 2011 to June 2012

Location
OS: 506333E 93783N
WGS84: Latitude: 50° 44.036' N  Longitude: 00° 29.677' W

Water Depth
~10 m CD

Instrument Type
Datawell Directional Waverider Mk III

Data Quality

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Storm Analysis

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<th>Tₚ (s)</th>
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<td>2.1</td>
<td>0.20</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Table D1: Highest storms during the reporting period, July 2011 to June 2012

A storm is defined using the Peaks-over-Threshold method (Figure D1). Each storm is then examined in detail, and covers the period 16 hours either side of the storm peak, so as to include both the build-up and decay of the storm. This is the procedure recommended by the CIRIA Beach Management Manual (second edition) since it covers the build-up and decay typical of mid-latitudes depression.

The threshold used for Rustington is 3.5m. Originally, the threshold was 3m, which necessarily erred on the low side for the first few years of deployment. The revised value has been determined using extremes analysis of 8 years of measured data (based on 3 hourly values) and the 0.25 year return period is used to identify 4 storms in an average year.

Figure D1: Storm definition

* Tidal information is obtained from the nearest recording tide gauge (the gauge on Arun Platform). The surge shown is the residual at the time of the highest Hₜ. The maximum tidal surge is the largest positive surge during the storm event.
Summary

This reporting year was relatively quiet in terms of number of storms, concentrated in December and January, but also experienced the highest waves measured since the deployment of the buoy. Apart from some isolated periods of moderate waves, the winter months from mid-January to March were unusually quiet.

Figure D2: Incidence of storms during reporting period (top) and since deployment (bottom)

Acknowledgements

TASK2000 tidal prediction software was kindly provided by the Permanent Service for Mean Sea Level, Proudman Oceanographic Laboratory.
Monthly time series of Hs

Figure D3: Monthly time series of Hs at Rustington. Storm threshold, shown in red, is 3.5 m
Highest storm

This was the highest storm since the deployment of the wave buoy in 2003 and waves were breaking at the buoy for several hours during this storm; where breaking waves were clearly present in the measured time series, the parameters have been omitted. Accordingly, there are likely to have been short periods where measured significant wave heights the values shown.

The storm was associated with a deep depression (central pressure 946 hPa), situated to the west of Scotland (Figure D5) and saw a typical rapid rise in significant wave height from 3 to ~4.5m and subsequent decay within 8 hours. There is evidence of some long period swell some 14 hours prior to the storm peak. Wave direction backed from SW to SSW during the hours of highest waves, veering back to SW as the seas reduced below 3m. The main period of high waves spanned High Water, on a spring tide, but tidal surge was quite small (~0.3m).

Rustington - Storms during Jul 2011 to Jun 2012

Figure D4: Highest storm of the reporting period
Figure D5: Surface Pressure chart on 13 December 2011 at 00:00Z

Figure D6: Surface Pressure chart on 14 December 2011 at 00:00Z
Second highest storm

This storm also resulted from a deep depression (central pressure 968 hPa) off northwest Ireland (Figure D8), but was shorter-lived and with no evidence of a long period swell train. Storm direction remained SW for the duration of the storm, the peak of which occurred around mid-tide on a neap tide.

Figure D7: Second highest storm of the reporting period
Figure D8: Surface Pressure chart on 03 January 2012 at 00:00Z
Seaford Waverider Buoy - July 2011 to June 2012

Location
OS: 546444E 98367N
WGS84: Latitude: 50° 45.984' N  Longitude: 00° 04.517' E

Water Depth
~13 m CD

Instrument Type
Datawell Directional Waverider Mk III

Data Quality

<table>
<thead>
<tr>
<th>Recovery rate (%)</th>
<th>Sample interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>97</td>
<td>30 minutes</td>
</tr>
</tbody>
</table>

Storm Analysis  

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>$H_s$ (m)</th>
<th>$T_o$ (s)</th>
<th>$T_z$ (s)</th>
<th>Dir. (o)</th>
<th>Water level elevation (OD)</th>
<th>Tidal stage (hours re. HW)</th>
<th>Tidal range (m)</th>
<th>Tidal surge* (m)</th>
<th>Max. surge* (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-Dec-2011 03:00</td>
<td>5.21</td>
<td>10.0</td>
<td>7.4</td>
<td>207</td>
<td>1.17</td>
<td>HW +3</td>
<td>5.5</td>
<td>0.34</td>
<td>0.41</td>
</tr>
<tr>
<td>03-Jan-2012 12:00</td>
<td>4.33</td>
<td>8.3</td>
<td>6.7</td>
<td>221</td>
<td>-0.81</td>
<td>HW +5</td>
<td>2.7</td>
<td>0.42</td>
<td>0.44</td>
</tr>
<tr>
<td>06-Sep-2011 13:00</td>
<td>3.85</td>
<td>8.3</td>
<td>6.2</td>
<td>225</td>
<td>-1.02</td>
<td>HW -5</td>
<td>2.9</td>
<td>0.04</td>
<td>0.15</td>
</tr>
<tr>
<td>05-Jan-2012 02:30</td>
<td>3.74</td>
<td>8.3</td>
<td>6.2</td>
<td>235</td>
<td>-1.21</td>
<td>HW -6</td>
<td>3.2</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>08-Dec-2011 17:30</td>
<td>3.72</td>
<td>9.1</td>
<td>6.2</td>
<td>225</td>
<td>-1.44</td>
<td>HW -4</td>
<td>4.0</td>
<td>-0.04</td>
<td>-0.37</td>
</tr>
</tbody>
</table>

Table D1: Highest storms during the reporting period, July 2011 to June 2012

A storm is defined using the Peaks-over-Threshold method (Figure D1). Each storm is then examined in detail, and covers the period 16 hours either side of the storm peak, so as to include both the build-up and decay of the storm. This is the procedure recommended by the CIRIA Beach Management Manual (second edition) since it covers the build-up and decay typical of mid-latitudes depression.

The threshold used for Seaford is 3.5 m.

* Tidal information is obtained from the nearest recording tide gauge (the National Network gauge at Newhaven). The surge shown is the residual at the time of the highest $H_s$. The maximum tidal surge is the largest positive surge during the storm event.
Summary

This reporting year contained several storms above the 3.5m threshold, concentrated in December and January, but with a moderately high storm in September 2011. Apart from some isolated periods of moderate waves, the winter months from mid-January to March were unusually quiet.

Figure D2: Incidence of storms during reporting period (top) and since deployment (bottom)

Acknowledgements

Tidal data were supplied by the British Oceanographic Data Centre as part of the function of the National Tidal and Sea Level Facility, hosted by the Proudman Oceanographic Laboratory and funded by DEFRA and the Natural Environment Research Council.
Monthly time series of Hs

Figure D3: Monthly time series of H_s at Seaford. Storm threshold, shown in red, is 3.5 m
**Highest storm**

The largest storm of the reporting period was associated with a deep depression (central pressure 946 hPa), situated to the west of Scotland and saw a typical rapid rise in significant wave height from 3 to ~5m and subsequent decay within 12 hours, with peak wave periods around 10s. Wave direction backed from SW to S during the hours of highest waves, veering back to SW as the seas reduced below 3m. The main period of high waves spanned High Water, on a spring tide, but tidal surge was quite small (~0.3m).

*Figure D4: Highest storm of the reporting period*
Figure D5: Surface Pressure chart on 13 December 2011 at 00:00Z

Figure D6: Surface Pressure chart on 14 December 2011 at 00:00Z
Second highest storm

This pattern of this storm was very similar to the highest storm of the reporting period, although less long-lived and the peak of the storm occurred around High Water, accompanied by a minor surge. Storm direction was from the SW.

Figure D7: Second highest storm of the reporting period
Figure D8: Surface Pressure chart on 03 January 2012 at 00:00Z
Third highest storm

This was a short-lived storm from the SW, again with the peak occurring around Low Water and with negligible storm surge.

Figure D9: Third highest storm of the reporting period
Annex H

February 2012 Lancing Recycling Report
May 2012 Shoreham Port Material Deposition Email
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CONTENTS

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Annex A: Difference Models
1 Executive Summary

This report provides a detailed analytical overview of beach changes occurring as a consequence of recycling beach material along the Lancing frontage in West Sussex.

The study area consists of thirteen distinct groyne bays, labelled ‘GB1’ to ‘GB13’ from Brooklands lake in the West to the vicinity of Golden Sands park in the East.

The recycling event has been undertaken by the Environment Agency in response to the erosion that occurred due to the mid-December and early January winter storms, with a full topographic OUT survey conducted on the 27 January 2012 following the recycling operation.

Comparisons of the OUT survey with the Design, Action and Emergency profiles of the beach, as given in the 2003 Beach Management Plan for Shoreham and Lancing, have highlighted several intervention works required at the site.

Table 1.1 below gives a priority list of works required in the recycling area.

<table>
<thead>
<tr>
<th>Immediate Emergency Works:</th>
<th>1. Increase berm width in GB3 to more than 5m.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Increase berm width in GB13 to more than 5m.</td>
</tr>
<tr>
<td>Recommended Works:</td>
<td>3. Increase berm width in GB3 to more than 10m.</td>
</tr>
<tr>
<td></td>
<td>4. Increase berm width in GB13 to more than 10m.</td>
</tr>
<tr>
<td></td>
<td>5. Increase berm width in GB4 to more than 10m.</td>
</tr>
<tr>
<td></td>
<td>6. Increase berm width in GB1 to more than 10m.</td>
</tr>
<tr>
<td>Ideal Works:</td>
<td>7. Increase berm width in GB3 to at least 12m.</td>
</tr>
<tr>
<td></td>
<td>8. Increase berm width in GB13 to at least 12m.</td>
</tr>
<tr>
<td></td>
<td>9. Increase berm width in GB4 to at least 12m.</td>
</tr>
<tr>
<td></td>
<td>10. Increase berm width in GB9 to at least 12m.</td>
</tr>
<tr>
<td></td>
<td>11. Increase berm width in GB10 to at least 12m.</td>
</tr>
<tr>
<td></td>
<td>12. Increase berm width in GB1 to at least 12m.</td>
</tr>
</tbody>
</table>

Table 1.1 Priority List of ideal, recommended and emergency works at the recycling site

---

1 Shoreham and Lancing Sea Defences Beach Management Plan, Halcrow 2003
2 Introduction

This report provides a detailed analytical overview of beach changes occurring as a consequence of recycling beach material along the Lancing frontage in West Sussex. The recycling event has been undertaken by the Environment Agency in response to the relatively severe erosion that occurred during mid-December 2011 and early January 2012 storms. Figure 2.1 shows the recycling area location.

Figure 2.1 Location of Recycling Area

The recycling area consists of thirteen distinct groyne bays, labelled for this report as ‘GB1’ to ‘GB13’ from Brooklands lake in the West to the vicinity of Golden Sands park in the East, as shown in Figure 2.2.

Figure 2.2 Groyne Bays labelled GB1 to GB13 in Recycling Area
2.1 Design Conditions
Tide Levels from the UK Hydrographic Office for the recycling area are given in Table 2.1 below.

<table>
<thead>
<tr>
<th>4d-MU9A</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tide Level</strong></td>
<td><strong>Tide Height (mODN)</strong></td>
</tr>
<tr>
<td>Mean High Water Springs</td>
<td>3.03</td>
</tr>
<tr>
<td>Mean High Water</td>
<td>2.28</td>
</tr>
<tr>
<td>Mean High Water Neaps</td>
<td>1.53</td>
</tr>
<tr>
<td>Mean Sea Level</td>
<td>0.13</td>
</tr>
<tr>
<td>Mean Low Water Neaps</td>
<td>-1.37</td>
</tr>
<tr>
<td>Mean Low Water</td>
<td>-2.02</td>
</tr>
<tr>
<td>Mean Low Water Springs</td>
<td>-2.67</td>
</tr>
<tr>
<td>Springs Tidal Range (m)</td>
<td>5.7</td>
</tr>
<tr>
<td>Neaps Tidal Range (m)</td>
<td>2.9</td>
</tr>
</tbody>
</table>

*Table 2.1 4d-MU9A - UK Hydrographic Office Tide Levels.*

Table 2.2 below shows the extreme water level predictions given in the 2003 Beach Management Plan for Shoreham and Lancing.¹

<table>
<thead>
<tr>
<th>Return Period (1:x year)</th>
<th>Water Level (mODN) 2000</th>
<th>Water Level (mODN) with Sea Level Rise 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.69</td>
<td>3.94</td>
</tr>
<tr>
<td>2</td>
<td>3.77</td>
<td>4.02</td>
</tr>
<tr>
<td>5</td>
<td>3.87</td>
<td>4.12</td>
</tr>
<tr>
<td>10</td>
<td>3.95</td>
<td>4.20</td>
</tr>
<tr>
<td>20</td>
<td>4.03</td>
<td>4.28</td>
</tr>
<tr>
<td>50</td>
<td>4.13</td>
<td>4.38</td>
</tr>
<tr>
<td>100</td>
<td>4.21</td>
<td>4.46</td>
</tr>
</tbody>
</table>

*Table 2.2 Extreme Water Level Predictions with and without Sea Level Rise.*

¹ Shoreham and Lancing Sea Defences Beach Management Plan, Halcrow 2003
Table 2.3 shows the extreme wave condition predictions given in the 2003 Beach Management Plan for Shoreham and Lancing, based on analysis undertaken in the Rivers Adur to Arun Coastal Defence Strategy Plan.  

<table>
<thead>
<tr>
<th>Return Period (1:x year)</th>
<th>Water Level (mODN) with Sea Level Rise 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4.19</td>
</tr>
<tr>
<td>2</td>
<td>4.47</td>
</tr>
<tr>
<td>5</td>
<td>4.81</td>
</tr>
<tr>
<td>10</td>
<td>5.13</td>
</tr>
<tr>
<td>50</td>
<td>5.63</td>
</tr>
<tr>
<td>100</td>
<td>6.03</td>
</tr>
<tr>
<td>200</td>
<td>6.40</td>
</tr>
</tbody>
</table>

Table 2.3 Extreme Water Level Predictions with and without Sea Level Rise.

2.2 Design, Action and Emergency Profiles

The 2003 Beach Management Plan (BMP) for Shoreham and Lancing outlined the conditions for the ‘Design’, ‘Action’ and ‘Emergency’ states of the beach.

The Design Profile is considered the ideal profile of the beach following a recycling or recharge operation. The profile consists of a berm width of at least 12m along the whole frontage, with a beach face slope of 1:7. The BMP states this profile will provide a 1:100 year Standard of Protection.

The Action Profile is the state of the beach at which it is recommended remedial work is undertaken. This consists of a berm width of 10m along any continuous 20m length of the frontage, and a beach face slope of 1:7.

The Emergency Profile is the state of the beach at which remedial work is required immediately. This consists of a berm width of 5m along any continuous 20m length of the frontage, and a beach face slope of 1:7.

These parameters are summarised below in Table 2.4.
### Table 2.4 Design, Action and Emergency conditions for the Recycling Area

<table>
<thead>
<tr>
<th>Beach State</th>
<th>Berm Width</th>
<th>Slope</th>
<th>Frontage Length</th>
<th>Level of intervention required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>12m</td>
<td>1:7</td>
<td>Whole Frontage</td>
<td>None- 1:100 year Standard of Protection (SoP)</td>
</tr>
<tr>
<td>Action</td>
<td>10m</td>
<td>1:7</td>
<td>Any continuous 20m length</td>
<td>Remedial work recommended</td>
</tr>
<tr>
<td>Emergency</td>
<td>5m</td>
<td>1:7</td>
<td>Any continuous 20m length</td>
<td>Remedial work required immediately</td>
</tr>
</tbody>
</table>

#### 3 Topographic Surveys

Surveys completed by the Worthing Borough Council Coastal Survey Team currently use Real Time Kinematic (RTK) GPS receivers mounted on All Terrain Vehicles (ATV's), where beach access allows. The contours of the beach are driven, recording the elevations at a maximum spacing of 5m, concurrently recording the material type or ‘feature code’ (FC).

Following post survey data processing, including verticality corrections to allow for the angle of the quad bike whilst recording points, the data has been used to create Digital Terrain Models (DTMs), allowing beach volume calculation and comparison with the Design, Action and Emergency Profiles of the beach.

##### 3.1 IN and OUT Surveys

The recycling works conducted over the late December and early January period were undertaken as a rapid response to relatively severe winter storms. As such, the IN survey was unable to be scheduled before the commencement of the works. Therefore comparison of the beach’s initial condition to the post-works condition does not form part of this report, and analysis is instead limited to a comparison between the post-works beach and the Design, Action and Emergency beach profiles.

The OUT survey was successfully conducted on 27 January 2012.

#### 4 Beach Volumes

Volumes for the OUT Survey, Design Profile, Action Profile and the Emergency Profile have been calculated from Digital Terrain Models created for each.

Table 4.1 summarises calculated beach volumes above Mean Low Water Neaps (-1.37mODN) in each groyne bay for each DTM.
The volume figures show that each groyne bay contains more than enough material to achieve the Design Profile, with the exception of GB3 which currently requires some 1,369m$^3$ to achieve Design conditions.

Figures 4.1 to 4.3 in Annex A compare the OUT survey with the Design Profile, the Action Profile and the Emergency Profile respectively, showing volume differences in each case for each groyne bay. The maps also show lengths of frontage below the Action and Emergency Profiles to highlight where intervention is required.

Table 4.2 below summarises the findings from the difference models, giving the immediate, recommended and ideal intervention required for each groyne bay.

<table>
<thead>
<tr>
<th>Groyne Bay</th>
<th>OUT Survey</th>
<th>Design Profile</th>
<th>Action Profile</th>
<th>Emergency Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB1</td>
<td>35,252</td>
<td>28,625</td>
<td>27,181</td>
<td>23,531</td>
</tr>
<tr>
<td>GB2</td>
<td>18,331</td>
<td>16,107</td>
<td>15,312</td>
<td>13,298</td>
</tr>
<tr>
<td>GB3</td>
<td>23,881</td>
<td>25,249</td>
<td>24,141</td>
<td>21,357</td>
</tr>
<tr>
<td>GB4</td>
<td>30,191</td>
<td>27,722</td>
<td>26,223</td>
<td>22,494</td>
</tr>
<tr>
<td>GB5</td>
<td>44,224</td>
<td>29,112</td>
<td>27,647</td>
<td>23,946</td>
</tr>
<tr>
<td>GB6</td>
<td>57,131</td>
<td>33,956</td>
<td>32,171</td>
<td>27,666</td>
</tr>
<tr>
<td>GB7</td>
<td>55,270</td>
<td>31,395</td>
<td>29,454</td>
<td>24,729</td>
</tr>
<tr>
<td>GB8</td>
<td>49,806</td>
<td>38,831</td>
<td>36,768</td>
<td>31,566</td>
</tr>
<tr>
<td>GB9</td>
<td>26,209</td>
<td>22,688</td>
<td>21,380</td>
<td>18,104</td>
</tr>
<tr>
<td>GB10</td>
<td>31,904</td>
<td>26,118</td>
<td>24,750</td>
<td>21,305</td>
</tr>
<tr>
<td>GB11</td>
<td>42,826</td>
<td>33,227</td>
<td>31,511</td>
<td>27,198</td>
</tr>
<tr>
<td>GB12</td>
<td>58,724</td>
<td>47,365</td>
<td>44,900</td>
<td>38,710</td>
</tr>
<tr>
<td>GB13</td>
<td>54,393</td>
<td>52,608</td>
<td>49,847</td>
<td>42,847</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>528,143</strong></td>
<td><strong>413,003</strong></td>
<td><strong>391,287</strong></td>
<td><strong>336,750</strong></td>
</tr>
</tbody>
</table>

Table 4.1 Beach Volumes
<table>
<thead>
<tr>
<th>Groyne Bay</th>
<th>Length of Frontage Below Profile</th>
<th>Material Available in Groyne Bay (m³)</th>
<th>Immediate Intervention Required</th>
<th>Length of Frontage Below Profile</th>
<th>Material Available in Groyne Bay (m³)</th>
<th>Recommended Intervention</th>
<th>Length of Frontage Below Profile</th>
<th>Material Available in Groyne Bay (m³)</th>
<th>Ideal Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB1</td>
<td>-</td>
<td>11,721</td>
<td>None</td>
<td>24m</td>
<td>8,070</td>
<td>Increase berm width</td>
<td>29m</td>
<td>6,627</td>
<td>Increase berm width</td>
</tr>
<tr>
<td>GB2</td>
<td>-</td>
<td>5,033</td>
<td>None</td>
<td>-</td>
<td>3,019</td>
<td>None</td>
<td>-</td>
<td>2,224</td>
<td>None</td>
</tr>
<tr>
<td>GB3</td>
<td>25m</td>
<td>2,524</td>
<td>Increase berm width</td>
<td>71m</td>
<td>-260</td>
<td>Increase berm width, using material from another groyne bay</td>
<td>71m</td>
<td>-1,369</td>
<td>Increase berm width, using material from another groyne bay</td>
</tr>
<tr>
<td>GB4</td>
<td>3m</td>
<td>7,697</td>
<td>None</td>
<td>25m</td>
<td>3,967</td>
<td>Increase berm width</td>
<td>70m</td>
<td>2,469</td>
<td>Increase berm width</td>
</tr>
<tr>
<td>GB5</td>
<td>-</td>
<td>20,278</td>
<td>None</td>
<td>-</td>
<td>16,577</td>
<td>None</td>
<td>-</td>
<td>15,111</td>
<td>None</td>
</tr>
<tr>
<td>GB6</td>
<td>-</td>
<td>29,464</td>
<td>None</td>
<td>-</td>
<td>24,959</td>
<td>None</td>
<td>-</td>
<td>23,174</td>
<td>None</td>
</tr>
<tr>
<td>GB7</td>
<td>-</td>
<td>30,540</td>
<td>None</td>
<td>-</td>
<td>25,815</td>
<td>None</td>
<td>-</td>
<td>23,874</td>
<td>None</td>
</tr>
<tr>
<td>GB8</td>
<td>-</td>
<td>18,239</td>
<td>None</td>
<td>-</td>
<td>13,037</td>
<td>None</td>
<td>-</td>
<td>10,975</td>
<td>None</td>
</tr>
<tr>
<td>GB9</td>
<td>-</td>
<td>8,105</td>
<td>None</td>
<td>15m</td>
<td>4,829</td>
<td>None</td>
<td>40m</td>
<td>3,521</td>
<td>Increase berm width</td>
</tr>
<tr>
<td>GB10</td>
<td>-</td>
<td>10,599</td>
<td>None</td>
<td>5m</td>
<td>7,153</td>
<td>None</td>
<td>31m</td>
<td>5,786</td>
<td>Increase berm width</td>
</tr>
<tr>
<td>GB11</td>
<td>-</td>
<td>15,627</td>
<td>None</td>
<td>-</td>
<td>11,315</td>
<td>None</td>
<td>-</td>
<td>9,598</td>
<td>None</td>
</tr>
<tr>
<td>GB12</td>
<td>-</td>
<td>20,013</td>
<td>None</td>
<td>-</td>
<td>13,824</td>
<td>None</td>
<td>-</td>
<td>11,359</td>
<td>None</td>
</tr>
<tr>
<td>GB13</td>
<td>23m</td>
<td>11,546</td>
<td>Increase berm width</td>
<td>99m</td>
<td>4,546</td>
<td>Increase berm width</td>
<td>153m</td>
<td>1,785</td>
<td>Increase berm width</td>
</tr>
</tbody>
</table>

Table 4.2 Summary of Difference Model Comparisons
5 Profile Change Analysis

Analysis of the beach profiles has been carried out using the January 2012 OUT survey and previous complete beach surveys. As the study area crosses the 4d-MU8B and 4d-MU9A Management Unit boundary, the dates of the previous surveys vary for each Management Unit. Table 5.1 below shows the survey dates and profile names that have been used in the analysis.

<table>
<thead>
<tr>
<th>Profile Name</th>
<th>Management Unit</th>
<th>Previous Survey Date</th>
<th>Baseline Survey Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>4d00758A</td>
<td>4d-MU8B</td>
<td>09/06/2011</td>
<td>08/02/2008</td>
</tr>
<tr>
<td>4d00759A</td>
<td>4d-MU8B</td>
<td>09/06/2011</td>
<td>08/02/2008</td>
</tr>
<tr>
<td>4d00761A</td>
<td>4d-MU8B</td>
<td>09/06/2011</td>
<td>08/02/2008</td>
</tr>
<tr>
<td>4d00762A</td>
<td>4d-MU8B</td>
<td>09/06/2011</td>
<td>08/02/2008</td>
</tr>
<tr>
<td>4d00764A</td>
<td>4d-MU8B</td>
<td>09/06/2011</td>
<td>08/02/2008</td>
</tr>
</tbody>
</table>

Table 5.1 Profiles and Survey Dates

Figure 2.2 shows the locations of the profiles in the recycling area.

Figure 2.2 Profile locations in Recycling Area
Graphs of individual profiles are included on the CD attached to this report. The graphs also include the Master Profile which is held constant for a given profile line. For the Shoreham frontage, the lower boundary of the Master Profile is typically set at -1.5mODN and the landward boundary is the back of the active beach.

The Cross-Sectional Area (CSA) has been calculated for all beach profiles. This is calculated as the area of profile above the Master Profile. CSA charts for each individual profile line are included on the attached CD to reflect changes of beach heights during the recycling event.

The cross-sectional area trends, calculations and beach profile plots for the analysed profiles can be found on the enclosed CD in the ‘Analysis \ Topo’ directory, under ‘CSA_Charts’, ‘CSA_Data’ and ‘Profile_Charts’ respectively.
Annex A

Design Profile Adjustments
Figure 4.1 Difference Model of OUT Survey and Design Profile

(2008 Aerial Photography)
Figure 4.2 Difference Model of OUT Survey and Action Profile

Groyne Bay: GB1
Volume Difference (m³): 1,000

Red = Beach Below Action Profile
Blue = Beach Above Action Profile

(2008 Aerial Photography)
Figure 4.3 Difference Model of OUT Survey and Emergency Profile

Change in Elevation (m) between Emergency Profile and February 2012

- Red = Beach Below Emergency Profile
- Blue = Beach Above Emergency Profile

Groyne Bay: GB1
Volume Difference (m³): 1,000

SDCG - Lancing to Shoreham
From: Brian Rousell
Sent: 16 May 2013 18:04
To: Strategic Monitoring
Cc: Tony Parker
Subject: RE: Shoreham Harbour Deposition

Follow Up Flag: Follow up
Flag Status: Flagged

Dan

To confirm our earlier telephone conversation I have attempted to outline the works carried out along our frontage in the last 12 months to back up your survey findings.

In May 2012 we had some serious concerns following the unseasonably high winds that spring about two critical points of our coast defences. These were the east spending beach (profile ref 4d00644) and opposite Gate 5 along basin road south (ARC Terminal). The timing coincided with Adenstar Developments Ltd completing the western extension to our Shed 9 close to the east breakwater, so we commissioned them to “borrow” some rock from the existing groynes to create small informal rock revetments to stem the retreat. If you look at the latest Bing Maps aerial photos of the area you can actually see the May 2012 work going on!
At the time we took approx 100 tonnes of beach material to backfill behind the revetment on the east spending beach, together with a similar amount of clean concrete arisings from the construction project. I’m afraid I cannot quantify it much more accurately than that.

In December 2012/January 2013 we had further concerns about the integrity of our coast defences both at both locations and also had confirmation/approval of capital expenditure for two new/refurbished timber groynes on Southwick beach. We employed JT Mackley to undertake some emergency works to dismantle the ineffective rock groyne (referred to on your logs as RG3) and re-distribute the rock to bolster the informal revetments both at the ARC and east spending beach sites.

Again, it is difficult to accurately quantify the amount of rock moved, but now that the new timber groynes are almost complete the beach is rapidly recovering it’s levels.

If I can be of any further assistance please don’t hesitate to call.

Best regards
Brian

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*From:* Dan Amos *On Behalf Of* Strategic Monitoring  
*Sent:* 16 May 2013 11:04  
*To:* Brian Rousell  
*Subject:* Shoreham Harbour Deposition

Hi Brian,
I’m in the process of writing the 2012 Shoreham BMP Report and note that a significant quantity of material has been place in the bay just west of the eastern most harbour arm, in the area that is crossed by profile ref 4d00644, as shown in the attached map. Do you have a deposition form for this so that the quantities and timing can be identified and added to our database?

Regards

**Dan Amos**
Coastal Cell 4d Data Analyst / Project Manager
Strategic Regional Coastal Monitoring Programme

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