

## Project Appraisal Report

Authority scheme  
reference

IMSO 000648

Defra/WAG LDW  
number

Promoting  
authority

Environment Agency , South east region

Scheme  
name

Shoreham Adur Tidal Walls



Reach W1 gardens during a storm



Reach E1 at high tide



Reach W4 at high tide



Reach W7 at high tide

Date

November 2012

Version

Draft V5

## PAR for *Shoreham Adur Tidal Walls*

Version	Status	Signed off by:	Date signed	Date issued
1	Draft	P Borsberry	8 October 2012	
2	Draft for Project Board review	P Borsberry	22 October 2012	
3	Draft for head of NCPMS	P Borsberry	26 October 2012	
4	Final	P Borsberry	9 November 2012	
5	Final for LPRG	P Borsberry	16 November 2012	

Template version – April 2011

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## **For technical approval of the business case**

**Environment Agency Region: South East**

**Project name: Shoreham Adur Tidal Walls**

**Approval Value: £ 26.4m**

**Sponsoring Director: David Jordan          Director of Operations**

### **Financial scheme of delegation**

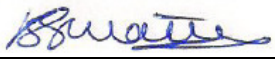
Section A2 of the Financial Scheme of Delegation states that, for a Flood Risk Management project within an agreed strategy the following officers are authorised to give approval. Chief Executive in consultation with Director of FCRM and Director of Operations approval is required for project expenditure over £20m.

### **Approval Route**

National Capital Programme Manager	Miles Jordan
Large Project Review Group	Ken Allison
Regional Director	Howard Davidson
Director of Operations	David Jordan
Chief Executive	Paul Leinster



# Approval history sheet

APPROVAL HISTORY SHEET (AHS)			
1. Submission for review (to be completed by team)			
Project Title: Shoreham Adur Tidal Walls		Project Code: IMSO000648	
Project Manager: Peter Borsberry		Date of Submission: January 2013	
Lead Authority: Environment Agency		Version No:	
Consultant Project Manager: Darren Milsom		Consultant: Halcrow	
The following confirm that the documentation is ready for submission to PAB or LPRG. The Project Executive has ensured that relevant parties have been consulted in the production of this submission.			
Position	Name	Signature	Date
Project Executive	Katharine Matthews		14/11/12
	Job Title:	ncpms Project Executive	
2. Review by: Large Projects Review Group (LPRG)			
Date of Meeting(s):		Chairman: Ken Allison	
Recommended for approval: In the sum of £:		Date:	Version No:
3. Environment Agency FSoD approval <i>Officers in accordance with the FSoD.</i>			
Version No:		Date:	
Project Approval	By: In the sum of: £	Date:	
4. Defra or WAG approval <i>(Delete as appropriate)</i>			
Submitted to Defra / WAG or Not Applicable (as appropriate)		Date:	
Version No. (if different):			
Defra/ WAG Approval: or Not applicable (as appropriate)		Date:	
Comments:			

# FINANCIAL SCHEME OF DELEGATION (FSoD) COVERSHEET

1. <b>Project name</b>	Shoreham Adur Tidal Walls	<b>Start date</b>	2005
		<b>End date</b>	2016
<b>Business unit</b>	South East	<b>Programme</b>	FDGIA
<b>Project ref.</b>	IMSO 000648	<b>FSoD ref &amp; date</b>	-


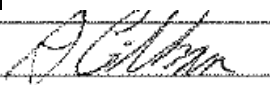
2. <b>Role</b>	<b>Name</b>	<b>Post Title</b>
<b>Project Sponsor</b>	Andrew Gilham	Area Flood and Coastal Risk Manager
<b>Project Executive</b>	Katharine Matthews	ncpms Project Executive
<b>Project Manager</b>	Peter Borsberry	ncpms Project Manager

3. <b>Risk Potential Assessment (RPA) Category</b>	<b>Low</b>	<input checked="" type="checkbox"/>	<b>Medium</b>	<input type="checkbox"/>	<b>High</b>	<input type="checkbox"/>
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FSoD schedule		Description	Delegation	
			Regional – up to	Environment Agency – up to
<b>A1</b>	<input type="checkbox"/>	Projects (includes FCRM revenue)	£5m	£5m
<b>A2</b>	<input checked="" type="checkbox"/>	FCRM capital project within approved strategy	£10m capital	£100m WLC Defra/£5m capital NAW
<b>A3</b>	<input type="checkbox"/>	FCRM capital project outside of approved strategy	£5m capital	£100m WLC Defra/£5m capital NAW
<b>A5</b>	<input type="checkbox"/>	Consultancy project	£300k	£500k
<b>T2</b>	<input type="checkbox"/>	Purchase or lease of land and buildings	£1m purchase/£50k pa lease	£5m

5. <b>FSoD value</b>	<b>£k</b>
<b>Preparation costs for PAR</b>	1,150
<b>Project costs</b>	26,400
<b>Whole Life Costs (WLC) of FCRM Project or Strategy</b>	99,900

6. <b>Required level of Environmental Impact Assessment (EIA)</b>	<b>N/A</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

7. <b>FSoD approver name</b>	<b>Post title</b>	<b>Signature</b>	<b>Date</b>
Paul Leinster	Chief Executive		
Howard Davidson	Regional Director (South East)		
David Jordan	Director of Operations		
<b>FSoD consultee name</b>	<b>Post title</b>	<b>Signature</b>	<b>Date</b>
Ken Allison	PAB/LPRG Chair		
Miles Jordan	Head of Asset Operational Services		12/11/12
Andrew Gilham	flood and Coastal Risk Manager		9/11/12

8. <b>Form G</b>	<b>Form G value (£k)</b>	<b>Regional FSoD ref.</b>	<b>Head Office FSoD ref.</b>	<b>Latest FSoD authorised cost (£k)</b>
1			-	
2				
3				



# 1 Executive summary

## 1.1 Introduction and background

### Location and background

- 1.1.1 This report seeks approval for a flood and erosion risk management scheme on the east and west banks of the River Adur at the historic harbour town of Shoreham-by- Sea, West Sussex, under Section A2 of the Financial Scheme of Delegation. This is a change project supported by the approved *Rivers Arun to Adur Flood and Erosion Management Strategy* (the Strategy). The scheme is delivered in partnership with Adur District Council (Adur DC) and West Sussex County Council (WSCC). The Environment Agency is the lead organisation.
- 1.1.2 The Shoreham Adur Tidal Walls scheme covers a 7.2 km stretch of the river, 1.8km on the east bank between Coronation Green and the A27 road bridge and 5.4km on the west bank between the river mouth and the A27 (refer to Key Plan 1, Section 1.7).
- 1.1.3 The frontage is divided in to eight reaches on the west bank and three reaches on the east bank, with a further reach added to the east bank to investigate options to the north of the Strategy boundary, (see Key Plan 2). Existing defences are a mixture of steel sheet pile and concrete walls and earth embankments and have a Standard of Protection (SoP) ranging from 1 in 5 (20%) to 1 in 300 (0.33%).
- 1.1.4 North of the scheme boundary there is low lying agricultural land bordered by the A283 Steyning Road. The defences here are earth embankments with an average SoP in excess of 1 in 30 (3.33%) and a residual life estimated at 10 to 20 years. This area is within the boundary of the Tidal River Adur Strategy which is currently being prepared.
- 1.1.5 Two of the deprived wards within Shoreham are ranked 6th & 7th most deprived in the county and fall within the 20% most deprived wards in England. The commercial harbour and Shoreham airport are vital for employment and economic activity in the town.
- 1.1.6 The study area contains the nationally designated Adur Estuary Site of Special Scientific Interest (SSSI) and a Royal Society for the Protection of Birds (RSPB) reserve, with overwintering bird populations and significant areas of saltmarsh and mudflat Biodiversity Action Plan (BAP) habitat. The estuary is a transitional water body designated as a heavily-modified for navigation purposes under the Water Framework Directive with a current status of Moderate Ecological Potential.
- 1.1.7 The study area has significant heritage features including Old Shoreham Fort Scheduled Monument, several listed buildings and a line of WWII pill boxes. There are two Conservation Areas on the east bank, see Key Plan 2. The estuary is a popular leisure destination for walkers, cyclists, fishing and boating enthusiasts.
- 1.1.8 Proposed works will be undertaken under the powers of Section 165 of the Water Resources Act 1991.

### Approved FCRM strategy

- 1.1.9 The Strategy covers 32km of defences protecting the coastline and tidal frontages between the River Arun at Littlehampton and the River Adur at Shoreham by Sea. The Strategy frontage is divided into nine Operational Management Units (OMU's). OMU8

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(River Adur West) and OMU9 (River Adur East) section 1 are within this scheme's boundaries (see Key Plan 1).

- 1.1.10 The Strategy recommended raising and replacing defences along the River Adur West Bank (OMU8) frontage to achieve a 1 in 300 (0.33%) standard of protection (SoP) as a priority action. The East Bank frontage (OMU9i) is also recommended for raising and replacing to achieve a 1 in 200 (0.5%) by 2013.
- 1.1.11 The Strategy optimised the standard from 1 in 200 (0.5%) to 1 in 300 (0.33%) for OMU8 with a robust Incremental Benefit Cost (IBCR) ratio of 7.3 (see Table 2-1) in line with the Project Appraisal Guidance (PAG). Following completion of the Strategy the guidance relating to extreme sea levels and climate change has changed and the PAG has been replaced by the Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG), in order to assess these changes the optimisation of defence standard has been reassessed as part of this report.
- 1.1.12 The scheme promotes a consistent SoP of 1 in 300 (0.33%) to align with existing defences along the frontage. Piling is the dominant solution, the difference in height and cost between the 1 in 200 (0.5%) and 1 in 300 (0.33%) is minimal. The revised IBCR is 17.7 which is robustly greater than 5, as set out in FCERM-AG.

## 1.2 Problem

- 1.2.1 The current standard of protection on the River Adur is an assortment of defence levels. There are eight reaches which have a current SoP from 1 in 5 (20%) to 1 in 50 (2%), the remaining reaches vary from 1 in 50 (2%) to 1 in 300 (0.33%). The residual lives vary from less than 20 years in seven reaches to between 20 and 50 years in the remaining reaches.
- 1.2.2 The main flood risk is from overtopping or catastrophic breach of defences during a flood event. Due to the low lying nature of large areas of Shoreham Beach and Lancing on the west bank, the onset of flooding would be rapid with fast flowing water up to 1.8m deep over large residential areas, with a high risk of death and injury. The flooding of these low lying areas would also cut transport links, marooning more than 1400 properties in the higher areas of Shoreham Beach and making access difficult or impossible for emergency services. The required combination of high tide and tidal surge has not occurred in recent history to test the existing defences. However, due to rising sea levels and the deteriorating condition of the defences in reaches W5 and W7 it is envisaged that catastrophic failure of these defences would occur on an event with a 1 in 20 (5%) chance of occurring each year, leading to flooding of 1,795 residential and 126 commercial properties.
- 1.2.3 There are currently 2,328 residential and 169 commercial properties, mainly shops and small businesses, at risk of flooding from a 1 in 200 (0.5%) chance of flooding in any year, due to breach and catastrophic failure of the defences. Of these, 111 residential properties are classified as 'deprived households' within the lowest 20% of ranked wards within England. Of the properties at risk 1,795 are at very significant risk of flooding, 352 at significant risk and 181 at moderate risk.
- 1.2.4 The number of residential and commercial properties at risk rises to 4,454 and 333 respectively by 2110 including allowance for the change factor climate change predictions (0.834m), differences in actual climate change could vary this level by -53% (low end estimate) to +276% (H++ scenario). In addition, for 3,521 of these properties, the cost of flood damage would exceed the market value of the property over the 100-year period.

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## 1.3 Options considered for implementing the FCRM strategy

- 1.3.1 The following forms of defence types were considered: raising and repairing the existing defences, earth embankments, rock revetment and steel sheet pile wall. The defence type in conjunction with varying alignments comprised the list of options that would fulfil the recommendations of the strategy. We screened the options using multi-criteria analysis and then appraised the short list in accordance with the FCERM-AG, further details are available in the Options Appraisal Reports in Appendix F. An adaptive approach has been taken with respect to climate change uncertainty and this is reflected in the preferred options. In line with the recommendations of the strategy an assessment will be undertaken in Year 50 to confirm the preferred option for the following 50 years, this is envisaged to include either the construction of a new tidal barrier or further raising of the existing defences.
- 1.3.2 A range of standards of protection have been appraised; 1 in 75yr, 100yr, 200 yr and 300yr (1.3%, 1%, 0.5% and 0.33%). This process provided a short-list of options which are described, appraised and detailed in this report. In addition to the environmental consideration, public support, future operational, maintenance and buildability risks, a comparative option costing assessment of all viable options supported this process.

## 1.4 Preferred option Description

- 1.4.1 The preferred option, Improve 4, provides a consistent standard of protection of at least 1 in 300 (0.33%) over 100 years, initially the standard will be in excess of 1 in 1000 (0.1%), falling to 1 in 300 (0.33%) in year 50. This option has an average benefit cost ratio (ABCR) of 23.2 and an IBCR of 17.7.
- 1.4.2 The scheme will include the following works:
- Reach W1: 330m of steel sheet piled retaining wall and new rock revetment with timber and brick cladding, constructed directly in front of the existing defence and an additional 220m of brick clad steel sheet piled retaining wall constructed in Year 20. Works in Year 20 have been included in the economic analysis but are not included as part of this funding application.
- Reach W2: 500m of brick clad reinforced concrete retaining wall with a further 250m to be undertaken in Year 20.
- Reach W3, W4 & W5: 1605m of new brick clad steel sheet piled wall.
- Reach W6: 625m of new embankment with scour protection. Plus 260m of new brick clad steel sheet piled wall to be constructed in Year 20.
- Reach W7: 1250m of new realigned earth embankment.
- Reach W8 & E4: No works required.
- Reach E1: 300m of new timber and brick clad steel sheet piled retaining wall constructed directly in front of the existing defence.
- Reach E2: 40m of brick clad reinforced concrete wall including reinstatement of the promenade.

Reach E3: 230m of new brick clad steel sheet piled wall and 700m of earth embankment raised with 315m of new scour protection. Plus 180m of new earth embankment and 200m of public highway raised by up to 1.6m.

## Key Constraints

- 1.4.3 The main constraints are related to delivering the works in an urban location, these include private property boundaries, both residential and commercial, navigation for commercial and leisure craft and the ecological interest of the Adur Estuary.
- 1.4.4 Disturbance during construction to residents and visitors, overwintering birds and migratory fish will be minimised through restricted working periods.

## Environmental considerations

- 1.4.5 A statutory Environmental Impact Assessment (EIA) is required, which will be undertaken at detail design stage. An Environmental Statement (ES) will be produced to support a planning application required for Reaches E3 and W7 and the advert under EIA (Land Drainage Improvement Works) Regulations. The remainder of the scheme will be constructed under permitted development rights.
- 1.4.6 A scoping report has been produced to establish the environmental baseline and key constraints. This has been consulted on internally and externally and comments have generally been positive with no major issues raised.
- 1.4.7 The scheme contributes to the hydromorphology and ecology of the Adur transitional water body by retreating embankments and enhancing marginal aquatic habitat in Reach W7 and Reach E3. This will prevent deterioration caused by coastal squeeze and provide habitat for fish, which are currently at Moderate status with an objective to reach Good by 2027. All mitigation measures for the water body are currently in place and the scheme will not alter this. The scheme is therefore compliant with WFD.
- 1.4.8 The scheme will result in an immediate net gain in intertidal habitat of 1.25 ha, which will reduce to 0.2 ha over the next 50 years as sea-levels rise. A population of reptiles will need to be removed from the embankment to a receptor site prior to construction. Natural England supports the preferred option as an environmentally acceptable solution.
- 1.4.9 Landscape mitigation, such as cladding and soft landscaping, will be included in the scheme design to minimise the visual impact of the raised defences, especially within Conservation Areas. Improvements to Old Shoreham Fort car park are planned, which have the support of English Heritage. The scheme maintains and improves footpaths and river access points and integrates with planned leisure improvements such as the footbridge.
- 1.4.10 The preferred option conforms to the Environment Agency Sustainable Construction Policy.

## Costs and Benefits

- 1.4.11 Implementation costs were estimated in the Strategy at £ 28.1 m for OMUs7, 8 and 9i (including fees, inflation and 60% optimism bias). Updated implementation costs are based on the winning tender return from the mini-bid and are estimated at £ 26.3 m (including fees, inflation and 50<sup>th</sup> percentile risk).

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- 1.4.12 Efficiency savings of £919k have been incorporated into the scheme through the optimal programming of the east and west bank works. Further savings will be sought during detailed design and construction through detailed investigation into the seepage through the site and standardisation of certain design elements.
- 1.4.13 A further efficiency saving of £700k has been identified if this scheme can be packaged with the Littlehampton Arun Tidal Walls East Bank. The approval sums and economics do not include this saving since funding for both projects to proceed has not yet been confirmed.

**Table 1-1 Project Costs (£k)**

	<b>Economic appraisal</b>	<b>Whole life cash cost</b>	<b>EA FSoD approval</b>
Costs to PAR	N/A – sunk costs	1,150	1,470
Costs post PAR			
Environment Agency staff	200	215	215
Consultant & CDM-C fees	1,440	1,170	1,170
Early Contractor Involvement (ECI)	10	11	11
Site investigation & survey	326	341	341
Construction	15,700	17,200	17,200
Environmental mitigation	1,830	2,020	2,020
Environmental enhancement	32	36	36
Site supervision	0	379	379
Compensation	454	503	503
Risk contingency			
95%ile (represents 9% of project FSoD approval)			2,440
50%ile	1,250	1,370	
Inflation	N/A	N/A	1,760
Future costs (const. + maintenance)			
	12,910	75,300	N/A
Other	214	223	223
<b>TOTAL</b>	<b>34,400</b>	<b>99,900</b>	<b>26,400</b>
Contributions - Local Levy			297
Contributions - Adur DC			500

## **Economic summary, outcome measures and priority**

- 1.4.14 The economic appraisal period is 100 years and Defra FCERM-AG has been followed. The initial duration period of benefits is 48 years (see Table 1-2). Following this, works will be undertaken to construct a new tidal barrier or raise the existing defences, depending on the actual and forecast sea level rise. If the defences are to be raised this will include replacement of sheet piling in Reach W2 and E2, raising of concrete capping beams in Reaches W1, W3, W4, W5, E1, E3; raising of embankments in Reaches W6, W7 and E3 and replacement of the concrete wall in Reach W8.

**Table 1-2 Benefit-cost ratios and outcome measures**

<b>Contributions to outcome measures</b>	
OM1 – Economic Benefit	
PV Benefits	561,000
PV Costs	25,200
Duration of benefits	48
Benefit/Cost ratio	22
OM2 – Households at risk (Nr)	2328
OM2b – Households moving risk bands (Nr)	2147
OM2c households in deprived areas (Nr)	111
OM3 - Households better protected against coastal erosion	0
OM4 – statutory environmental obligations met (Ha)	1.25
PV FDGiA contribution (£k)	24,400
Raw Score	168.00%
PV Total Contributions offered (towards capital and PV maintenance), £k	780
Adjusted PF Score	173.00%

## Funding and contributions

- 1.4.15 Our partner in this project, Adur DC has led on seeking funding contributions and has collected a £500k contribution towards the preferred option. This contribution, combined with a £280k contribution from Local Levy, increases the partnership funding score from 168.00% to 173.00%, which makes this a strong candidate for Flood Defence Grant in Aid (FDGiA).
- 1.4.16 The contribution of £500K is comprised of a £400K contribution from West Sussex County Council (WSCC) and a £100K Contribution from Albemarle, Shoreham Airport Limited. Adur DC has provided a letter of intent outlining their commitment (see Appendix S). Following approval of this report, we will work with Adur DC to agree the terms and conditions of a legal agreement to govern the relationship between the partners. This will be finalised and signed by both parties prior to Gateway 3 (Contract Award).
- 1.4.17 The PV benefit attributable to commercial properties within the airport is approximately 5% of the overall PV benefit. Commercial property as a whole forms approximately 11% of the overall PV benefit. There are no other significant beneficiaries to the scheme.
- 1.4.18 WSCC are constructing a new pedestrian footbridge between Reaches E1 and W4 in advance of the flood defence works. Early discussions have been undertaken and an opportunity to deliver parts of the flood defence works as part of the bridge construction has been agreed. A legal agreement is being prepared to confirm the funding split for these works.
- 1.4.19 Funding has been allocated in the Indicative Allocation (Oct 2012) for financial year 13/14, 14/15, 15/16 and 16/17.
- 1.4.20 It is proposed to package this project with Littlehampton Arun East Bank Tidal Walls project for the implementation stage. Negotiations with the preferred contractor for both projects has resulted in a potential saving of £700k assuming both projects are approved and construction occurs in quick succession.

## Key delivery risks (economic, social and environmental)

- 1.4.21 A risk register was developed by the project team through a risk workshop. The risk register is included in Appendix K. Table 1-3 details the key delivery-phase project risks.

Table 1-3 Risks and mitigation

Key project risk	Adopted mitigation measure
Owners or lessees of the Airport withdraw their agreement to the realignment for habitat mitigation.	Agreement reached with owners and lessee. Legal agreement to be prepared following funding approval. Liaison to be undertaken with Tidal Adur Strategy team to ensure habitat can be created to the north if required. Scheme footprint to be kept to a minimum to reduce the amount of habitat mitigation required.
Additional cost of earthworks materials over base allowance.	Local sources of material from other construction projects in the area to be investigated as construction approaches.
Additional reinstatement required within individual properties.	Landowner consultation to be undertaken during design and agreements reached on working areas and reinstatement.
Requirement to provide temporary accommodation for residents on both sides of the embankment in Reach W5 due to the proximity of the works to the residences where access cannot be maintained and to minimise potential public H&S risks.	Continued consultation with residents in the reach, programming and construction methods to be assessed to minimise the risk.
Volatile steel prices above 2.5% p.a. inflation allowance.	Steel prices to be monitored and early purchase of piles to be considered if prices are rising.
Piling method fails to meet design toe levels due to ground conditions in Reach E1.	Piling method to be reassessed against additional ground investigation and using the knowledge of the recently installed footbridge. Consider taking samples from within the riverbed.

## 1.5 Recommendation

- 1.5.1 It is recommended that the Shoreham Adur Tidal Walls scheme be approved with a cost (FSOD) of £26,400k, including a 95%ile risk contingency of £2,440k. By 2016 1,795 properties at very significant risk of flooding, 352 at significant risk and 181 at moderate risk will be moved to low risk.

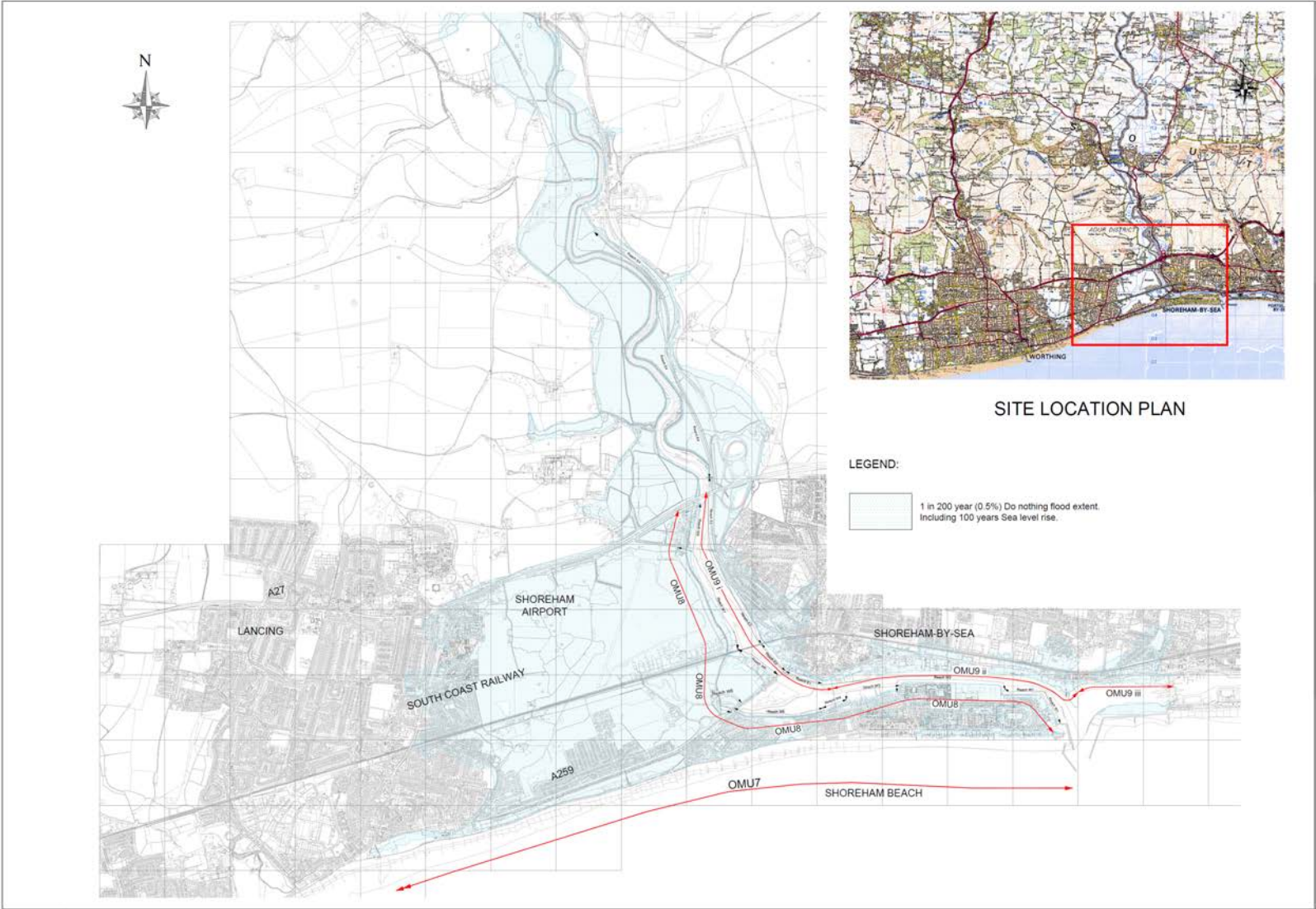
## 1.6 Director's briefing paper

<b>Region:</b>	South East		<b>Project Executive:</b>	Katherine Matthews	
<b>Function:</b>	Flood Risk Management		<b>Project Manager:</b>	Peter Borsberry	
<b>Project Title:</b>	Shoreham Adur Tidal Walls			<b>Code:</b>	IMSO 000648
<b>NEECA Consultant:</b>	Halcrow	<b>NCF Contractor:</b>	Volker Stevin	<b>Cost Consultant:</b>	Arcadis AYH
<b>The Problem:</b>	Shoreham, Shoreham Beach and Lancing are defended from tidal flooding by approximately 7.2km of tidal defences. The level and condition of the defences vary considerably with some defences providing a standard of protection as low as 1 in 1 (100%). The condition of the defences varies with many areas having a residual life of less than ten years. It is anticipated that a 1 in 20 (5%) flood would lead to breach and catastrophic failure of embankments on the west bank,				
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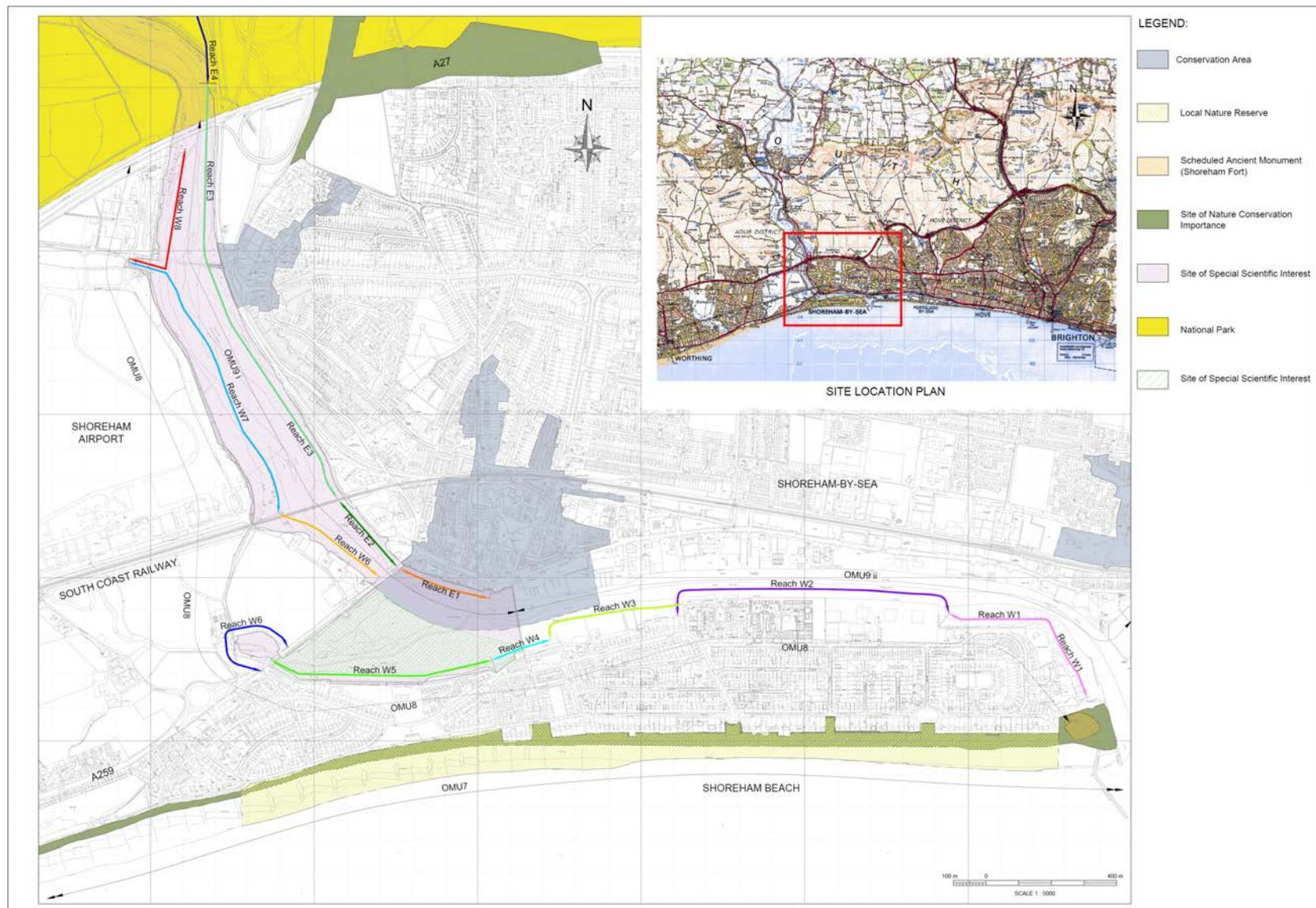
		flooding 1,795 residential and 126 commercial properties and marooning a further 1,400. Flood water would be fast flowing, up to 1.8m deep over large residential areas with a high risk of death and injury.			
Assets at risk from flooding:		A 1 in 200 year (0.5%) flood event would lead to flooding of 2,328 residential and 169 commercial properties.			
Existing standard of flood protection:		Varies from 1 in 1 (100%) to 1 in 300 (0.33%)		Proposed standard of flood protection:	1 in 300 (0.33%)
Description of proposed scheme:		Reconstruct and raise the existing tidal defences over 7.2km of the River Adur, 1.8km on the east bank and 5.4km on the west bank. Defences constitute sheet piling, concrete walls and earth embankments.			
Costs (PVC): (100 year life inc. maintenance)	£34,200k	Benefits: (PVb)	£795,000k	Ave. B: C ratio: (PVb/PVc)	23.8
NPV:	£761,600k	Incremental B: C ratio:	16.0	Whole life cost (cash value):	£98,700k
Choice of Preferred Option:		Combination of new defences and raising of existing defences to a SoP of 1 in 300 (0.33%)			
Total cost for which approval is sought:				£ 26,400k (incl. £1,760k inflation & £2,440k contingency)	
Delivery programme:		Planning Approval: October 2014 Award Construction Contract: October 2014 Construction Start: February 2015 Construction end: April 2016			
Are funds available for the delivery of this project?				The indicative allocation currently confirms that funds will be available.	
External approvals:		Planning permission for Reaches E3 and W7 (realignment) and Marine Management Organisation licence.			
Outcome measures		OM1: 22.20 ; OM2: 2328; OM2b:2147; OM2c:111 OM4a:1.25ha. Raw FDGiA Funding Score:168.00%; Adjusted Partnership Funding Score:173.00%			



1.7 Key plans



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**Key Plan 2 Environmental designations**

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REACH E1  
VIEW 1



REACH E2  
VIEW 2



REACH E2  
VIEW 3



REACH E3  
VIEW 4



REACH E3  
VIEW 5



REACH E3  
VIEW 6

#### LEGEND:

- Conservation Area
- Local Nature Reserve
- Scheduled Ancient Monument (Shoreham Fort)
- Site of Nature Conservation Importance
- Site of Special Scientific Interest
- National Park
- Site of Special Scientific Interest

### Key Plan 3 East bank photos

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**Key Plan 4 West bank photos**

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## 2 Introduction and background

### 2.1 Purpose of this report

- 2.1.1 This report presents a business case for the implementation of a flood risk management scheme on the west and east banks of the River Adur at Shoreham-by-Sea, West Sussex. The Rivers Arun to Adur Flood and Erosion Management Strategy (adopted by Defra 2010) recommends a 'Phased Improve' option for the stretches of the River Adur west and east banks that form the study area for this business case. This business case is in accordance with that recommendation.
- 2.1.2 The business case supports an application for Flood Defence Grant in Aid (FDGiA) funding. Approval for the scheme is sought under section A2 of the Environment Agency Financial Scheme of Delegation (FSOD). This is a Change Project supported by an approved Strategy and is presented in partnership with Adur District Council (Adur DC).
- 2.1.3 The appraisal has been undertaken in line with the latest Flood and Coastal Erosion Risk Management - Appraisal Guidance, March 2010, and associated Environment Agency policies and procedures.

### 2.2 Background The approved FCRM strategy

- 2.2.1 The Rivers Arun to Adur Flood and Erosion Management Strategy (the Strategy) describes the 100-year plan for managing flood and erosion risk for a 32km tidal frontage in West Sussex, covering the lower tidal reaches of the Rivers Arun and Adur and the coastline in between. The Strategy area covers the stretch of urbanised coastline from the east bank of the River Arun (TQ 014 030) in Littlehampton including the coastline moving east past Worthing to include both the east and west banks of the River Adur, downstream of the A27, in Shoreham-by-Sea (TQ 241 049). See the Strategy Executive Summary, included in Appendix A, for further information. The full Strategy documentation is available on request.
- 2.2.2 The Strategy was developed by the Environment Agency in partnership with the other Operating Authorities; Arun District, Worthing Borough and Adur District Councils and was approved by the Environment Agency's Board in May 2009 and adopted by Defra in April 2010.
- 2.2.3 The Strategy area is divided into nine Operational Management Units (OMUs). The River Adur OMU 8 defends the Shoreham Beach and Lancing flood cell on the west bank of the Adur OMU 9 defends Shoreham-by-sea on the east bank of the Adur. The area on the west of the river is also defended by OMU 7 on the open coast. OMU9 is further divided into 3 sub-units, 9i upstream to 9iii downstream, see Key Plan 1. OMU8 and OMU9i border the Adur Estuary Site of Special Scientific Interest (SSSI), see Key Plan 2.

### Strategy Recommendation

- 2.2.4 The Strategy preferred option for OMU 8 and 9i is 'Phased Improve'. For the first 50 years it recommends raising of the walls along the river banks. For the next 50 years it recommends either the construction of a tidal barrier, or further raising of the defence height to maintain the standard of protection (SoP) up to year 100. This follows the adaptive approach to climate change recommended in the Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG). As it was considered a priority scheme, the Strategy recommendation for OMU 8 was further optimised to recommend

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'Improve by raising the existing defences using the least cost structural solution' to provide a 1 in 300 (0.33%) SoP, with an incremental benefit cost ratio (IBCR) of 7.3 as detailed in Table 2-1. No optimisation of design standard was undertaken for the River Adur East Bank upstream reach (OMU 9i). However, the defences for both banks need to be consistent as it is now clear this is one flood cell (see 2.2.6).

**Table 2-1 Strategy optimisation of design standard**

Option	PV Damage PVd (£k)	PV Benefit (£k)	PV Cost with OB (£k)	BC Ratio	Inc. BC Ratio
OMU7 Sustain (0.33%) OMU8 Improve (low cost) (1%)	3,490	759,207	25,914	29.3	18.3 (From OMU8 Maintain, OMU7 Sustain 0.33%)
OMU7 Sustain (0.33%) OMU8 Improve (low cost) (0.5%)	2,840	759,857	25,991	29.2	8.4 (From OMU8 Improve 1% OMU7 Sustain 0.33%)
OMU7 Sustain (0.33%) OMU8 Improve (low cost) (0.33%)	2,189	760,508	26,080	29.2	7.3 (From OMU8 Improve 0.5% OMU7 Sustain 0.33%)
OMU7 Sustain (0.2%) OMU8 Improve (low cost) (0.2%)	Assume zero	762,697	27,480	27.8	1.6 (From OMU7 Sustain (0.33%) OMU8 Improve (0.33%)

2.2.5 An £18m investment was made to the coastal defences in OMU 7 between 2003 and 2005 with rock groynes and shingle recharge to provide erosion protection and a defence in excess of 1 in 300 (0.33%) chance of flooding each year. However, the benefits of this cannot be fully realised without the improvements to OMU8 recommended by this PAR.

2.2.6 Hydraulic modelling has shown that were the West Bank (OMU 8) defences constructed in isolation, flooding to properties on the east bank would be increased by up to 400mm. The works to the East Bank (OMU 9i) required to mitigate this risk are included in this business case and are inline with the recommendations of the strategy.

2.2.7 This Project Appraisal Report (PAR) therefore describes the priority scheme recommended by the Strategy for OMU8 and also includes OMU9i which was an action recommended for Years one to three of the Strategy investment programme.

2.2.8 The Strategy recommendations for the remainder of the River Adur Estuary, OMU's 9ii and 9iii are Sustain and No Active Intervention respectively, with works proposed for OMU9ii in Year 10. These works are not proposed as part of this business case as they do not attract enough Flood Defence Grant in Aid (FDGiA) funding to be progressed without large external contributions. Adur DC are therefore looking at the long term development of the area defended by this frontage. Any redevelopment would require an improvement to the standard of defence which would need to be undertaken as part of any future development.

2.2.9 The Strategy preferred option also recommended that further studies be progressed to investigate the construction of 39ha of Biodiversity Action Plan (BAP) habitat to provide freshwater or inter-tidal habitat north of the A27 on the River Adur, in addition to areas required for scheme mitigation. These would provide habitat enhancement in excess of that required to offset any potential long-term losses from coastal squeeze and defence footprint in the Adur Estuary. This is not being progressed as part of this business case

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as it is outside the scheme boundary, but will be investigated as part of the Tidal River Adur Strategy which is currently at an early stage.

## Previous studies

- 2.2.10 The Strategy preferred option is consistent with the Beachy Head to Selsey Bill Shoreline Management Plan Review (SMP2), approved in February 2010, which recommended a preferred policy option of “hold the line” for OMU7. This scheme is within the boundaries of the River Adur Catchment Flood Management Plan (CFMP) approved in 2009, which assesses fluvial risk in the Adur Estuary as low, with only 15 properties deemed to be at risk from a flood with a 1 in 100 (1%) chance of occurring in any one year. The CFMP does not recommend improvement of defences due to fluvial flood risk, but notes that “Flood risk from the sea is a significant consideration in this policy unit. Therefore, fluvial flood risk management options must fit with the shoreline management plan policy and actions”. The recommendations of this business case are in line with the SMP2.

## Location and designations

- 2.2.11 Shoreham-by-Sea is an historic town located on the West Sussex coast between the town of Worthing and the city of Brighton and Hove. It is bordered on the north by the South Downs National Park. The Shoreham scheme extends approximately 1.8km on the east bank from Coronation Green to the A27 and approximately 5.4km on the west bank from the mouth of the river to the A27. For the purposes of this business case OMU8 has been broken down into 8 reaches (W1 to W8) and OMU9i into 3 (E1 to E3), with a further reach added to the east bank (E4) to investigate options to the north of the Strategy boundary, as shown in Key Plan 2, this reach was discounted see section 4.2.5.
- 2.2.12 The lower reaches of the River Adur are generally heavily urbanised with the main area of Shoreham-by-Sea to the east and the areas of Lancing and Shoreham Beach to the west. The area to the west also includes some areas of arable land, a golf course, which is currently under construction, and Shoreham Airport with associated industrial and commercial business. The general landform can be seen in Key Plan 1.
- 2.2.13 The scheme area contains the Adur Estuary SSSI, which extends upstream of the footbridge and borders Reaches E1 to E3 (OMU9i) and W4 to W7 (OMU8); and a Royal Society for the Protection of Birds (RSPB) reserve, located adjacent to Reaches W5 and W6 (OMU8), and is bounded to the south by the Shoreham Beach Site of Nature Conservation Interest (SNCI) and to the north by the South Downs National Park, as shown in Key Plan 2.
- 2.2.14 Key ecological features include saltmarsh and mudflat within the river, reptiles along sections of the river banks, birds (particularly wintering birds using the saltmarsh and mudflats), fish (the river is a Salmonid river and provides a migratory, spawning and nursery habitat) and a small nature reserve on the west bank which protects an area of Chidding Pink (a nationally rare and protected plant species).
- 2.2.15 The study area lies within the boundaries of the South East River Basin Management Plan (SERBMP), published in December 2009 and includes the following watercourses designated under the WFD:
- a) Adur - transitional - immediately adjacent to scheme
  - b) Brighton Chalk Block - groundwater to east of the Adur
  - c) Chichester-Worthing-Portsmouth Chalk - groundwater to west of the Adur
- 2.2.16 The Adur transitional water body has been designated as heavily modified due to navigation pressure, but the classification also noted the presence of raised man-made

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defences (embankments, revetments, concrete and brickwork walls and sheet-piled walls) along both banks of the channel. Its objective is to achieve Good Ecological Potential (GEP) by 2027. Both Brighton Chalk Block and Chichester-Worthing-Portsmouth Chalk are in current poor status with an objective to reach good status by 2027.

- 2.2.17 There are eight mitigation measures listed for the Adur transitional water body in Appendix B of the SERBMP. All of the identified mitigation measures for the Adur transitional water body are in place. However, the status is moderate ecological potential due to the classification for fish.
- 2.2.18 The Shoreham Old Fort Scheduled Monument (SM) lies on the west bank, adjacent to the scheme boundary near the mouth of the River Adur, whilst The Marlipins SM is located landward of the High Street on the east bank (Reach E1). Five World War Two (WWII) pillboxes are located within the scheme boundary and, although not designated, are deemed to form part of the best preserved WWII defence line in Sussex. Shoreham and Old Shoreham Conservation Areas are located on the east bank (Reaches E1 and E2/3 respectively), together with a number of listed buildings, which are also located close to the scheme in Reaches E1 to E3, and the Old Shoreham Toll Bridge which links Reaches E3 and W7 is also listed.
- 2.2.19 Key environmental features of the study area are shown on the Indicative Landscape Plans in Appendix B.

## Legislative framework

- 2.2.20 The majority of the scheme will be progressed by the Environment Agency as permitted development under section 165 of the Water Resources Act. However, Reaches W7 and E3, where the new defences are to be realigned (see section 4), will require planning permission. A statutory Environmental Impact Assessment (EIA) will be undertaken and an Environmental Statement (ES) prepared for the entire scheme. The ES will be submitted to Adur DC with the planning application for Reaches W7 and E3 under the Town and Country Planning (Environmental Impact Assessment) Regulations 2011. The ES will also be advertised and made publicly available prior to undertaking the remainder of the works under permitted development rights in accordance to the Environmental Impact Assessment (Land Drainage Improvement Works) Regulations 1999.
- 2.2.21 A screening opinion will be sought from the Marine Management Organisation (MMO) on the requirement for an EIA to be undertaken under the Marine Works (Environmental Impact Assessment) Regulations 2007 as amended. As a statutory EIA is already being undertaken, allowances have been made in the project risk register for additional surveys that may be requested by the MMO, such as benthic surveys of the intertidal mud.
- 2.2.22 A licence will be required under the Marine and Coastal Access Act 2009, for the deposit or removal of a substance or object below the Mean High Water Springs (MHWS) mark.
- 2.2.23 Consent will be required from the Environment Agency under the Water Resources Act 1991 for works in, over, under or adjacent to main rivers.
- 2.2.24 Assent from Natural England will be required under Schedule 9 of the Wildlife and Countryside Act 1981 (as amended by the Countryside and Rights of Way Act 2000), for all proposed works adjacent to and within a SSSI.

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2.2.25 A Water Framework Directive (WFD) assessment is required to ensure that the scheme will meet the legal compliance requirements for 'no deterioration', will not prevent the achievement of good ecological status or potential in any water bodies and to identify opportunities to contribute to the delivery of the SERBMP. Compliance with the WFD is detailed in section 5.3.15.

2.2.26 Diversion Orders will be required relating to Public Rights of Way.

## **Social and political background**

2.2.27 The scheme is located within the boundaries of Adur DC, who are the local planning authority and have been represented on the project board and project team during project appraisal.

2.2.28 Shoreham, Shoreham Beach and Lancing are heavily urbanised, typical of many coastal communities on the Sussex Coast. Residents in these areas have been consulted and involved during the outline design of the scheme through targeted stakeholder engagement, as detailed in section 4.4.

2.2.29 There are 42 houseboats moored adjacent to the tidal defences within the scheme boundary, the majority of which are located at the flood defence embankment to the south of the A259, Reach W5. The proximity of the houseboats to the defence, and their ownership of the embankment footprint, has required extensive engagement with the Adur Houseboat Association to agree a defence type and alignment that has the least impact on all stakeholders within the reach.

2.2.30 Adur DC's Employment Land Review 2006 (part of the ongoing Adur Local Development Framework) highlights Shoreham Airport as one of the key sites for future development to meet local employment needs. The Airport is located in Reach W7 (refer to Key Plan 2) and the current level of flood risk means that future development cannot proceed without improvement of the defences. Implementation of the scheme is therefore integral to the future development of Adur District, which has been reflected in the contributions to this scheme from Adur DC, see section 5.3.29.

## **History of Flooding**

2.2.31 There have been no significant or catastrophic events affecting the scheme area within the last 50 years. However, defences have regularly overtopped in recent years leading to flooding of gardens and local roads, although volumes have not been significant enough to flood property. This is partly due to the lack of severe storm events to test the current flood defences and due to the continued maintenance of the defences with recent patch repairs being undertaken in Reaches E3 and W1. Coastal protection works undertaken in OMU7 in 2005 raised the coastal defences to in excess of 1 in 300 (0.33%) which also provide protection to Shoreham Beach and Lancing.

## **2.3 Current approach to flood risk management**

### **Measures to manage the probability of flood risk**

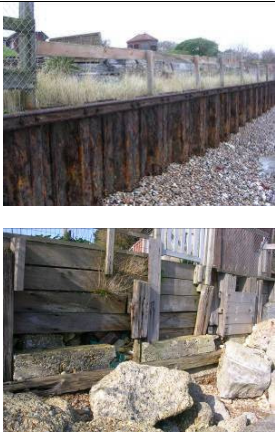


2.3.1 The existing frontage within the scheme area is approximately 7.2km long, 1.8km on the east bank and 5.4km on the west bank, comprising a mixture of flood defence types including earth embankments, steel sheet piled walls, concrete and masonry walls and shingle beach with timber groynes. The existing defences are at varying heights with varying residual lives, providing standards of defence ranging from 1 in 5 (20%) chance of flooding each year to in excess of 1 in 300 (0.33%) chance of flooding each year, as detailed in Table 2-2. Further details of the existing defences in all reaches can be found in Appendix C.





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- 2.3.2 The defences are operated and maintained by a combination of the Environment Agency, West Sussex County Council (WSCC), Adur DC and private landowners on an ad-hoc basis. The defences are owned by a mixture of private landowners, WSCC and Adur DC; refer to the land owner plans in Appendix D.
- 2.3.3 There is no regular maintenance regime along this length of the River Adur, but repairs are undertaken as and when required. The Environment Agency spends approximately £30k per annum on maintenance of the existing defences.
- 2.3.4 As detailed in Section 2.2.3, OMU7 also provides protection to the Shoreham Beach/Lancing flood cell, having a standard of protection in excess of 1 in 300 (0.33%), and is sustained through an existing beach maintenance regime undertaken by the Environment Agency.


## Measures to manage the consequences of flood risk

**Table 2-2 Details of existing frontages**

Reach	Existing defences	Standard of Protection <sup>1</sup>	Residual Life	Likely failure mechanism	Key Issues
W1	<p>A combination of steel sheet piles, rock revetment, timber groynes, concrete revetment and shingle bank.</p> 	20%	1-20 years (some areas have failed and been repaired)	Critical loss of steel thickness or failure of groynes leading to loss of shingle beach material.	Shoreham Old Fort Scheduled Monument adjacent to working area.
W2	<p>Steel sheet piled walls</p> 	20% (at the upstream end) - 0.33% (at the downstream end)	10 years (at the downstream end) – 40 years (at the upstream end)	Critical loss of steel thickness.	Proximity of residential properties to the defence.
W3	<p>A combination of brick, timber, concrete and steel sheet piled walls.</p> 	10%	5 – 15 years	Critical loss of steel thickness or, for the concrete wall, failure of toe support due to wash out of supporting material.	Proximity of residential properties to the defence.  Saltmarsh habitat adjacent to the defence.

Reach	Existing defences	Standard of Protection <sup>1</sup>	Residual Life	Likely failure mechanism	Key Issues
W4	Concrete and steel sheet piled walls. 	20%	10 years	Critical loss of steel thickness or failure of the concrete wall due to wash out of supporting material.	SSSI Saltmarsh habitat and RSPB Reserve adjacent to the defence.  New footbridge being installed by West Sussex County Council.
W5	An earth embankment with concrete crest footpath. 	10% - 2%	1 – 10 years	Wash out of embankment material leading to piping or rotational failure.	SSSI Saltmarsh habitat adjacent to the defence.  Proximity of houseboats and residential properties to the defence.  The defence is designated SSSI due to an existing reptile population.
W6	Earth banks with some concrete revetment. 	10% to 0.33%	5 – 30 years	Wash out of embankment material leading to piping or rotational failure.	SSSI Saltmarsh habitat adjacent to the defence.  This area is an historic landfill.
W7	Earth embankment with some masonry and concrete revetment. 	20%	5 – 20 years	Wash out of embankment material leading to piping or rotational failure.	SSSI Saltmarsh habitat adjacent to the defence.  Historic WWII pillboxes situated along defence line.

Reach	Existing defences		Standard of Protection <sup>1</sup>	Residual Life	Likely failure mechanism	Key Issues
W8	Concrete walls		>0.33%	40 – 50 years	Rotational failure during flood loading.	SSSI Saltmarsh habitat adjacent to the defence.
E1	Steel sheet piled, concrete and timber walled river frontage		5%	5 – 30 years (some stretches are very close to failure)	Critical loss of wall thickness.	SSSI mudflat habitat next to defence.  Situated in a Conservation Area.  Residential properties in close proximity to the defence.
E2	Steel sheet piled walls		5% - >0.33%	50+ years	Critical loss of steel thickness.	This area is an historic landfill.  Borders Network Rail embankment.
E3	Earth embankment with some concrete revetment		20% - 1%	10 – 50 years	Wash out of embankment material leading to piping or rotational failure.	Located within a Conservation Area and adjacent to the South Downs National Park.  SSSI saltmarsh habitat next to defence.  Borders Network Rail embankment.

Reach	Existing defences		Standard of Protection <sup>1</sup>	Residual Life	Likely failure mechanism	Key Issues
E4	Earth embankment		20% - 0.5%	10 – 30 years	Wash out of embankment material leading to piping or rotational failure.	Located in South Downs National Park.  SSSI saltmarsh habitat next to defence.

Notes: <sup>1</sup>Excludes any allowance for freeboard.

2.3.5 Further details of the existing defences can be found in Appendix C.

2.3.6 In addition to the existing defences Shoreham-by-Sea is covered by the Environment Agency's East Worthing and Shoreham flood warning system, with the area having an uptake of approximately 88% (2010). Warnings are issued by the Environment Agency's automated Flood Warnings Direct system, there are no loudhailer or siren systems within the scheme boundaries. Adur DC's emergency response plan details the roles and responsibilities in the management of an emergency incident, including flooding, and notes the sand bag protocol for West Sussex. No further measures are in place to manage the consequence of flooding.

## 3 Problem definition and objectives

### 3.1 Outline of the problem

- 3.1.1 The existing standard of protection on these reaches of the River Adur is poor with the defence levels varying from as low as 1 in 5 (20%) chance of flooding each year locally in Reaches W1, W2 and W4, where the defences are known to have overtopped, to 1 in 300 (0.33%) in Reach W2, W8 and E2, refer to Table 2-2. The standard of protection is projected to fall with sea level rise, to less than 1 in 1 (100%) chance of flooding each year by Year 100.
- 3.1.2 The residual life of the defences is also poor with parts of the defences in reaches W1, W3, W5, W6, W7 and E1 having residual lives of less than 10 years. Walls in Reaches W1 and E1 have lost significant thickness with holes forming in some areas which are deemed to already have failed and since been repaired or are very close to failure. If no works are undertaken, then rapid deterioration and further failures would be expected in the short term (within the next 5 to 10 years).
- 3.1.3 The construction of the existing embankment in Reaches W5 and E3, means that failure due to seepage and piping could occur prior to overtopping, leading to breach and catastrophic flooding. Sections of Reach E3 have had to be repaired to prevent seepage in the recent past. The long-section defence plans in Appendix C provide a further summary of the current defence type, standard of defence and residual life of each of the existing flood defence structures.
- 3.1.4 The main mechanism of flooding in the scheme area is through overtopping and breach of defences during a flood event. Due to the low lying nature of large areas of Shoreham Beach and Lancing on the west bank, the onset of flooding would be rapid with fast flowing water up to 1.8m deep over large residential areas, with a high risk of death and injury. The flooding of these low lying areas would also cut transport links, marooning more than 1400 properties in the higher areas of Shoreham Beach and making access difficult or impossible for emergency services. The required combination of high tide and tidal surge has not occurred in recent history to test the existing defences. However, due to rising sea levels and the deteriorating condition of the defences in reaches W5 and W7 it is envisaged that catastrophic failure of these defences would occur on an event with a 1 in 20 (5%) chance of occurring each year, leading to flooding of 1,795 residential and 125 commercial properties.
- 3.1.5 Flooding to residential areas of the east bank would also be extensive with flood depths up to 0.9m. The defences in Reach E1 are also in a poor state of repair and nearing the end of their useful life. When these defences fail there is a risk of undermining and eventual erosion of properties in the high street area. It is also important to note that if the defences were only raised on the west bank, flood depths on the east bank would increase by up to 400mm, putting an additional 72 properties at risk.
- 3.1.6 Breach of the defences during an extreme event would result in damage to the number of properties identified in Table 3-1.

**Table 3-1 Properties at risk from flooding**

Event	2010 (defences assumed to breach without any remedial work)			2110 (Do Nothing)		
	Residential	Commercial	Total	Residential	Commercial	Total
1 in 10 (10%)	0	0	0	3,038	252	3,290
1 in 20 (5%)	1,795	126	1,921	4,319	327	4,646
1 in 75 (1.33%)	2,147	135	2,282	4,091	327	4,418
1 in 100 (1%)	2,328	169	2,497	4,301	327	4,628
1 in 200 (0.5%)	2,328	169	2,497	4,454	333	4,787
1 in 300 (0.33%)	2,398	190	2,588	4,524	354	4,878

## 3.2 Details of approved strategy

### Details of the approved option

- 3.2.1 The Strategy option for the River Adur, OMU8 and 9i is 'Phased Improve', recommending 'Improve by raising the existing defences' to provide an increased SoP by Year 50, optimised to a standard of protection of 1 in 300 (0.33%) on the west bank. For the following 50 years the Strategy recommends either the construction of a tidal barrier, or further raising of the defence height to maintain the SoP up to year 100.
- 3.2.2 The Strategy preferred option also recommended that further studies be progressed to investigate the construction of 39ha of Biodiversity Action Plan (BAP) habitat. This is not being progressed as part of this business case and it is outside the scheme boundary but will be taken forward under the Tidal River Adur Strategy and subsequent implementation.

### Economic assessment

- 3.2.3 Updates to the guidance on extreme sea levels and climate change since the completion of the Strategy has led to the economic damages being reassessed see sections 4.2.23 and 4.6.
- 3.2.4 Within the economic assessment the costs and benefits for OMU7, OMU8 and OMU9i are considered, in line with the Strategy benefits calculations. OMU7 and OMU8 protect the same flood cell. However, this appraisal is only seeking funding for works to OMU's 8 and 9i as OMU7 already provides a standard of protection of 1 in 300 (0.33%) to the Shoreham Beach and Lancing flood cell.

### Key constraints

- 3.2.5 The key constraints on the approved scheme options is the developed nature of the river frontage over the majority of the scheme length and the ecological interest, particularly in the northern half of the scheme. Private property boundaries extend to the river's edge and sometimes into the river in Reaches W3 and W5, with land developed up to and over the existing defence alignment. The river immediately adjacent to many of the frontages includes high quality saltmarsh and mudflat BAP habitat. Other technical and environmental constraints are presented below.

### Technical Constraints

- 3.2.6 Shoreham Recreation Ground is directly adjacent to Reach W6 and is an historic landfill site. To prevent erosion of the site and pollution of the estuary, all options in this reach require erosion protection. Landward re-alignment of the defences in this reach is not viable due to the pollution risk.

- 3.2.7 West Sussex County Council (WSCC) is replacing the pedestrian footbridge that spans between Reaches E1 and W4. The footbridge replacement is outside of the proposed working area in Reach E1 but interacts with the defences in Reach W4. The bridge replacement is being undertaken in advance of construction of the flood defences. In order to integrate the two schemes, it has been agreed that the bridge will be constructed over the level of the proposed defences in Reach W4 with a ramp back to ground level. In order to achieve this with minimal overall disruption to the local community, elements of the flood defence construction in Reach W4 will be undertaken at the same time as the footbridge construction. To facilitate this, these elements are being designed and constructed by WSCC's contractor, with a funding contribution from the Environment Agency.
- 3.2.8 Access for construction plant is difficult in a number of locations throughout the scheme area due to existing infrastructure, proximity of properties to the defences and the developed, urban nature of Shoreham-by-Sea. Early Contractor Involvement (ECI) at the options appraisal phase has enabled us to understand and address these issues accordingly. This is particularly key in Reach E1 where properties are located right up to the estuary edge and therefore marine plant will be required to construct the main elements of the wall; Reaches W1, W3 and E3 where plant will need to work on the wet side of the defences and in Reach W5 where the restricted access will require the use of specialist plant.

### Environmental Constraints

- 3.2.9 The Adur Estuary SSSI is designated for its saltmarsh and mudflats within the river, and reptiles along the top of the flood defences along the west bank. Any works affecting these features will require mitigation (translocation of reptiles and the provision of compensatory estuarine habitat) and assent from Natural England.
- 3.2.10 Overwintering birds within the RSPB reserve/SSSI and migratory fish within the river may be affected during the construction period and therefore represent constraints on the methods and timing of construction. Any works affecting birds within the RSPB reserve will need to be agreed with the RSPB.
- 3.2.11 The area of Childing Pink within the nature reserve on the west bank of the river may also be affected during construction period and therefore represents a constraint on construction.
- 3.2.12 The scheme will need to be in keeping with the existing and local character of the area. Careful consideration needs to be given to the visual appearance of the defences especially within the South Downs National Park and the two Conservation Areas on the East Bank.
- 3.2.13 Other cultural heritage interests, notably Shoreham Old Fort SM, listed buildings (including Shoreham Old Toll Bridge) and the World War II pill boxes along the river banks need consideration to ensure that no physical damage is incurred, that their setting is not adversely affected and to incorporate enhancement works where feasible.
- 3.2.14 The presence of approximately 42 houseboats moored against the tidal defences on the West Bank, the close proximity of residential properties along both banks of the river and the recreational use of both footpaths along the river banks and the river itself need consideration to ensure that any impacts are minimised.
- 3.2.15 The location of these sites and features can be found on the Indicative Landscape Plans within Appendix B and further information can be found in the Environmental Scoping Report in Appendix E.



## Objectives

3.2.16 The objectives of the scheme, in accordance with the objectives of the Strategy, are:

- a) To reduce the risk of life to human beings and protect and enhance their well-being.
- b) To protect commercial and residential property and existing infrastructure.
- c) To protect and enhance biodiversity, cultural heritage and landscape.

3.2.17 Specific objectives for the scheme which will contribute to the achievement of the above objectives are:

- a) To deliver the recommendations of the Strategy to improve the standard of protection to Shoreham-By-Sea, Shoreham Beach and Lancing for the next 50 years.
- b) To integrate a comprehensive flood defence scheme in accordance with the emerging Adur Local Plan and other relevant local infrastructure plans to support future economic growth.
- c) To work in partnership with the relevant local authorities and other stakeholders to seek opportunities for contributions where appropriate.
- d) Protect and enhance the ecological value of the River Adur estuary and preserve its heritage value.
- e) Maintain the interests of, and access to the estuary of the many marine and recreational user groups and local residents.
- f) Ensure that the most environmentally suitable options are progressed.

3.2.18 The scheme specific objectives were agreed by the project team and approved by the Project Board.

## 3.3 Consequences of doing nothing

3.3.1 Under the Do Nothing option no further maintenance or improvement would be undertaken to the defences along the frontages. The defences would deteriorate over time and fail through loss of section of steel and concrete walls leading to collapse, and the overtopping and under seepage of embankments leading to piping and washout and rotational failures. This would result in increased flooding damages and an increasingly unsustainable community. Without intervention, failure of embankments in Reaches W5 and W7 and the river walls in Reaches W1 and E1 would be expected within the next 5 to 10 years, with the extent of flooding shown on Key Plan 1. Breach of the embankments is expected to occur on a 1 in 20 year (5%) flood event leading to catastrophic flooding of at least 1,795 residential properties with flood depths up to 1.8m deep, with a high risk of loss of life, flooding of local roads would also strand a further 1,400 residences preventing access by emergency services.

3.3.2 By 2110 a do-nothing approach would result in the following.

- a) Loss of 3,521 residential and 219 commercial properties, with flood depths in excess of 2.8m.
- b) A further 933 residential and 114 commercial properties being at risk in a 1 in 200 (0.5%) flood event.
- c) Shoreham Airport and some small agricultural areas would become unusable.
- d) Part of the A259 main coast road would be regularly flooded and impassable.
- e) The main coastal sewerage line would require relocation.
- f) The historic landfill site in Reach W6 would be regularly flooded which may lead to localised pollution.
- g) The Shoreham Old Fort and The Marlipins SM's and 6 listed buildings would be at an increased risk of flooding.
- h) The World War II pillboxes in Reach W7 would either be damaged or completely washed out.

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- 3.3.3 These damages include allowance for the change factor climate change predictions (0.834m). Differences in actual climate change could vary this level by -53% (low end estimate) to +276% (H++ scenario).
- 3.3.4 The Present Value (PV) Damage under the Do Nothing scenario is £809m, see section 4.6.
- 3.3.5 OMU7 also defends the Shoreham Beach and Lancing flood cell. A Do Nothing option for the west bank would therefore compromise the protection afforded by the coastal works completed in 2005, preventing the realisation of the full benefits of this £18m investment.

## 4 Options for implementing the approved strategy

### 4.1 Options considered

- 4.1.1 The preferred strategic option for improving the SoP to the west and east banks, was reviewed to assess potential variations on how the option could be implemented. This assessment included variations to the alignment (route) of the defences and to the type (form) of defences. The Options Appraisal Report (Appendix F) identifies the variations considered and the appraisal process applied.
- 4.1.2 Four variations of alignment were identified for detailed appraisal:
- 4.1.3 Local set-back alignment in Reaches W2 and W3 – potential lower cost relative to raising the front line defence.
- 4.1.4 Local set-back alignment in Reach W6 – potential to make space for water by allowing the recreation ground to flood.
- 4.1.5 Local set-back alignment in Reach W7 and E3 – potential improved environmental mitigation relative to raising the front line defence.
- 4.1.6 Tie-in to high ground in Reach E4 – potential for environmental enhancements and additional protection to highway infrastructure by tying-in to high ground upstream of the Strategy boundary in Reach E4.
- 4.1.7 In addition a number of technical solutions were considered for each reach including concrete walls, earth embankments and steel sheet piled walls. The following solutions were also considered for specific reaches:
- 4.1.8 Replacement of the existing timber groins was assessed against constructing a new rock revetment in Reach W1, to retain the foreshore level in front of the defences.
- 4.1.9 The use of floodgates across the marina in Reach W2 was investigated to assess if the removal of the raised defences around the marina reduced the whole life cost.
- 4.1.10 In Reach W5 different solutions for raising the defence were considered against the constraint of the moored houseboats along the reach.
- 4.1.11 Installation of individual property protection in Reach E1 was assessed as a potential option to reduce the whole life cost in the reach.
- 4.1.12 A seepage cut-off was identified as being required in Reach E3, see Appendix H, and the use of plastic piles or a slurry trench were considered to selection of the most cost effective solution.
- 4.1.13 To review the impact of the FCERM-AG decision rule and updated extreme sea level and sea level rise guidance introduced after the Strategy, a range of standards for the preferred option has been included in this detailed appraisal, based on applying the same SoP for both banks. The options considered are 1 in 75yr, 1 in 100 yr, 200yr and 300yr (1.3%, 1%, 0.5% and 0.33%) chance of occurring each year.

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- 4.1.14 All options will be assessed against baseline options of Option 1: Do Nothing and Option 2: Do Minimum, and therefore both are included in the option long list.

## 4.2 Technical details

- 4.2.1 Appraisal Summary Table's (AST's) (refer to Appendix G) were developed to assist in the assessment of the long listed options and confirm the variations to be included in the short-listed options.

### Short Listed alignments for Appraisal

- 4.2.2 A set back alignment in Reaches W2 and W3 has not been selected as the benefits of protecting the properties adjacent to the river outweighed the cost savings of the defence realignment, by 56 to 1.
- 4.2.3 Local realignment in Reach W6 has not been selected as the site is a former landfill with an existing issue of erosion of the landfill material into the river. The realignment of the defences would increase the risk of erosion and leaching of contaminants into the estuary.
- 4.2.4 The local set back in Reach W7 and E3 (estimated PV cost £475k) has been selected in order to provide environmental mitigation in line with the schemes objectives. This option allows for the creation of new intertidal habitat between the new and existing defence alignments, to compensate for habitat lost to the scheme footprint and coastal squeeze over the first 50 years of the scheme, closer to the location of the losses and in a more cost effective manner than providing habitat upstream, as recommended by the Strategy (estimated PV cost £1.15m).
- 4.2.5 The potential to tie-in to high ground in Reach E4 (estimated PV cost £4,213k) has not been selected as the benefits of raising the defences further upstream were far outweighed by the increase in costs compared to tying in within Reach E3 (estimated PV cost £2,934k). The A283 is higher than the surrounding ground, with flooding only expected to occur on floods exceeding 1 in 200 year (0.5%) chance of occurring each year, reducing to 1 in 20 (5%) by Year 50. This option would have been undertaken in an area outside of the approved Strategy. The Tidal River Adur Strategy is at an early stage and will assess this stretch of river to confirm the preferred strategic option the area. The defences will therefore be tied-in to high ground in Reach E3 to the south of the A27.

### Short Listed solutions for Appraisal

- 4.2.6 In Reaches W1, W3, W4 and part of E3 steel sheet piled defences were selected as the preferred option to provide a cut-off to seepage beneath the defences, where insufficient space was available to construct a wide embankment, this is the only technically feasible solution at these locations.
- 4.2.7 In Reach W1 rock revetment was selected as the preferred option for preventing erosion in front of the defences, as with an estimated cost of £610k it was cheaper than providing groynes and beach nourishment at an estimated cost of £870k.
- 4.2.8 In Reaches W2 concrete walls were selected as the preferred option for raising the capping to the existing defences. The use of floodgates was not selected as with an estimated cost of £580k it was more expensive than constructing walls around the marina, estimated at £400k, and carried a higher ongoing operation and maintenance liability when compare to the additional length of relatively maintenance free walls around the marina.

- 4.2.9 A steel sheet piled wall on the landward side of the embankment (approximate cost £1.3m) was chosen as the preferred option in Reach W5. This was the cheapest technical solution that provided the required standard of protection and a barrier to seepage in this space constrained reach. The alternative options considered included widening the footpath and providing terracing to the rear of the wall with estimated costs of £1.8m and £1.7m respectively.
- 4.2.10 Raised earth embankments were chosen as the preferred option in Reach W6 and part of Reach E3 as they are the cheapest technical solution with the least environmental impacts, and space is available to accommodate the increased footprint of the defences.
- 4.2.11 In Reach E1 the construction of a new wall was selected as the preferred option as the installation of individual property protection had no adaptability for variation in climate change and may not provide protection to the older properties in the reach, two of which are listed buildings. Many of the existing river walls are also in a bad state of repair, requiring replacement in the next ten years.
- 4.2.12 In reach E2 a concrete wall has been selected following discussion with Network Rail as they wanted to minimise the footprint of the defence adjacent to the railway to accommodate their future maintenance requirements.
- 4.2.13 In the remainder of Reach E3 a slurry trench has been selected in combination with embankment raising in order to prevent seepage through and beneath the old embankment. A raised wall in the existing embankment was not considered environmentally acceptable due to the barrier it provided to wildlife. The slurry trench was the most cost effective solution for providing a cut-off, with an estimated cost of £330k compared to an estimated £400k for plastic piling.
- 4.2.14 Further details on the alignments and solutions can be found in the Options Appraisal Reports in Appendix F.
- 4.2.15 The optimal alignments and solutions have been combined in order to confirm the design standard of defence, as detailed in section 4.1.13. The resulting options taken forward for appraisal are therefore:
- 4.2.16 Do Nothing – Do Nothing is the baseline option against which the impacts and benefits of all other options are measured. Under this option maintenance of the existing flood defences and river walls would cease. Consequently, these structures will deteriorate with time and become less effective as sea levels rise. The risk of a breach and flooding from wave overtopping increases. Once an embankment or wall has failed no works would be carried out to repair it. Flooding will become more regular and widespread.
- 4.2.17 Do Minimum – Do Minimum represents the expenditure required to reactively maintain the defences in their current alignment/form repairing the defences as they fail. The Do Minimum option does not include works to raise the defences in response to predicted sea level rise thus the standard of defence afforded would fall over time.
- 4.2.18 Improve 1 – Improve SoP to 1 in 75yr (1.3%). This option comprises raising and strengthening or replacing the defences adjacent to the river, including local realignments in Reaches W7 and E3 (refer to section 5.3).
- 4.2.19 Improve 2 – Improve SoP to 1 in 100yr (1%). As Improve 1, but crest levels typically 30mm higher.

- 4.2.20 Improve 3 – Improve SoP to 1 in 200yr (0.5%). As Improve 1, but crest levels typically 110mm higher.
- 4.2.21 Improve 4 - Improve SoP to 1 on 300yr (0.33%). As Improve 1, but crest levels typically 160mm higher.

### Technical details of the Options

- 4.2.22 The study area comprises approximately 7.4km of existing defences on the east and west banks of the tidal River Adur. This has been divided into 11 reaches, based on existing defence type and the surrounding land use, with Reaches E1 to E3 on the left bank and Reaches W1 to W8 on the right bank. Reach locations are indicated in Key Plan 1.
- 4.2.23 The proposed defence levels have been based on the levels derived from the EA/Defra R&D project 'Coastal and Estuary Extremes' (SC060064) with allowance for climate change at the change factor level as detailed in Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk management Authorities, Environment Agency, 2011. All defences are designed to a level of 4.7mOD plus freeboard.
- 4.2.24 The flood defence improvements comprise.
- a) Approximately 2.5km of new sheet piled defences,
  - b) 0.7km of new reinforced concrete wall,
  - c) 0.8km of raised embankments,
  - d) 2km of new or realigned embankment, and
  - e) 0.6km of scour protection.
- 4.2.25 An adaptive approach has also been taken to the defences required within the first 50 years with a further 250m of concrete wall and 550m of steel sheet piling being constructed in year 20 to raise the existing defences in Reach W2 and defend the A259 in Reach W6 as sea levels rise. Defences in these areas currently provide a standard of protection in excess of 1 in 300 years (0.33%) chance of occurring each year. These works are estimated at £1.7m, equivalent to approximately 10% of the current construction cost.

### Climate change

- 4.2.26 Climate change allowances considered for the appraisal over the next 100 years follow the guidance in the Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk management Authorities, Environment Agency, 2011.
- 4.2.27 In line with the Strategy recommendations and FCRM-AG, an adaptive approach to climate change has been adopted within the design of the Improve options, with 50 years of sea level rise incorporated within the design (320mm). The initial design standard on completion of the scheme will therefore be considerably higher. A new tidal barrier or further improvement work, including replacement of sheet piling in Reach W2 and E2, raising of concrete capping beams in Reaches W1, W3, W4, W5, E1, E3; raising of embankments in Reaches W6, W7 and E3 and replacement of the concrete wall in Reach W8, to sustain the design standard may be required in Year 50 if sea level rise is in line with current predictions.
- 4.2.28 The defences have been designed to accommodate further raising should the level of the existing defences need to be increased in Year 50 and beyond. The foundations of the sheet piled defences have been designed to allow raising to the upper end climate change estimate in Year 100, 5.4mOD plus freeboard, 900mm higher than the existing design level.

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- 4.2.29 If climate is lower than assumed and occurs in line with the lower end estimate, then adaptation in the form of raising the defences or construction of a barrier may not be required until Year 95. Conversely, if climate change accelerates, occurring in line with the upper end or H++ estimates, adaptation may need to be brought forward to year 47 or 30 respectively. Sensitivity to acceleration in climate change has been considered in section 5.2.2.

## 4.3 Environmental assessment

### Strategic Environmental Assessment

- 4.3.1 A Strategic Environmental Assessment (SEA) was undertaken for the Strategy. The SEA identified that the preferred option for OMU 8 and 9i would encroach within the estuary and would result in potentially significant impacts on ecology (particularly on the SSSI and reptiles that it supports) that would require the creation of compensatory habitat, reptile mitigation and close communication with Natural England to avoid adverse impacts. Potentially significant impacts on the townscape and visual amenity were identified as being dependant on the height of raising required, and requiring continued consideration at the project level.

### Environmental Assessment of Options

- 4.3.2 An environmental appraisal of options was undertaken alongside the technical and cost appraisals. Two options appraisal workshops were held during the appraisal process (addressing the West and East Banks respectively), with a wide range of internal and external, statutory and non-statutory consultees.
- 4.3.3 The primary issues raised by consultees concern the key environmental features of the study area which are presented in sections 2.2 and 3.2. The results of the appraisal process were fed into the AST's, presented in Appendix G.
- 4.3.4 Potential contamination from past landfill was considered the over-riding environmental constraint to local realignment in Reach W6.
- 4.3.5 The option to tie-in to high ground in Reach E4 could have allowed for ecological habitat creation, but could also have resulted in other potentially adverse environmental impacts, such as a greater impact on reptiles and landscape within the South Downs National Park. It would also have required the import of considerable volumes of material.
- 4.3.6 The preferred option of local set-back alignment in Reach W7 and E3 was considered an overall environmentally preferred option, as it will provide environmental mitigation (allowing for the creation of new intertidal habitat between the new and existing defence alignments required to compensate for habitat lost to the scheme footprint and coastal squeeze over the first 50 years of the scheme) without some of the environmental disadvantages associated with the option to tie-in to high ground in Reach E4.
- 4.3.7 Consideration of how the options could contribute to WFD objectives and the ecology of the estuary was factored in to the options appraisal process, with options that would provide most ecological benefit scoring more highly. The main opportunity for providing WFD-related benefits on the west bank was identified in Reach W7, where set-back defences would create additional marginal habitat. On the east bank, due to the built-up areas inland of the riverside, significant habitat creation opportunities are limited to north of the A27. The alignment of all short-listed options was designed to allow these opportunities to be achieved in the future. The results of the WFD assessment are presented in Appendix 6 of the Scoping Report (Appendix E).

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4.3.8 The key environmental issues for each option are summarised in Table 4-1.

Table 4-1 Key environmental impacts, mitigation and opportunities

Key positive impacts	Key negative impacts	Mitigation/enhancement opportunity
<b>Option Do nothing</b>		
No change to features of ecological, landscape or cultural heritage interest in the short term from new structures. No disturbance to people during construction.	Gradual decline in the level of protection afforded to people and the environment, with an unacceptable risk to life and property as a result of failure of the defences. More specifically, there would be a failure of structures and beach erosion in Reach W1, resulting in the loss of Shoreham Old Fort SM, a breach of the embankment in Reaches W5 and W7, which would result in permanent loss of ecological habitat within the SSSI, and loss of WWII cultural heritage features. Overtopping in Reach E3 would result in flooding of Old Shoreham Conservation Area, numerous listed buildings, including Old Shoreham Toll Bridge. Coastal squeeze and the loss of structures into the river would also affect ecological habitats.	N/A
<b>Option Do Minimum</b>		
No change to ecological, landscape or cultural heritage features in the short term from new structures over and above that currently caused by existing maintenance practices. No disturbance to people during construction.	Gradual decline in level of protection afforded to people and the environment, with an unacceptable risk to life and property as sea level rise reduces the standard of protection afforded. Gradual increase in flood risk, with more frequent overtopping of the defences, affecting local features and resources as listed under the Do Nothing Option. The maintenance of the defences on their current alignment will lead to a loss of 1.1ha of saltmarsh (a BAP habitat), due to coastal squeeze.	N/A
<b>Option Improve (All improve options have the same environmental impacts, mitigation and opportunities)</b>		
<b>Human Beings</b>		
Reduced risk of flooding, resulting a major beneficial impact on the population and socio-economy.	Temporary disturbance to local residents, businesses, amenity resources (footpaths, bridleways and slipways) and visitors during construction.	Careful control of construction to be specified during detailed design. Improvement to footpaths.



Key positive impacts	Key negative impacts	Mitigation/enhancement opportunity
<b>Ecology</b>		
<ul style="list-style-type: none"> <li>- With mitigation, 1.45ha of salt marsh habitat will be created. This will lead to an immediate gain of 1.25ha of habitat which will be mostly lost over time with sea level rise (see negative impacts) with a net long term gain of 0.2ha. There may be potential to extend the boundary of the SSSI to include this new area of saltmarsh habitat.</li> </ul>	<ul style="list-style-type: none"> <li>- Disturbance and damage to sensitive ecological features (e.g., saltmarsh, mudflat, birds and fish) during construction.</li> <li>- Potential damage to an area of Childing Pink (a nationally rare plant) in Reach W1.</li> <li>- Disturbance and harm to reptiles along Reaches W1, W4, W5, W6, W7, E2 and E3, with some being within the SSSI.</li> <li>- Scour protection introduces hard engineering into estuary edge</li> </ul>	<ul style="list-style-type: none"> <li>- Continued consultation with Natural England and RSPB, especially with respect to the timing of construction.</li> <li>- Sensitive ecological habitat, such as saltmarsh will be protected from damage through construction of temporary haul roads to protect the marsh beneath the working areas and designing the defences to minimise encroachment into the estuary.</li> <li>- The area of Childing Pink will be protected by ensuring the works avoid this area.</li> <li>- Reptile translocation required, with work already undertaken to prepare reptile receptor sites.</li> <li>- Habitat creation sites have been identified within the scheme boundary to provide 1.4ha of habitat in Reach W7 plus 0.05ha in Reach E3.</li> <li>- Investigate viability of soft engineering techniques for scour protection</li> </ul>
<b>Air Quality</b>		
<ul style="list-style-type: none"> <li>- None</li> </ul>	<ul style="list-style-type: none"> <li>- Temporary short term impacts on air quality during construction.</li> </ul>	<ul style="list-style-type: none"> <li>- Careful control of construction to be specified during detailed design</li> </ul>
<b>Landscape and Visual Amenity</b>		
<ul style="list-style-type: none"> <li>- In the more open Reaches W6, W7 and E3, there will be an improvement to views and visual amenity through improvements to the footpath located along the crest of the defences which will also benefit pedestrians.</li> <li>- Improvements to character of E1 and W3 which are visually cluttered and in varying states of disrepair at the moment</li> </ul>	<ul style="list-style-type: none"> <li>- Changes to the townscape/ landscape and visual aspect of the riverfront within Shoreham and the more open rural areas to the north through an increased visual intrusion of the flood defences. These changes will be outside but potentially visible from within the South Downs National Park.</li> <li>- Some reduction of views across the river in the residential areas between Reaches W1 and W5 and Reaches E1 to E2 from residential properties adjacent to the river will be unavoidable due to raising the defences.</li> </ul>	<ul style="list-style-type: none"> <li>- Careful consideration of alignment to fit with existing field patterns and landscape features</li> <li>- Careful consideration of the finishes and materials to minimise adverse impacts, especially within the Conservation Areas</li> <li>- Improvements to Shoreham Old Fort car park as mitigation for the siting of the site compound.</li> </ul>

Key positive impacts	Key negative impacts	Mitigation/enhancement opportunity
<b>Cultural Heritage</b>		
<ul style="list-style-type: none"> <li>- Protection of Shoreham Old Fort SM (provided measures are put in place to ensure its protection from damage during construction – see mitigation), and it will benefit from landscape opportunities at its car park.</li> <li>- Protection of other features of cultural heritage interest, including Old Shoreham Conservation Area and numerous listed buildings, the World War II pill boxes along the riverfront will also be protected from erosion.</li> </ul>	<ul style="list-style-type: none"> <li>- Potential effect on the setting of Shoreham and Old Shoreham Conservation Areas.</li> <li>- Potential impact from construction on previously unrecorded buried archaeological and palaeo-environmental remains in the river bed and intertidal zone.</li> </ul>	<ul style="list-style-type: none"> <li>- Careful attention to detailed design to avoid any significant adverse long term effect on the setting of the Conservation Areas and listed buildings.</li> <li>- Incorporation of favourable outcomes through improvement to the setting of the WWII pill boxes.</li> <li>- Further assessment of mitigation requirements during the detailed design in consultation with the Environment Agency's archaeologist and West Sussex County Archaeologist. Mitigation may need to include a foreshore survey prior to construction or a geoarchaeological survey which would identify the nature of any remedial action required.</li> </ul>
<b>Water Quality</b>		
<ul style="list-style-type: none"> <li>- Possible benefit from any reduction in leaching of pollutants from contaminated land.</li> <li>- Prevention of the ongoing scour of the landfill site in Reach W6, improving the local water quality.</li> </ul>	<ul style="list-style-type: none"> <li>- Potential contamination of water due to release of contaminants.</li> </ul>	<ul style="list-style-type: none"> <li>- Methods for pollution prevention will be incorporated during the detailed design stage.</li> </ul>
<b>Traffic and Transportation</b>		
<ul style="list-style-type: none"> <li>- None</li> </ul>	<ul style="list-style-type: none"> <li>- Temporary disruption to vehicle travellers and other road users during construction.</li> </ul>	<ul style="list-style-type: none"> <li>- Careful control of construction to be specified during detailed design.</li> </ul>
<b>Soils and Ground Conditions</b>		
<ul style="list-style-type: none"> <li>- None</li> </ul>	<ul style="list-style-type: none"> <li>- Potential risk to construction workers from contaminants released during construction.</li> </ul>	<ul style="list-style-type: none"> <li>- Careful control of construction to be specified during detailed design.</li> </ul>

## 4.4 Social and community impacts

- 4.4.1 The key social and community impacts are listed below; further details on all impacts can be found in the Appraisal Summary Tables found in Appendix G.
- 4.4.2 Under the Do Minimum scenario the existing defences are expected to breach during a flood with a 1 in 20 (5%) chance of occurring each year flooding 1,795 residential properties and on this basis will have a negative impact on the local community.
- 4.4.3 With no investment, sea level rise will reduce the effective standard of service, and the risk to life will increase. Part of the town will become uninhabitable beyond 2060 as flood frequency increases. All options except do nothing and Do Minimum will reduce the impacts of flooding and associated social, economic and environmental risks.
- 4.4.4 The widening of the embankment in Reach W7 will improve the safety and amenity of this well used footpath.

- 4.4.5 Delivery of additional enhancements in partnership with Adur DC will be undertaken during detailed design and construction, ensuring that, where possible, public areas of Shoreham are improved as part of the scheme.

## Consultation

- 4.4.6 Consultation with internal Environment Agency technical specialists and external stakeholders has been undertaken throughout preparation of the scheme design. Meetings have been held with stakeholders and local community groups. A summary of consultation activities and consulted parties is provided in Table 4-2, with a full list of consultees provided in Appendix I.

**Table 4-2 Consultation summary**

Who	How	When	Feedback summary
General public	Newsletters  Public Exhibition  Website, including newsletter and engagement drawings	November 2009 - September 2012  October 2010 (West Bank)  June 2012 (East Bank)  October 2010 – October 2012	Most respondents recognise the need for improvements to the flood defences and welcome the improvements, some suggestions have been received and incorporated in to the design.
Landowners	Meetings	February 2010 (West Bank) February and March 2012 (East Bank)  December 2009, March 2010, May 2010, September 2010, April 2011 (Reach W5 specific)	Landowners were generally supportive of the improvements to the flood defences. Some issues raised regarding alignment and access, which have been addressed in the current design of the scheme.  Discussions are ongoing with Adur Houseboat Association regarding the preferred option for Reach W5. Not all of the riparian owners agree with the preferred option as it impacts upon their land and will cause disruption during construction without any perceived benefits to them.
Statutory Consultees and other stakeholders	Scoping Consultation Document Environmental workshop Phone calls E-mails Meetings Joint Site Visits	November 2009 – September 2012	Generally supportive, with specific issues raised by stakeholders: these have been addressed during scheme development (see Scoping report in appendix E)

- 4.4.7 Extensive stakeholder engagement has been undertaken during scheme preparation and will continue through design and construction.

## 4.5 Option costs

- 4.5.1 An NCF2 mini-bid tendering process was undertaken in December 2010 to determine the preferred contractor for Reaches W1 to W7. The preferred contractor is Volker Stevin. The costs for Reaches E1 to E3 have been prepared by the winning contractor and benchmarked by the project cost advisor. Capital costs for the Improve 4 option are based on the winning tender return for reaches W1 to W7, uplifted to a price date of 2012 Q2, and subsequent costing of reaches E1 to E3. Construction costs for the Improve 1 and 2 options have been derived using costs provided for Improve 4. Future construction costs for works in Year 20 (phased improvement) are also estimated based on the tender cost information as appropriate.
- 4.5.2 Other project delivery phase costs have been estimated jointly by the team (Environment Agency, Halcrow Group Limited, Arcadis and other suppliers). Cost estimates include allowances for additional survey and investigation, detail design, cost consultancy, CDMc services, planning and consent fees, legal and estates fees, compensation and construction supervision.
- 4.5.3 The base date for the cost estimates and benefit prices is 2012 Q2. The financial cost of inflation over the 3 year delivery programme (not included in economic analysis) has been based on an estimated 2.5%.
- 4.5.4 The costs for future operation, maintenance and repair for the 100 year appraisal period have been estimated based on the nature of the flood defence assets, and in liaison with Environment Agency operations staff. It is estimated that the new defences will require an additional £14k per annum for maintenance above the existing £30k per annum budget for mowing of the increased embankments and operation and maintenance of the new floodgates.
- 4.5.5 A Summary of the option costs is included in Table 4-3 for each option. Full details and a breakdown of individual items are given in Appendix J.
- 4.5.6 Costs for the Do Minimum option have been adopted from the Strategy and updated to the current base date using the consumer price index.
- 4.5.7 A Risk Register was developed for the preferred option, and a Monte Carlo analysis undertaken (refer to Appendix K). The 50th percentile risk budget cost from the project risk register has been applied to the Improve 4 option for the capital works. As the works required for the Improve 1 and 2 options only vary by the small difference in design level the same risk figure has been applied to these options.

**Table 4-3 Summary of options costs**

	Do Minimum	Improve 1	Improve 2	Improve 3	Improve 4
Environment Agency staff	50	215	215	215	215
Consultant fees	150	973	973	973	973
Early Contractor Involvement (ECI)	6	10	10	10	10
Cost consultant fees	30	194	194	194	194
Site investigation & survey	40	341	341	341	341
Construction	817	16,300	16,500	17,000	17,200
Environmental mitigation		2,020	2,020	2,020	2,020
Environmental enhancement		36	36	36	36
Site supervision	30	379	379	379	379
Compensation	0	503	503	503	503
Risk contingency (50%)	245	1,370	1,370	1,370	1,370
Other		223	223	223	223
<b>Sub Total</b>	<b>1,370</b>	<b>22,600</b>	<b>22,800</b>	<b>23,300</b>	<b>23,600</b>
Future costs (Capital)	10,100	60,800	60,900	61,200	61,300
Future costs (maintenance)	9,830	14,100	14,100	14,100	14,000
<b>Total Whole Life Cost</b>	<b>21,300</b>	<b>97,400</b>	<b>97,700</b>	<b>98,700</b>	<b>99,000</b>
<b>Total PV Cost</b>	<b>7,180</b>	<b>33,300</b>	<b>33,500</b>	<b>34,200</b>	<b>33,600</b>

## 4.6 Options benefits

- 4.6.1 The Do Nothing option when applied to OMU's 7, 8 and 9i, would result in 2,066 residential and 219 commercial properties being at increased flood risk, an additional 3,521 residential and 219 commercial properties being written off, the A259 coast road and adjacent areas of agricultural land would be subjected to flooding on each tide and main coastal sewerage lines, 299 beach huts and 78 caravans would be lost to erosion.
- 4.6.2 The PV Do Nothing damages for OMU7, 8 and 9i are £809m over the 100 year appraisal period.
- 4.6.3 The scheme damages and benefits from flooding from OMU's 7, 8 and 9i have been derived from flood extents extracted from the Strategy flood modelling results, with flood depths updated in line with the latest extreme water levels and climate change guidance. The Annual Average Damages for each property were calculated using the Multi Coloured Manual (MCM) 2010 data.
- 4.6.4 The damages for erosion loss within OMU7 have been taken from the Strategy and updated in line with the Consumer Price Index (CPI) to a price date of 2012 Q2. The damages within the Strategy were based on the FCDPAG suite, including supplementary notes where appropriate. Further details can be found in Appendix L of the Strategy. Table 4-4 provides a summary of the monetised benefits for each option.

**Table 4-4 Summary of Present Value (PV) Damages and Benefits (£k)**

	Monetised Damage (PVd)	Monetised Damage Avoided	Monetised Benefits (PVb)	Key non-monetarised benefits
<b>Do-nothing</b>	809,000			
<b>Maintain</b>	311,000	498,000	498,000	
<b>Improve 1</b>	40,400	768,000	768,000	
<b>Improve 2</b>	25,400	783,000	783,000	
<b>Improve 3</b>	14,200	795,000	795,000	
<b>Improve 4</b>	10,700	798,000	798,000	

- 4.6.5 Project benefits increase from the Do Nothing through the Do Minimum and the Improve options due to the protection of additional properties and infrastructure. Details of the benefits of each option are included in the Appraisal Summary Tables (Appendix G).

## 5 Selection and details of the preferred option

### 5.1 Selecting the preferred option

5.1.1 Table 5-1 summarises the monetised benefit cost assessment excluding contributions. The benefits presented in Table 5-2 incorporate the contributions from Adur DC and Local Levy.

**Table 5-1 Benefit-cost assessment (excluding contributions)**

	PV Costs (£k)	PV Benefits (£k)	Av. Benefit/Cost Ratio	Incremental BCR	Option for Incremental Calculation
Do-nothing	-	-			
Do Minimum	7,180	498,000	69.4		
Improve 1	33,300	768,000	23.1	10.4	Do Minimum
Improve 2	33,500	783,000	23.4	75.4	Improve 1
Improve 3	34,200	795,000	23.2	16.0	Improve 2
Improve 4	34,400	798,000	23.2	17.7	Improve 3

**Table 5-2 Benefit-cost assessment (including contributions)**

	PV Contributions (£k)	PV Costs (£k)	PV Benefits (£k)	Av. Benefit/Cost Ratio	Incremental BCR	Option for Incremental Calculation
Do-nothing	-	-	-			
Do Minimum	0	7,180	498,000	69.4		
Improve 1	765	32,600	768,000	23.6	10.7	Do Minimum
Improve 2	765	32,700	783,000	23.9	75.4	Improve 1
Improve 3	765	33,400	795,000	23.8	16.0	Improve 2
Improve 4	765	33,600	798,000	23.7	17.7	Improve 3

5.1.2 The decision process applied below complies with FCERM-AG. Further details of the economic analysis can be found in Appendix L.

5.1.3 All of the improve options provide increasing standards of protection. From Table 5-1, Do Minimum has the highest average benefit cost ratio (ABCR) of 69.4. The next highest option is Improve 1, with a ABCR of 23.1 and an incremental benefit cost ratio (IBCR), relative to Maintain, of 10.4, this is robustly greater than 3 and Improve 1 would therefore be selected ahead of Maintain. With a ABCR of 23.4 and an IBCR, relative to Improve 1, of 75.4, Improve 2 would be selected ahead of Improve 1. Improve 3, has a ABCR of 23.2 and an IBCR of 16.0, and would therefore be selected ahead of Improve 2. The final option, Improve 4 has a ABCR of 23.2 and IBCR of 17.7 compared to Improve 3. The IBCR is robustly greater than 5 and as such Improve 4 is selected as the preferred option.

5.1.4 With the introduction of contributions in Table 5-2 it can be seen that the ABCRs for the options improve. With an improved ABCR of 23.7 and IBCR of 17.7 Improve 4 is still selected as the preferred option.

5.1.5 Scoring and weighting has not been undertaken for the options as any benefits that have not been quantified will be minimal in comparison to property damages and would not affect the outcome of the appraisal. The economic benefit associated with habitat creation benefits has also not been included as the majority of the area is required to mitigate for losses over the first 50 years of the scheme. The 0.2ha of habitat that will be gained will have minimal impact when compared to the property damages and would not affect the outcome of the appraisal.

- 5.1.6 Improve 4 meets the objectives for the scheme by reducing flood risk to people, property and the environment whilst retaining the existing recreational use of the Adur Estuary. Impacts upon the designated sites have been minimised and mitigation provided where appropriate.

## 5.2 Sensitivity testing

- 5.2.1 The sensitivity of the options to fluctuations in steel prices was assessed due to the quantity required for the scheme. To assess this, a 50% premium was added to the cost of steel. Based on this assessment the ABCR of the preferred option, including contribution, reduced from 23.7 to 22.4, confirming that the choice of option is not sensitive to steel price fluctuations. The partnership funding score for Improve 4 reduces from 173% to 163% under this option.
- 5.2.2 The sensitivity of options to climate change has also been undertaken. This has been assessed by bringing forward the costs of the construction of the barrier to year 40, mid way between the required years for adaptation for the change factor (Year 50) and H++ scenario (Year 30). Bringing forward the cost of the barrier reduces the ABCR from 23.7 to 22.2, confirming that the choice of option is not sensitive to a fluctuation in the climate change allowances. This scenario reduces the partnership funding score from 173% to 157%.

## 5.3 Details of the preferred option

### Technical aspects

- 5.3.1 The preferred option consists of approximately 7.2km of new and raised tidal defences. The works comprise a combination of steel sheet piled walls, concrete walls and earth embankments, details of which can be found in the scheme drawings, Appendix M.
- 5.3.2 In addition to the main works elements, a number of slipways, steps and ramps are required to maintain access to the river and private land.
- 5.3.3 Wherever possible the design has been undertaken to select the most sustainable solutions with minimal future operation and maintenance. It has been possible to design operation free defences for the majority of the scheme. However, it has been necessary to design five floodgates in Reach E1 to maintain access to existing slipways as there is insufficient space to design new slipways over the new defence line. Investigation has been undertaken to assess the potential for reducing the number of slipways in the reach, this will be continued through detailed design to minimise the future operation and maintenance liability of the scheme.
- 5.3.4 The detailed designs will be undertaken to allow future raising of the defences in year 50, where possible, to minimise the need for reconstruction and disruption to the local community in the future.
- 5.3.5 The works also include creation of a minimum of 1.4 ha of salt marsh BAP habitat along Reach W7 and 0.05ha along Reach E3 to mitigate for loss of existing marsh due to the footprint of the works (0.15 ha) and compensate for losses due to coastal squeeze over the first 50 years (1.1 ha).
- 5.3.6 In order to tie in the new footbridge being constructed by WSCC, discussed in section 3.2.7, WSCC will be constructing the flood defences in the vicinity of the bridge.
- 5.3.7 To receive the reptile population from the west bank, 10ha of translocation habitat has been established at two off-site locations in advance of the construction works. Translocation of these reptiles are planned to be undertaken over Summer 2014. The

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two receptor sites are currently suitable for use, but some minor maintenance works (clearance of intrusive scrub) may be required to retain them in a suitable condition. For reptiles on the east bank, it is proposed to enhance existing areas to the north.

- 5.3.8 The delivery phase of the scheme is programmed for completion over 3 years (refer to Appendix N).
- 5.3.9 The local Environment Agency Operations team has participated in the project appraisal and will undertake the long term management and operation of the improved defences.
- 5.3.10 In advance of the construction works, condition surveys will be undertaken of all affected private properties and reinstatement requirements agreed with landowners.
- 5.3.11 The design has been developed to reduce health and safety risks both during construction and operation. A Buildability Statement, Designers Risk Assessment (in the form of a Hazard Elimination and Management List) and Red, Amber, Green (RAG) list have been completed for the outline design, and will be further developed as part of the detail design phase.
- 5.3.12 The preferred option conforms to the Environment Agency Sustainable Construction Policy and broader social and environmental sustainability issues. A Carbon Calculator, draft Site Waste Management Plan and Sustainability Register & Risk Assessment have been prepared (refer to Appendices O, P and Q respectively).
- 5.3.13 The key technical aspects of the design within each reach are detailed in Table 5-3. Further details are included in the outline design drawings, Appendix M.



**Table 5-3 Technical details**

Reach	Technical details
W1	<ul style="list-style-type: none"> <li>• 180m of new timber and brick clad steel sheet piled retaining wall.</li> <li>• A further 150m of brick clad steel sheet piled defence.</li> <li>• 330m of new rock revetment and removal of existing timber groynes.</li> <li>• 220m of brick clad steel sheet piled retaining wall constructed in year 20<sup>1</sup>.</li> </ul>
W2	<ul style="list-style-type: none"> <li>• 500m of brick clad reinforced concrete walls.</li> <li>• New access ramps over the raised defences to the mooring basin.</li> <li>• Raising and extending the existing slipway.</li> <li>• 250m of reinforced concrete retaining wall to be undertaken in Year 20<sup>1</sup>.</li> </ul>
W3	<ul style="list-style-type: none"> <li>• 700m of new brick clad steel sheet piled wall.</li> <li>• Removal of the existing concrete and masonry defences over 580m.</li> <li>• Provision of access over the defence for properties.</li> <li>• Existing timber 10x10m canoe shed removed and replaced with new steel framed shed.</li> <li>• Access road raised to maintain property access.</li> </ul>
W4	<ul style="list-style-type: none"> <li>• 275m of brick clad steel sheet piled wall.</li> <li>• 250m of existing concrete and steel defences removed.</li> </ul>
W5	<ul style="list-style-type: none"> <li>• 630m of brick clad steel sheet piled wall.</li> <li>• New access steps over the defence for landowners.</li> </ul>
W6	<ul style="list-style-type: none"> <li>• 100m of existing embankment raised.</li> <li>• 625m of new embankment.</li> <li>• 425m of scour protection.</li> <li>• 60m of brick clad reinforced concrete wall.</li> <li>• 260m of brick clad steel sheet piled wall to be constructed in Year 20<sup>1</sup>.</li> </ul>
W7	<ul style="list-style-type: none"> <li>• 1000m of new realigned earth embankment.</li> <li>• 950m of existing embankment levelled to create new intertidal habitat.</li> <li>• 200m of new embankment to tie existing WWII pillboxes into new defence alignment.</li> <li>• 50m of reinforced concrete wall.</li> </ul>
W8	<ul style="list-style-type: none"> <li>• No works required.</li> </ul>
E1	<ul style="list-style-type: none"> <li>• 300m of timber and brick clad steel sheet piled retaining wall, constructed from the river.</li> <li>• Surface to 3 existing slipways broken out and recast.</li> <li>• 5 new floodgates, varying in width from 1.2m to 9.5m at slipways.</li> <li>• 1 set of access steps to the foreshore at raised Public Hard.</li> </ul>
E2	<ul style="list-style-type: none"> <li>• 40m of brick reinforced concrete wall.</li> <li>• 40m of masonry retaining wall.</li> <li>• Raised pathway and landscaping to tie-in to formal landscaping.</li> </ul>
E3	<ul style="list-style-type: none"> <li>• 230m of brick clad steel sheet piled wall.</li> <li>• 700m of earth embankment raised with formal path removed and reinstated to crest.</li> <li>• 700m long 5m deep slurry trench providing seepage cut-off.</li> <li>• 315m of new scour protection.</li> <li>• 180m of new earth embankment.</li> <li>• 200m of public highway raised by up to 1.6m.</li> </ul>
E4	<ul style="list-style-type: none"> <li>• No works required.</li> </ul>

## Environmental aspects

5.3.14 It is likely that the majority of the scheme will be progressed by the Environment Agency as permitted development. However, Reaches W7 and E3, where the new defences will be realigned, will require planning permission (this has been confirmed by Adur DC).

<sup>1</sup> Works in Year 20 are included within the economic appraisal but do not form part of this application.

A statutory EIA will be undertaken and an ES prepared for the entire scheme. The ES will be submitted to Adur DC with the planning application for Reaches W7 and E3 under the Town and Country Planning (Environmental Impact Assessment) Regulations 2011. The ES will also be advertised and made publicly available prior to undertaking the remainder of the works under permitted development in accordance with the Environmental Impact Assessment (Land Drainage Improvement Works) Regulations 1999. Confirmation will be sought from the Marine Management Organisation on whether an EIA is required under the Marine Works (Environmental Impact Assessment) Regulations 2007 as amended.

- 5.3.15 The WFD assessment undertaken during the outline design stage indicated that the scheme will not result in significant changes to water quality, flows, sediment transport, morphology or habitat quality or compromise any of the mitigation measures for the river. In terms of habitat, there will be a loss of an estimated 0.1 ha of saltmarsh mudflat due to the footprint of the works. Estimated losses due to coastal squeeze over the next 50 years may account for a further 1.1 ha across both banks. The creation of a minimum of 1.2 ha intertidal saltmarsh (with associated mudflat) in Reach W7 and an estimated 0.2 ha in Reach E3, will mitigate for the losses and provide some additional habitat.
- 5.3.16 The assessment concluded that the scheme is compliant with the Water Framework Directive and the scheme will not prevent the Adur transitional reaching good ecological potential by 2027. No adverse affects on neighbouring water bodies were identified and an exception test under article 4.7 will not be needed.
- 5.3.17 The works do not fall under the scope of the Habitat Regulations and Natural England have confirmed that no appropriate assessment will be required. However, assent from Natural England will be required under the Wildlife and Countryside Act for works adjacent to a SSSI. A letter of comfort from Natural England has been obtained, a copy of which is presented in Appendix R.
- 5.3.18 A copy of the Scoping Report, which details the EIA work undertaken to date and establishes the scope of work to be undertaken during the detailed design stage is presented in Appendix E.
- 5.3.19 The majority of environmental impacts can be mitigated through careful consideration during the detailed design stage and the application of good construction practice. Additional mitigation measures to be taken forward are.
- Protection of reptile habitat and/or translocation of reptiles to suitable reptile receptor sites.
  - Mitigation for a potential loss of saltmarsh and mudflat habitat due to the footprint of the scheme and coastal squeeze in the form of habitat creation within Reaches W7 and E3.
  - Measures to mitigate potential impacts on other protected fauna and flora, including wintering and breeding birds, fish and Chiding Pink.
  - Landscaping design, including appropriate use of materials, particularly brick cladding in residential areas, to mitigate adverse visual impacts caused by the proposed scheme, particularly in conservation areas.
  - Measures to mitigate potential impacts on recreation, including the replacement of footpaths and slipways, in continued consultation with Public Rights of Way (PRoW) officers.
  - Measures to ensure continued access to houseboats and their land.
  - Measures to mitigate potentially adverse impacts on construction workers, water quality (including any impacts associated with past land use), noise and vibration, and air quality during construction.

- Timing of construction activities and use of agreed construction methods to avoid adverse impacts on breeding and wintering birds and fish.
- 5.3.20 ILP's (Appendix B) have been prepared to detail the specific measures proposed to mitigate the landscape and visual amenity impacts.
- 5.3.21 There are potential opportunities to provide favourable biodiversity and social outcomes. The creation of a small amount of additional BAP habitat, over and above that lost to the scheme footprint and coastal squeeze, has been incorporated within the design of the scheme. Similarly, a diversity of habitats has been created at the reptile receptor sites.
- 5.3.22 The opportunity to provide a visually attractive scheme has also been sought, and measures to ensure this will be incorporated within the scheme design. This will aim to mitigate the increased defence height by providing a neutral effect to this public environment. The use of materials, particularly brick cladding in residential areas, to reduce visual impacts will be considered during detailed design in consultation with local residents, and enhancements to the car park adjacent to the Old Fort Scheduled Monument will be incorporated.
- 5.3.23 The survey and assessment work undertaken during the outline design stage of the project has identified and reduced the risk of potential environmental impacts and risks to the delivery of the project. However, a number of uncertainties remain which have potential to affect the progress of the project. These uncertainties are:
- The extent of the unknown archaeological resource, which might comprise significant remains within the foreshore zone, leading to design change or mitigation in advance of construction. The NEAS archaeologist has recommended undertaking a foreshore inspection in detailed design to better determine this risk.
  - The potential for the identification of additional protected species on site will be partly mitigated by pre-construction surveys.
  - The potential that the reptile receptor sites become over-populated by local populations of reptiles by the time that they are required for the translocated population. Action will be taken to delay maintenance works at the sites if delays threaten to cause this risk to materialise.
  - The potential that more reptiles are caught and require translocation than the receptor sites have capacity to receive.
  - Lack of agreement with the landowner of Reach W7 leading to inability to deliver sufficient saltmarsh and/or inter-tidal habitat for mitigation purposes. Initial discussions indicate the tenants and landowners are in agreement with the preferred option and legal agreements will be drawn up following PAR approval.
  - The granting of planning permission, consent from MMO and English Nature consent, and listed building or Conservation Area consents is not a certainty, and will benefit from consultation with local and national stakeholders during the final detailed design to ensure designs are appropriate to the relevant receptors.

## Costs for the preferred option

- 5.3.24 Economic, cash and FSoD approval costs for the preferred option are presented in Table 5-4 and include environmental mitigation costs for the works discussed in section 5.3.19 and an allowance for environmental enhancement to improve a public car park in Reach W1 and provide improvements to the setting of the Pill Boxes in Reach W7.
- 5.3.25 All costs have been prepared and agreed by the project team. Due to the changes to the incentivisation arrangements within the new Water and Environmental Framework (WEMF) an incentivised PAR (iPAR) arrangement has not been agreed. Inflation is included at the approved rate of 2.5% for future costs.

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**Table 5-4 Project costs for preferred option Improve 4 (£k)**

	Cost for economic appraisal (PV)	Whole life cash cost	EA FSoD approval project cost
<b>Costs to PAR:</b>			
Environment Agency staff	Sunk Costs	-	
Site investigation & survey	Sunk Costs	-	
Consultant fees	Sunk Costs	1,150	
Early Contractor Involvement (ECI)	Sunk Costs	-	
Cost consultant fees	Sunk Costs	-	
<b>Sub-total</b>	Sunk Costs	<b>1,150</b>	See note (3)
<b>PAR to Construction:</b>			
Environment Agency staff	117	123	123
Site investigation & Survey	326	341	341
Consultant fees	730	766	766
Early Contractor Involvement (ECI)	10	10	10
Cost consultant fees	50	53	53
Other costs (licence fees)	21	23	23
<b>Sub-total</b>	<b>1,255</b>	<b>1,317</b>	<b>1,317</b>
<b>Construction:</b>			
Construction costs	15,700	17,200	17,200
Inflation allowance for 30 months			1,760
Environmental enhancement	32.4	36	35.873
Environmental mitigation	1830	2,020	2019.688
Agency Environment Agency staff	83	92	91.8175
Consultant fees	529	207	207.023
Site supervision	0	379	378.603156
Cost consultant fees	127	141	140.672
Compensation	454	503	503
Other costs (WSOC bridge tie-in contribution)	193	200	200
<b>Sub-total</b>	<b>19,000</b>	<b>20,800</b>	<b>22,500</b>
<b>Future Costs:</b>			
Maintenance	2,980	14,000	
Future construction	9,930	61,300	
<b>Risk Contingency:</b>			
Monte Carlo 95% or similar			2,440
Monte Carlo 50% or similar	1,250	1,370	
<b>TOTAL</b>	<b>34,400</b>	<b>100,000</b>	<b>26,400</b>
<b>Contributions</b>			<b>797</b>

5.3.26 Table 5-5 shows the comparison of the estimated future costs versus those estimated in the Strategy.

**Table 5-5 Updated cost of strategy for whole cell/frontage**

<b>Cost</b>	<b>2009/10 (£K)</b>	<b>2010/11 (£K)</b>	<b>2011/12 (£K)</b>	<b>2012/13 (£K)</b>	<b>2013/14 (£K)</b>	<b>2014/15 - 2018/19 (£K)</b>	<b>Total (£K)</b>
<b>Latest Approved Strategy Implementation Cost</b>							
Capital	1,040	4,390	4,530	2,990	-	5,170	18,100
Non-Capital	678	3	21	21	21	977	1,720
Inflation at 5%	372	1,217	1,549	1,229	10	3,853	8,230
<b>Total</b>	<b>2,090</b>	<b>5,610</b>	<b>6,100</b>	<b>4,240</b>	<b>31</b>	<b>10,000</b>	<b>28,100</b>
<b>Current Forecast of Strategy Implementation Cost (inc 50% risk)</b>							
	<b>2012/13</b>	<b>2013/14</b>	<b>2014/15</b>	<b>2015/16</b>	<b>2016/17</b>	<b>2017/18 - 2021/22</b>	<b>Total</b>
Capital	-	1,040	5,440	17,100	-	-	23,600
Non-Capital	30	30	30	30	44	263	426
Inflation at 2.5%	1	54	420	1,778	6	54	2,310
<b>Total</b>	<b>31</b>	<b>1,120</b>	<b>5,890</b>	<b>18,900</b>	<b>50</b>	<b>317</b>	<b>26,300</b>

5.3.27 The total cost of £26.3m for Improve 4 is approximately £1.8m less than the Strategy Cost of £28.1m. The capital cost of £23.6m is approximately 23% greater than the Strategy. Key changes that have varied the cost since the Strategy estimate are:

- The removal of 45ha of habitat creation, estimated at £2.9m in the Strategy, replaced with realignment of the embankment in Reach 7 estimated at £0.5m.
- The assessment of seepage through the underlying geology showing that a significant cut-off was required within reaches W3 and W4, W5 and E3 leading to the requirement for sheet piling instead of concrete walls in Reaches W3, W4 and W5 and a combination of sheet piles and a slurry trench in Reach E3.
- The replacement of the footbridge requiring additional works to construct the bridge over the new defence level in Reach W4, estimated at £0.2m.
- The walls in Reach E1 were assumed to be repaired as part of a maintenance regime over a number of years. Further assessment of the condition of the defences and their proximity to properties, these works have been brought into the capital cost of the scheme.
- The timetable of the works being delayed leading to an increase in inflation.

5.3.28 The Strategy estimated the benefits at £761,000k approximately 4% less than the current estimate of the benefits. This small increase is down to the use of the improved national receptor database, updated MCM data and the addition of risk to life benefits. Coupled with the revised costs and contributions this improves the benefit cost ratio from 20.6, as estimated in the Strategy, to 23.7.

## Contributions and funding

5.3.29 Funding contributions have been sought toward the cost of the scheme. Our project partners Adur DC lead this process and sourced contributions totalling £500k, it is anticipated that they will also provide land for site compounds and working areas as contribution to the scheme. A further £297k has also been secured from Local Levy, providing a total of £797k of partnership funding for the scheme. Adur DC has provided a letter of intent outlining their commitment (see Appendix S).

5.3.30 The PV benefit attributable to commercial properties within the airport is approximately 5% of the overall PV benefit. Commercial property as a whole forms approximately 11% of the overall PV benefit.

## Outcome measures and funding priority

5.3.31 Table 5-6 shows the Priority Funding (PF) score for the Shoreham Adur Tidal Walls scheme. It can be seen that the scheme qualifies for full funding under FDGiA with a Raw score of 168%.

5.3.32 The duration of benefits for the scheme is 48 years, from the completion of the scheme until the construction of a barrier or raising of the defences in Year 50. The benefits and costs have been factored for the first 50 years.

**Table 5-6 Outcome measure contributions and prioritisation score**

Outcome Measure 1 – Economics						
PVc Whole Life Costs, for 50 year duration (£k)	25,200					
PVb Whole Life Benefits, for 50 year duration (£k)	561,000					
Duration of Benefits (years)	48					
OM1 Benefit - Cost Ratio	22.20					
Outcome Measure 2 –households better protected against flood risk						
Number of households in:	BEFORE			AFTER		
20% most deprived areas	0	15	96	0	0	0
21 - 40% most deprived areas	0	176	233	0	0	0
60% least deprived areas	181	161	1466	0	0	0
	Moderate Risk	Significant Risk	Very Significant Risk	Moderate Risk	Significant Risk	Very Significant Risk
OM2 Number of households moved out of any flood probability category	2328					
OM2b Number of households reduced from significant or greater	2147					
OM2c Number in 20% deprived moved from significant or greater	111					
Outcome Measure 3 – Households better protected against coastal erosion						
not applicable	0					
Outcome Measure 4 – statutory environmental obligations met						
OM4a Hectares of net water-dependent habitat created	1.25					
OM4b Hectares of net intertidal habitat created	0					
OM4c Kilometres of protected river improved	0					
Summary: prospect of FDGiA funding						
PV FDGiA Contribution (£k)	24,400					
Raw Score	168.00%					
PV Total Contributions offered (towards capital and PV maintenance), £k	780					
Adjusted PF Score	173.00%					

## 6 Implementation

### 6.1 Project planning

#### Phasing and approach

- 6.1.1 The construction period is envisaged to be 14 months allowing works in constrained areas to be undertaken during the required times of year.
- 6.1.2 Translocation of reptiles from the working areas to the prepared translocation sites will need to be undertaken in advance of the works in summer 2014.
- 6.1.3 Service diversions will be required in Reaches W5 and E3. It is anticipated that these will be undertaken in advance of the works but could be programmed at the same time as works in other reaches.
- 6.1.4 Works to the footbridge are currently being undertaken by WSCC and are programmed to be completed by autumn 2013. The footbridge Contractor will undertake the construction of the flood defences that tie into the footbridge with a contribution from the Environment Agency.
- 6.1.5 No further enabling works other than planning permission and licences are necessary for the main construction phase to commence.

#### Programme and spend profile

- 6.1.6 The project programme has been agreed by the project team.
- 6.1.7 The proposed programme and spend profile are indicated in Table 6-1 and Table 6-2 respectively.

**Table 6-1 Key dates**

Activity	Date
Commencement of detailed design	
Risk workshop/value engineering complete by	October 2014
Works information finalised by	September 2014
Planning permission received	October 2014
Target price agreed by	October 2014
Works start on site in	February 2015
Works substantially complete by	April 2016

**Table 6-2 Annualised spend profile**

	2013/14	2014/15	2015/16	Total
Environment Agency staff	70	58	87	215
Fees	706	602	829	2,140
Construction	200	4320	13000	17,500
Environmental mitigation	0	99.9	1800	1,900
Environmental enhancement	0	0	36	36
Compensation	0	0	0	0
Inflation	32	347	1380	1,760
Risk contingency (50% risk)	61	317	995	1,370
<b>Total*</b>	<b>1,070</b>	<b>5,740</b>	<b>18,100</b>	<b>25,300</b>

Notes: Fees includes site investigation, surveys and site supervision.

Figures include inflation at 2.5%

6.1.8 Further details of the expenditure profile are included in Appendix T.

6.1.9 The project costs have been prepared assuming that the east and west banks can be constructed together, in order to achieve the most economical programme. This has delivered savings of £919k versus constructing the two banks separately. This saving has been included within the cost estimate. Any future change to the delivery method may reduce this saving.

## 6.2 Procurement strategy

6.2.1 The tables below summarise the procurement strategy to date. Due to the tendering of the new WEMF a procurement strategy review will be undertaken following Framework award. The detailed design and construction contract will be awarded through an ECC Option C target price contract, see Appendix U.

**Table 6-3 Procurement Strategy to PAR**

Supplier	Contact	Procurement Strategy/Contract Type	Role
Halcrow Group Ltd	Darren Milsom	Mini bid package / PSC Option C	Designer
Volker Stevin	Windsor Young	Direct Award / PSC Option E	ECI
Arcadis AYH	Mark Simons	Direct Award / PSC Option E	Cost Consultant
Black & Veatch	Ray Fuller	Regional framework, effectively reimbursed cost	CDM Co-ordinator



**Table 6-4 Procurement Strategy for Remaining Stages**

Supplier	Contact	Procurement Strategy/Contract Type	Role
TBC	TBC	Direct Award / PSC Option C	Designer
TBC	TBC	Competitive tender / PSC Option E	ECI
TBC	TBC	Regional framework, effectively reimbursed cost	CDM Co-ordinator
TBC	TBC	Direct Award / PSC Option E	ECC PM
TBC	TBC	Competitive tender / ECC	Principal Contractor
Arcadis AYH	Mark Simons	Direct Award / PSC Option E	Cost Consultant

**Table 6-5 Key Staff**

Agency Staff		Framework Staff	
Client		NEECA Team	
Asset Manager		Project Manager	TBC
Client Representative	Andrew Manville	Design Team Leader	TBC
		EIA Team Leader	TBC
		ECC Supervisor	TBC
NCPMS (Appraisal & Delivery)		NCF Team	
Project Executive	Katherine Matthews	Contracts Manager	TBC
Project Manager	Peter Borsberry	M&E Co-ordinator	N/A
Technical Advisors		NCCF Team	
Procurement	Graham Heath	Cost Consultant	Mark Simons
M&E Engineer	N/A	ECC PM	TBC
NEAS	Richard Woodward		
Estates Officer	James Godber		

6.2.2 Previous schemes have been used in target setting and benchmarking including River Hull Stabilisation, Sandwich Tidal defences and Rye Harbour Western training Walls.

6.2.3 It is proposed to package this project with the Littlehampton Arun Tidal Walls East Bank, thus enabling potential savings for this project of about £700k. The approval sums and economics do not include this saving since funding for both projects to proceed has not yet been confirmed.

6.2.4 If this saving were included in the economics it would have the affect of increasing the ABCR from 23.7 to 24.2 and the PF score from 173% to 177%.

## 6.3 Delivery risks

### High level risk register

6.3.1 The risk register and mitigation actions were identified by the integrated team including the designer, ncpms, NEAS, ECI, cost consultant and Environment Agency area team. The risks were identified during a risk workshop and refined for inclusion in the PAR. A summary of the key risks is included in Table 6-6. The full risk register is included in Appendix K.

<b>Title</b>	Shoreham Adur Tidal Walls					
<b>No.</b>	IMSO 000648	<b>Status:</b>	Final V5	<b>Issue Date:</b>	November 2012	Page 37

6.3.2 The 50th and 95th percentile risk figures have been calculated using @risk software and included in the iPAR and FSoD values respectively.

**Table 6-6 High level risk schedule and mitigation**

Key project risk	Adopted mitigation measure
Owners or lessees of the Airport withdraw their agreement to the realignment for habitat mitigation.	Agreement reached with owners and lessee. Legal agreement to be prepared following funding approval. Liaison to be undertaken with Tidal Adur Strategy team to ensure habitat can be created to the north if required. Scheme footprint to be kept to a minimum to reduce the amount of habitat mitigation required.
Additional cost of earthworks materials over base allowance.	Local sources of material from other construction projects in the area to be investigated as construction approaches.
Additional reinstatement required within individual properties.	Landowner consultation to be undertaken during design and agreements reached on working areas and reinstatement.
Requirement to provide temporary accommodation for residents on both sides of the embankment in Reach W5 due to the proximity of the works to the residences where access cannot be maintained and to minimise potential public H&S risks.	Continued consultation with residents in the reach, programming and construction methods to be assessed to minimise the risk.
Volatile steel prices above 2.5% p.a. inflation allowance.	Steel prices to be monitored and early purchase of piles to be considered if prices are rising.
Piling method fails to meet design toe levels due to ground conditions in Reach E1.	Piling method to be reassessed against additional ground investigation and using the knowledge of the recently installed footbridge. Consider taking samples from within the riverbed.

## Safety plan

6.3.3 The key parties under the CDM Regulations for the appraisal phase of the project have been the Environment Agency as the Client, Ray Fuller of Black and Veatch as the CDM co-ordinator and Halcrow as the Designer.

6.3.4 Public health and safety has been considered as part of the designer's Hazard Elimination and Management (HEM) process and will be continued through detailed design, culminating in the production of Public Safety Risk Assessments for all new structures.



## GENERAL DETAILS

Authority Project Ref. (as in forward plan):	IMSO 000648
Project Name (60 characters max.):	Shoreham Adur Tidal Walls
Promoting Authority: Defra ref (if known)	
Name	Environment Agency
Emergency Works:	<input type="checkbox"/> No <input type="checkbox"/> Yes/No
Strategy Plan Reference:	IMSO 000693
River Basin Management Plan	River Basin Management Plan South East River Basin District
System Asset Management Plan	Shoreham-by-sea
Shoreline Management Plan:	Beachy Head to Selsey Bill Shoreline Management Plan
Project Type:	Strategy Implementation
Shoreline Management Study/ Preliminary Study/ Strategy Plan/Prelim. Works to Strategy/ Project within Strategy/Stand-alone Project/ Strategy Implementation/Sustain SOS. Coast Protection/Sea Defence/Tidal Flood Defence/Non-Tidal Flood Defence/Flood Warning Tidal/Flood Warning - Fluvial/Special	

## CONTRACT DETAILS

Estimated start date of works/study:	June 2013
Estimated duration in months:	34
Contract type*	Framework

(\*Direct labour, Framework, Non Framework, Design/Construct )

## COSTS

	APPLICATION (£000's)
Appraisal:	1,150
Costs for Agency approval:	26,400
Total Whole Life Costs (cash):	100,000

For breakdown of costs see Table in Section 2.4

## CONTRIBUTIONS

Windfall Contributions:	797
Deductible Contributions:	
ERDF Grant:	
Other Ineligible Items:	

## LOCATION - to be completed for all projects

EA Region/Area of project site (all projects):	South east
Name of watercourse (fluvial projects only):	River Adur
District Council Area of project (all projects):	Adur District Council
EA Asset Management System Reference:	FR/11/SO56
Grid Reference (all projects):	TQ216048

(OS Grid reference of typical mid point of project in form ST064055)

## DESCRIPTION

Specific town/district to benefit:

Shoreham-by-sea and Lancing

Brief project description including essential elements of proposed project/study  
(Maximum 3 lines each of 80 characters)


## DETAILS

Design standard (chance per year):

1 in 300

yrs

Existing standard of protection (chance per year)

1 in 20

yrs

Design life of project:

100

yrs

Fluvial design flow (fluvial projects only):

N/A

m<sup>3</sup>/s

Tidal design level (coastal/tidal projects only):

4.7

m

Length of river bank or shoreline improved:

7400

m

Number of groynes (coastal projects only):

N/A

Total length of groynes\* (coastal projects only):

N/A

m

Beach Management Project?

No

Yes/No

Water Level Management (Env) Project?

No

Yes/No

Defence type (embankment, walls, storage etc)

Embankments and walls

\* i.e. total length of all groynes added together, ignore any river training groynes

## ADDITIONAL AGREEMENTS:

Maintenance Agreement(s):

Not Applicable

Not Applicable/Received/Awaited

EA Region Consent (LA Projects only):

Not Applicable

Not Applicable/Received/Awaited

Non Statutory Objectors:

No

Yes/No

Date Objections Cleared:

Not Applicable

Other:

Not Applicable

Not Applicable/Received/Awaited

## ENVIRONMENTAL CONSIDERATIONS

Natural England (or equivalent) letter:

Received

Not Applicable/Received/Awaited

Date received

01/10/12

## SITES OF INTERNATIONAL IMPORTANCE

(Answer Y if project is within, adjacent to or potentially affects the designated site)

Special Protection Area (SPA):

No

Yes/No

Special Area of Conservation (SAC):

No

Yes/No

Ramsar Site

No

Yes/No

World Heritage Site

No

Yes/No

Other (Biosphere Reserve etc)

No

Yes/No

**SITES OF NATIONAL IMPORTANCE** (Answer Y if project is within, adjacent to or potentially affects the designated site)

Environmentally Sensitive Area (ESA):	No	Yes/No
Site of Special Scientific Interest (SSSI):	Yes	Yes/No
National/Regional Landscape Designation:	No	Yes/No
National Park/The Broads	Yes	Yes/No
National Nature Reserve	No	Yes/No
AONB, RSA, RSC, other	No	Yes/No
Scheduled Ancient Monument	Yes	Yes/No
Other designated heritage sites	No	Yes/No

**OTHER ENVIRONMENTAL CONSIDERATIONS**

Listed structure consent	Not Applicable	Not Applicable/Received/Awaited
Water Level Management Plan Prepared?	No	Yes/No
FEPA licence required?	Awaited	Not Applicable/Received/Awaited
Statutory Planning Approval Required	Yes	Yes/No/Not Applicable

**COMPATIBILITY WITH OTHER PLANS**

Shoreline Management Plan	Yes	Yes/No/Not Applicable
River Basin Management Plan	Yes	Yes/No/Not Applicable
Catchment Flood Management Plan	Yes	Yes/No/Not Applicable
Water Level Management Plan	Not Applicable	Yes/No/Not Applicable
Local Environment Agency Plan	Not Applicable	Yes/No/Not Applicable

**SEA/ENVIRONMENTAL IMPACT ASSESSMENT**

SEA	Not Applicable	Statutory required/Agency voluntary/not applicable
EIA	Yes (schedule 2)	Yes (schedule 1); Yes (schedule 2); SI1217; not applicable
SEA/EIA status	Scoping report prepared	Scoping report prepared/draft/draft advertised/final

Other agreements	Detail	Result	(Not Applicable/Received/Awaited for each)

## Costs, benefits & scoring data

(Apportion to this phase if part of a strategy)

**Local authorities only:** For projects done under Coast Protection Act 1949, please separately identify: FRM = Benefits from reduction of asset flooding risk; CERM = Benefits from reduction of asset erosion risk**Benefit type** (DEF: reduces risk (contributes to Defra SDA 27); CM: capital maintenance; FW: improves flood warning; ST: study; OTH: other projects)

DEF

**LAND AREA**

Total area of land to benefit:		Ha
of which present use is:	FRM	CERM
Agricultural:		Ha
Developed:		Ha
Environmental/Amenity:		Ha
Scheduled for development		Ha



**PROPERTY & INFRASTRUCTURE PROTECTED**

	Number		Value (£'000s)	
	FRM	CERM	FRM	CERM
<sup>1</sup> Residential	2,328		131,661	
Commercial/industrial	169		384,905	
Critical Infrastructure				
Key Civic Sites				
Other (description below):				
Description:				

**costs and Benefits**

<sup>1</sup> Present value of total project whole life costs (£'000s):	34,400	
Project to meet statutory requirement? Y/N	N	
	Value (£'000s)	
	FRM	CERM
Present value of residential benefits:	712,000	
Present value of commercial/industrial benefits:	86,000	
Present value of public infrastructure benefits:		
Present value of agricultural benefits:		
Present value of environmental/amenity benefits:	146	
<sup>1</sup> Present value of total benefits (FRM & CERM)	798,000	
Net present value:	765,000	
Benefit/cost ratio:	23.7	
Base date for estimate:	Q2 2012	
PAG Decision Rule stage 3 applied		Yes/No
PAG Decision Rule stage 4 applied		Yes/No

**OTHER OUTCOME MEASURE SCORING DETAILS**

Super Output Area No*:		Indicate if deprived:	Yes (part)	Yes/No
(*as ranked by Indices of Multiple Deprivation)				
Risk:	VH	VH, H or N/A		
		Wetland	Saltmarsh/ Mudflat	
Net gain of BAP habitat:	1.25			Ha
SSSI protected:	0	Ha		
Other Habitat:	0	Ha		
Heritage Sites:	0	"I or II", "II or other" or "N/A"		

**Exemption Details (if exempt from OM scoring system)**

Exempt from Scoring:	No	Yes/No
Reason (max 100 chars):		



## Outcome measure prioritisation priority score

Stage 1 - Calculate individual scores							
Ref	Description	Project contributions (including adjustments)			Targets		Individual scores
OM1	Present value of Whole Life Benefits (£000s)	Error! Not a valid link. o1		Divided by	3,700,000 t1	Gives OM1 individual score	0.15 s1
OM2	Number of households moved from any flood / coastal erosion probability category to a lower one (households)	2,328 o2	Minus o2b				
OM2b	Number of households moved from the very significant or significant flood probability category to the moderate or low flood probability category; or equivalent coastal erosion probability categories (households)	2,147 o2b	Minus o3				
OM3	Number of households in deprived communities at reduced flood risk (households)	111 o3		Divided by	9,000 t3	Gives OM3 individual score	0.012 s3
OM5	The number of hectares Biodiversity Action Plan habitat created, net of compensatory habitat (Hectares)	1.25 o5		Divided by	800 t5	Gives OM5 individual score	0.00156 s5
Stage 2 - Calculate overall OM prioritisation score							
Score	Outcome Measure prioritisation score (total of individual scores divided by whole life cost)	0.12 (s1 + s2 + s2b + s3 + s5)		Divided by	Error! Not a valid link. Project whole life costs	Multiplied by 1,000,000	4.8 OM prioritisation score

