

Strategy Appraisal Report

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| Authority Scheme Reference | IMSO000802 |
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| Defra / WAG LDW Number | n/a |
|------------------------|-----|

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| Promoting Authority | Environment Agency Solent and South Downs Arun District Council |
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| Strategy Name | River Arun to Pagham Flood and Coastal Erosion Risk Management Strategy |
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|------|-----------|
| Date | July 2015 |
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| Version | 3.0 – Approved |
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River Arun to Pagham Flood and Coastal Erosion Risk Management Strategy Appraisal Report

| Version | Status | Signed off by: | Date signed | Date issued |
|---------|--|--------------------|-------------|-------------|
| 1.0 | Final for submission to Arun District Council. | Katharine Matthews | 07.10.2010 | 08.10.2010 |
| 1.1 | Final for submission to Arun District Council with amendments. | Katharine Matthews | 13.10.2010 | 13.10.2010 |
| 1.2 | Final for submission to Arun District Council with amendments. | Jo Tinnion | 28.10.2010 | 28.10.2010 |
| 2.0 | Draft Strategy for targeted re-consultation | Joe Pearce | 07.11.2014 | 07.11.2014 |
| 2.1 | Final for submission to LPRG | Joe Pearce | 20.03.2015 | 20.03.2015 |
| 2.2 | Final for recommendation for approval by LPRG | Joe Pearce | 22.05.2015 | 22.05.2015 |
| 3.0 | Approved | Joe Pearce | 21.07.2015 | 21.07.2015 |

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Glossary and Acronyms

Annual Exceedance Probability (AEP)

The statistical likelihood of a particular flood happening during a period of one year.

Average Annual Damage (AAD)

The average value of flood damage likely to occur in any one statistical year.

Beach Management Plan (BMP)

A programme of annual beach monitoring and future flood management interventions.

Benefit Cost Ratio (BCR)

BCRs are used to identify the relative worth of one approach over another. It is the ratio of the PV benefits to the PV costs for each option.

Breach

Failure of existing linear flood defences allowing flood water inundation of the land behind.

Consumer Price Index (CPI)

UK Government measure of inflation

Do Minimum

An option where the operating authority takes the minimum amount of action necessary to maintain an asset (FCERM-AG). For many places, this means patch and repair works of existing defences with no replacement should the defences fail.

Do Nothing

An option used in appraisal to act as a baseline against which all other options are tested. It assumes that no action whatsoever is taken. In the case of existing works, it assumes for the purposes of appraisal that Risk Management Authorities cease all maintenance, repairs and other activities immediately. In the case of new works, it assumes that there is no intervention, and natural and other external processes are allowed to take their course (FCERM-AG).

Flood and Coastal Defence Project Appraisal Guidance (FCDPAG)

A series of six volumes providing Defra guidance to Risk Management Authorities on the process for appraising flood and coastal defence projects to ensure best use of public money. This was superseded by the Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG) in September 2010.

Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG)

This is an updated version of FCDPAG published by the Environment Agency in 2010.

Flood Defence Asset

Any structure with the prime purpose to provide flood defence, e.g. groynes, beach and sea walls.

Flood and Coastal Risk Management Grant in Aid (FCRM GiA)

Government money allocated to Risk Management Authorities (Environment Agency, Local Authorities, Internal Drainage Boards) for capital works which manage and reduce flood and coastal erosion risk. Previously known as Flood Defence Grant in Aid (FDGiA).

Flood Risk Management Plans (FRMPs)

Flood Risk Management Plans (FRMPs) describe the risk of flooding from rivers, the sea, surface water, groundwater and reservoirs. They set out how Risk Management Authorities (RMAs) will work together with communities to manage flood risk, and are important to delivering the aims of the National Flood and Coastal Erosion Risk Management Strategy for England. They have been produced by the Environment Agency as required by the Flood and Water Management Act 2010.

Fluvial

Relating to the flow in the river which originates from the upstream catchment and not the sea

Hold the Line

Retain defences in their approximate existing position.

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Improve

Active intervention to increase the Standard of Protection provided by a linear defence.

Incremental Benefit Cost Ratio (IBCR)

The ratio of the additional benefit to the additional cost, when two options are compared.

Joint Probability

The probability of two separate events occurring at the same time.

LiDAR

Light Detection and Ranging – a remote-sensing technique used to map the height of terrain.

Maintain

Active intervention to keep defences at their current crest level.

Managed Realignment

The management of a process of establishing a new defence line, usually set back from the existing position, with the aim of improving the long-term sustainability of the defence, or contributing to other aims such as habitat creation.

Medium Term Plan (MTP)

Each year, Risk Management Authorities are invited to submit details of proposed flood and coastal erosion flood management works which require funding for future years. The bids are captured in a spreadsheet known as the Medium Term Plan.

Metres Above Ordnance Datum (mAOD)

Measured level of the ground or any structure relative to the Ordnance Survey datum.

Multi-coloured Manual (MCM)

The MCM provides techniques and data that can be used in benefit assessments for flood and coastal erosion risk management appraisals.

National Flood and Coastal Defence Database (NFCDD)

Centralised database for information on flood and coastal defence assets in England and Wales

Net Present Value (NPV)

The stream of all benefits net of all costs for each year of the projects life discounted back to the present date.

Outcome Measure (OM)

5 targets used by Defra to assess the priority of flood and coastal risk management schemes.

Present Value (PV)

The monetary value of ongoing or future costs, discounted to provide equivalent present day costs.

PV Benefits (pVB)

Those positive quantifiable changes that a project will produce over its lifetime.

PV Costs (pVC)

The cost for implementation of a particular scheme over its lifetime.

PV Damage Avoided

The economic damages avoided once an option has been implemented.

Recharge

Importation of additional beach material, usually by dredger from a licensed offshore dredging area or quarry.

Recycling

Removal of beach material from an area of excess to an area of depletion usually by lorry.

Residual Damages

The remaining economic damages once an option has been implemented.

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Roll Back

The process by which the foreshore and beach naturally retreat inland in response to wave action and sea level rise.

Scheduled Monument

A nationally important heritage site or monument which has been given legal protection by the Secretary of State for Culture, Media and Sport.

Site of Special Scientific Interest (SSSI)

UK national conservation area designated for its wildlife habitat or geological significance.

Special Protection Area (SPA)

Areas designated for rare or vulnerable birds or migratory birds and their habitats, classified under Article 4 of the EC Directive on the Conservation of Wild Birds.

Standard of Protection (SoP)

The design event standard, measured by AEP, that an existing asset or proposed scheme provides.

Strategic Environmental Assessment (SEA)

A process set out in European and domestic legislation that must be followed to ensure that significant environmental effects arising from policies, plans and programmes are identified, assessed, mitigated, communicated to decision-makers, monitored and that opportunities for public involvement are provided.

Strategy Appraisal Report (StAR)

A business case including a programme of works that supports a recommendation to implement a management plan. The plan is approved by the Environment Agency under the Non-Financial Scheme of Delegation from Defra and does not confer any financial authorisation. The plan is supported by technical appendices.

Sustain Standard of Protection (sustain)

Active intervention to raise defence levels to keep pace with sea level rise, thereby retaining the pre-existing Standard of Protection.

System Asset Management Plan (SAMP)

A collection of data that provides information to apply asset management principles to flood risk management structures

Water Framework Directive (WFD)

A European Directive to help to protect and enhance the quality of surface freshwater (including lakes, streams and rivers), groundwaters, groundwater dependant ecosystems, estuaries and coastal waters out to one mile from low-water.

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For Technical Approval

Environment Agency Area: Solent and South Downs

Project name: River Arun to Pagham Flood and Coastal Erosion Risk Management Strategy

Approval Value: £190 Million Whole Life Cost for 100 years (£5m potential FCRM GiA application and £15m external partnership funding contributions required to implement recommendations for the first 14 years)

**Sponsoring Director: Howard Davidson
Director of Operations South East**

Non-financial scheme of delegation


Part 11 of the Non-financial scheme of delegation states that approval of FCERM Strategies/Complex Change Projects, following recommendation for approval from the Large Projects Review Group, is required from Director of Operations.

Approval Route

| | |
|---|----------------|
| Large Projects Review Group (LPRG) | Ian Hodge |
| Deputy Director/Area Manager | James Humphrys |
| Executive Director of Operations South East | Toby Willison |

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APPROVAL HISTORY SHEET

| APPROVAL HISTORY SHEET (AHS) | | | |
|---|---|--|-----------------|
| 1. Submission for review | | | |
| Project Title: River Arun to Pagham Flood and Coastal Erosion Risk Management Strategy | | Project Code: IMSO000802 | |
| Project Manager: Edward Nichols | | Date of Submission: 23.07.2015 | |
| Lead Authority: Environment Agency | | Version No: 3.0 | |
| Consultant Project Manager: Chris Sadler | | Consultant: Atkins | |
| The following confirm that the documentation is ready for submission to PAB or LPRG (formerly NRG). The Project Executive has ensured that relevant parties have been consulted in the production of this submission. | | | |
| Position | Name | Signature | Date |
| Project Executive | Joe Pearce |  | 21.07.15 |
| | Job Title: | Project Manager 1, ncps | |
| 2. Review by: LPRG Large Projects Review Group (formerly NRG) | | | |
| Date of Meeting(s): N/A | | Chairman: Richard Nunn | |
| Recommended for approval: In the sum of £190,000k | | Date: 21/08/15 | Version No: 3.0 |
| 3. Environment Agency NFSoD approval Officers in accordance with the NFSoD: | | | |
| Version No: 3.0 | | Date: | |
| Project Approval | By: Toby Willison In the sum of: £ (if different from above) | Date: 04/09/2015 | |
| 4. Defra | | | |
| Submitted to Defra / WAG Not Applicable | | Date: | |
| Version No. (if different): | | | |
| Defra/ WAG Approval: Not Applicable | | Date: | |
| Comments: | | | |

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NON FINANCIAL SCHEME OF DELEGATION (NFSoD) COVERSHEET FOR A FCRM STRATEGIC PLAN

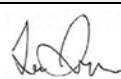
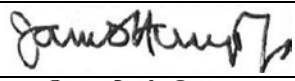
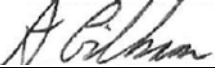
| | | | | | |
|----|----------------------|---|--------------------------|-------------------|-------------------------------|
| 1. | Project name | River Arun to Pagham Flood and Coastal Erosion Risk Management Strategy | | Start date | 2015 |
| | | | | End date | 2115 |
| | Business unit | FCRM | Programme | FCRM GiA | |
| | Project ref. | IMSO000802 | Regional SoD ref. | F/1516/0552 | Head Office SoD ref. - |

| | | | |
|----|--------------------------|----------------|--|
| 2. | Role | Name | Post Title |
| | Project Sponsor | Andrew Gilham | Solent and South Downs Area Flood and Coastal Risk Manager |
| | Project Executive | Joe Pearce | Project Manager 1, ncpsms |
| | Project Manager | Edward Nichols | Project Manager 2, ncpsms |

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| 3. | Outline Risk Assessment (ORA) Category N/A | Low | <input checked="" type="checkbox"/> | Medium | <input type="checkbox"/> | High | <input type="checkbox"/> |
|----|---|------------|-------------------------------------|---------------|--------------------------|-------------|--------------------------|

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| 4. | NFSoD value | £k |
| | Whole Life Costs (WLC) of Strategic Plan | 189,500 |

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| 5. | Required level of Environmental Impact Assessment (EIA) (undertaken SEA) | N/A | <input checked="" type="checkbox"/> | Low | <input type="checkbox"/> | Medium | <input type="checkbox"/> | High | <input type="checkbox"/> |
|----|---|------------|-------------------------------------|------------|--------------------------|---------------|--------------------------|-------------|--------------------------|

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| 6. | NFSoD approver name | Post title | Signature | Date |
| | Toby Willison | Executive Director of Operations | see Approvals | 04/09/2015 |
| | James Humphrys | Solent and South Downs Area Manager | see Approvals | 03/09/2015 |
| | NFSoD consultee name | Post title | Signature | Date |
| | Ian Hodge | LPRG Chair |  | 21/08/2015 |
| | James Humphrys | Solent and South Downs Area Manager |  | 18/08/2015 |
| Andrew Gilham | Area Flood and Coastal Risk Manager |  | 12/08/2015 | |

From: Davidson, Howard
Sent: 03 September 2015 08:27
To: Dagger, Judith E; Willison, Toby
Cc: McIntyre, Kathryn; Mitchell, Becky; Gallagher, Derry
Subject: RE: For NFSoD approval : F/1516/0552 Arun to Pagham Strategy Review

Hi Judith

I approve this strategy .

Howard

From: Willison, Toby
Sent: 04 September 2015 07:45
To: Davidson, Howard
Cc: Dagger, Judith E; McIntyre, Kathryn; Mitchell, Becky; Gallagher, Derry
Subject: Re: For NFSoD approval : F/1516/0552 Arun to Pagham Strategy Review

Judith, I'm happy to approve the strategy too.

Toby

Executive Summary

1.1 Purpose and Background

- 1.1.1 This Strategy Appraisal Report presents the business case and implementation plan for the River Arun to Pagham Flood and Coastal Erosion Risk Management Strategy (henceforth referred to as the 'Strategy'). This Strategy has been produced in partnership with Arun District Council.
- 1.1.2 There is no approved flood and coastal erosion risk management strategy in place for this stretch of coastline. In 2004 a Coastal Defence Strategy was developed on behalf of Arun District Council and the Environment Agency but it was not fully completed.
- 1.1.3 Starting in 2008 the 2004 Strategy was updated. It was completed and presented to the Environment Agency Large Projects Review Group in January 2010. Before the review was completed, the project was subject to a legal challenge relating to the consultation process that resulted in a Judicial Review hearing in March 2011. Meanwhile, in response to stakeholder comments received about the Climping frontage, we investigated engineering options and the economic case in greater detail. In this report we have updated and completed the Strategy, including revisions made as a result of the more detailed work and a targeted re-consultation undertaken in November 2014 to January 2015.
- 1.1.4 We have four objectives in producing the Strategy:
- a) Develop a strategic approach to sustainably manage flood and coastal erosion risk to people, property and other assets over the next 100 years;
 - b) Seek ways of enhancing the environmental, amenity and recreational value of the Strategy area;
 - c) Provide an Implementation Plan which allows Risk Management Authorities to work with local communities to prioritise flood and coastal erosion risk interventions ensuring the best use of money;
 - d) Ensure compliance with and contribute, where possible to, the objectives of the Water Framework Directive (WFD).
- 1.1.5 Since these objectives were defined, a further requirement has arisen due to changes under the new Defra policy for flood and coastal resilience partnership funding announced in May 2011. Partnership funding contributions are now expected for all flood and coastal erosion risk management projects. This gives the additional requirement for this Strategy to raise awareness of the partnership funding needs for recommended works.
- 1.1.6 The Strategy covers 15km of West Sussex coast from the eastern edge of Pagham Harbour at Aldwick, to the western bank of the River Arun at Littlehampton, and 5km up the western bank of the River Arun to Ford Railway Bridge (Key Plan 1). The Strategy area is bounded by approved coastal flood and erosion risk management strategies to the east and west and upstream on the Arun by the approved Lower Tidal River Arun Strategy.
- 1.1.7 A number of watercourses, locally termed rifes, drain inland areas between Bognor Regis and Climping. In this Strategy we do not consider flood risk from inland sources. In June 2012, around 200 properties within the Strategy area suffered surface water flooding following exceptional rainfall. Risk management options for sources including surface water, fluvial, groundwater and drainage are being considered in a separate multi-agency project outside of this Strategy. Information from this Strategy's preparation is being used to ensure that economic benefits are not double-counted.

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- 1.1.8 The Strategy area is divided into five frontages based on detailed modelling of the source and consequence of flood risk across the area (Key Plan 1). The frontages are:
- a) River Arun West Bank and Climping (joint coastal/tidal river);
 - b) Elmer (coastal frontage);
 - c) Middleton (coastal frontage);
 - d) Bognor Regis and Felpham (coastal frontage);
 - e) Aldwick (coastal frontage).
- 1.1.9 The Strategy's coastline is covered by the Beachy Head to Selsey Bill Shoreline Management Plan (SMP, 2006) which recommends a hold the line policy for all areas except the land close to the River Arun where it proposed managed realignment.
- 1.1.10 The River Arun and Western Streams Catchment Flood Management Plan (CFMP, adopted 2008) recommends a policy of taking action to sustain flood risk as it is now.
- 1.1.11 Part of the frontage between Climping and Elmer, is covered by two historic legal agreements between landowners and the Environment Agency (Key Plan 2). This Strategy considers management options along this section that are constrained by the need to fulfil the legal obligations. The minimum amount of work to fulfil these obligations is called "do minimum legal".
- 1.1.12 There are three Sites of Special Scientific Interest (SSSI) along the Strategy frontage: Climping Beach, Felpham and Bognor Reef geological SSSI (Key Plan 1). The Strategy boundary lies outside, but adjacent to the boundary of the Pagham Harbour Special Protection Area (SPA) and Ramsar site.

1.2 Problem

- 1.2.1 The Strategy frontages include sand and shingle beaches, beach control structures, earth bunds and concrete walls. At Aldwick and Middleton, these defences protect against the primary risk of coastal erosion. The defences also provide protection from flooding and the risk of breach at specific vulnerable points in all frontages. There are currently 561 total properties at risk of flooding from the sea and the west bank of the River Arun in a 1 in 200 flood event. Although concerns exist over erosion risk to properties at Pagham Beach, this lies beyond the boundary of this Strategy and is an area which will not be affected by recommended options. There are no properties imminently at risk from erosion in this Strategy's area.
- 1.2.2 The Standard of Protection (SoP) against flood risk varies along the frontages, ranging from 1 in 5 (20%) annual exceedance probability (AEP) at Middleton (overtopping) to 1 in 500 (0.2%) AEP at Elmer. However, this relies on continued maintenance of existing sea walls, groyne fields and beach levels. The volume of shingle on the beach has reduced over recent years, leading to exposure of the sea walls and increasing the risk of breach and erosion. A number of beach control structures have an estimated residual life of less than five years. The flood defence assets on the River Arun West Bank frontage vary in condition and standard of protection (as low as 1 in 10 (10%) in places).
- 1.2.3 If defences were not maintained, in 100 years the total number of properties at coastal flood and erosion risk would rise to 3,034 (including 319 at only erosion risk).
- 1.2.4 Securing funds to maintain and repair the existing defences will be a challenge. This Strategy provides risk management authorities with clarity on the technical issues that can be used as a framework for negotiating and securing contributions for future work.
- 1.2.5 The Strategy lies predominantly within the Sussex Coastal water body. This is a heavily modified water body with a WFD objective to reach Good Ecological Potential by 2027 through implementation of hydro-morphological mitigation measures.

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1.3 Options Considered

- 1.3.1 The following options were selected for consideration: Do Minimum, Maintain defences at current crest height, Sustain current SoP and Improve SoP. Works to meet the terms of the legal agreements are described throughout the Strategy as Do Minimum (Legal).
- 1.3.2 The economic appraisal has been carried out in accordance with the Defra Flood and Coastal Defence Project Appraisal Guidance (FCDPAG), and the successor Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG). The effect of the 2011 climate change advice has been considered in selecting the preferred option.
- 1.3.3 Environmental considerations have been included in the option selection by means of a Strategic Environmental Assessment and Water Framework Directive Assessment.

1.4 Recommended Strategy and Economic Case

- 1.4.1 For the Elmer, Middleton, Bognor Regis, Felpham and Aldwick frontages, we recommend Maintain options. Details of options recommended for all frontages are provided in Table 1-1.
- 1.4.2 We recommend 'Do Minimum (coastal) and Sustain (river)' for the Climping and River Arun West Bank frontage.
- 1.4.3 For the section of Climping coastal frontage that is not covered by legal agreements, the cost of major repair or renewal of defences is more than the economic benefits of doing the work. We recommend that Do Minimum maintenance should be undertaken as long as the benefit of ongoing flood risk management work remains greater than the costs. Once it becomes uneconomic to continue investment, or there is a significant breach in the defences requiring costly repairs, the Environment Agency will no longer be justified in further expenditure and will be required to cease maintenance. As with all recommendations, implementation of Do Minimum works at Climping are subject to funding being available.
- 1.4.4 For the section of frontage covered by legal agreements, the recommended Do Minimum (Legal) means carrying out work needed to comply with the existing agreements. The Environment Agency will continue to engage with the landowners concerning the requirements of the agreements and the future management of the affected coastline.
- 1.4.5 The recommendations accord with SMP and CFMP policies, apart from the proposed managed realignment west of Climping which was rejected as, environmentally the topography does not suit this option and economically its selection is not justified.
- 1.4.6 The recommended Strategy options are not expected to cause deterioration in status of any waterbodies or prevent them from meeting their RBMP objectives, and are therefore considered compliant with WFD. Under the preferred options, beach management practices undertaken sensitively will contribute to the WFD objectives of the Sussex Coastal water body relating to beach control and preserving habitats. Letters of support for the Strategy have been received from Natural England and Arun District Council.

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Table 1-1 Summary of preferred options and economic case

| Flood cell | | Preferred Option with current SoP | PV Costs (£k) | PV Benefits (£k) | Benefit/Cost Ratio | Cash Costs (£k) |
|--|---------------------------------|--|---------------|------------------|--------------------|-----------------|
| Climping & River Arun West Bank | Legal Agreement Frontage | Do Minimum (Legal) – Compliance | 6,100 | 0* | n/a | 20,800 |
| | Climping & River Arun West Bank | Do Minimum (coast) Sustain 1 in 10 (river) | 12,300 | 43,600 | 3.5 | 27,000 |
| Elmer | | Maintain 1 in 500 | 4,800 | 78,000 | 16.1 | 15,300 |
| Middleton | | Maintain against erosion (1 in 5 onset of overtopping) | 16,000 | 46,200 | 2.9 | 51,000 |
| Bognor Regis and Felpham | | Maintain 1 in 500 | 17,500 | 46,000 | 2.6 | 55,900 |
| Aldwick | | Maintain against erosion (1 in 8 onset of overtopping) | 5,600 | 18,800 | 3.4 | 19,500 |
| Whole Strategy | | As above | 62,300 | 232,600 | - | 189,500 |

Numbers are rounded for clarity when compared to Tables in Section 6.

Figures relate to economic appraisal over 100 years.

* No significant economic benefits derived.

1.5 Implementation and Partnership Funding

1.5.1 We recommend implementing maintenance and improvement works over the next five years. Works are subject to available funding, except where driven by legal obligation.

- a) Beach recharge and recycling between Elmer and Aldwick;
- b) Improvement to timber groynes, back defences and sea wall rock toe and other key assets between Elmer and Aldwick;
- c) At Climping, implement patch and repair works on the non-legal frontage whilst this remains economic and as budgets allow;
- d) Construction of defences on the River Arun West Bank, south of the A259;
- e) In combination with these capital works, Beach Management Plans will be initiated for the coastline, starting with the Elmer and Climping frontages;
- f) Works to comply with the legal agreements should be undertaken by the Environment Agency on the basis of the legal requirement.

1.5.2 Table 1-2 shows the annualised spend profile (cash cost) for works recommended in the first five years following Strategy approval. It also shows the calculated Partnership Funding (PF) level that determines how much flood and coastal erosion risk management grant in aid a project is eligible for and indicates minimum partnership contributions required.

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Table 1-2 Annualised Cash Spend Profile with PF Score (%) and duration of benefits

| Costs (£k) | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | Future Yrs | Total |
|---|-------|-------|-------|-------|-------|------------|--------|
| Legal Frontage | | | | | | | |
| Scheme works | - | - | - | - | - | 4,200 | 4,200 |
| Maintenance work | 170 | 170 | 170 | 170 | 170 | 15,800 | 16,600 |
| Climping and River Arun West Bank - PF score = 18% eligible of £6,457k over 14 years | | | | | | | |
| Scheme works | 210 | 250 | 2,800 | 2,800 | - | 13,200 | 19,300 |
| Maintenance work | 97 | 97 | 97 | 97 | 97 | 7,300 | 7,800 |
| Elmer - PF score = 31% eligible of £2,086k over 11 years | | | | | | | |
| Scheme works | 210 | 140 | 1,300 | - | - | 7,200 | 8,800 |
| Maintenance work | 62 | 45 | 63 | 63 | 63 | 6,100 | 6,400 |
| Middleton - PF score = 16% eligible of £6,107k over 14 years | | | | | | | |
| Scheme works | 140 | 140 | 2,000 | 1,800 | - | 23,100 | 27,200 |
| Maintenance work | 240 | 240 | 240 | 240 | 240 | 22,600 | 23,800 |
| Bognor Regis and Felpham – PF score = 18% eligible of £4,326k over nine years | | | | | | | |
| Scheme works | 70 | 70 | 1,200 | 660 | - | 20,300 | 22,300 |
| Maintenance work | 340 | 340 | 340 | 340 | 340 | 31,920 | 33,600 |
| Aldwick – PF score = 116% eligible of £389k over nine years | | | | | | | |
| Scheme works | 8 | 45 | - | - | 75 | 15,870 | 16,000 |
| Maintenance work | 50 | 35 | 35 | 23 | 35 | 3,300 | 3,500 |

1.6 Contributions and Funding

- 1.6.1 Partnership funding scores for works required in all frontages other than Aldwick are very low. Significant external contributions will be required to implement works and manage flood and erosion risks. Funding is limited for both maintenance and schemes to renew and/or improve defences and may not be available here if there are demands for higher priority work elsewhere.
- 1.6.2 Potential sources of contributions to undertake some short term maintenance activities at Climping have been explored through a series of collaborative funding meetings chaired by the local MP. The Environment Agency and Arun District Council will progress opportunities for contributions through local authorities, national and local public sources including the Local Enterprise Partnership (LEP), landowners and other key asset holders, and seek external contributions from other funding routes including local residents groups.
- 1.6.3 If external funding to implement recommended works is not forthcoming, Arun District Council and the Environment Agency will undertake Do Minimum works to prolong the life of the existing defences, as revenue budgets allow, and make clear the implications to those affected through the preparation of contingency plans.
- 1.6.4 Once approval is gained for the Strategy, funding our recommendations is the overriding issue for its implementation. Main risks are summarised in Table 1-3.

Table 1-3 Key Risks to Implementation

| Key Project Risk | Mitigation Measure |
|--|--|
| Insufficient external funding to enable recommended new schemes to proceed as scheduled. | Work with stakeholders and communities to seek funds. Carry out Do Minimum maintenance as long possible and practical and funding is available. Keep affected people informed as well as Regional Flood and Coastal Committee and Arun District Council's cabinet. |
| Maintenance works limited by funding availability increasing risk of asset failure. | Monitor. Inform Regional Flood and Coastal Committee and Arun District Council Cabinet. Provide practical support and advice to communities regarding resistance measures. Ensure emergency plans take account of developing situation. |
| Landowners object to works being undertaken. | Early and regular engagement with the affected landowners. Gain Planning Authority support. Seek funding and in-kind support from communities and landowners. |

1.7 Recommendations

- 1.7.1 We recommend the Strategy is approved for a Whole Life Cost (excluding inflation) of £190m, including optimism bias. The Strategy will, subject to available funding, reduce flood and coastal erosion risk to 3,034 residential properties over the 100 year appraisal period.
- 1.7.2 Around £15m present value cost of external partnership funding contributions is required to implement the Strategy over the first benefit period of 14 years to reduce flood and coastal erosion risk to 1,579 residential properties. The FCRM GiA investment for the first benefit period is £5.04m of the required total £24.4m cash cost.
- 1.7.3 This Strategy will enable the relevant Flood Risk Management Authorities to raise awareness among local people and groups who would be potentially affected by coastal flood and erosion risk. It will inform discussions and negotiations aimed at securing external partnership funding contributions to allow schemes to go ahead.
- 1.7.4 The Environment Agency will continue to work closely with Arun District Council and others to secure the necessary contributions to implement this Strategy. Flood resistance and resilience measures will continue to be promoted along with the development of contingency plans to help communities adapt to increasing flood risk.

Figure 1.1 Strategy Key Plan 1

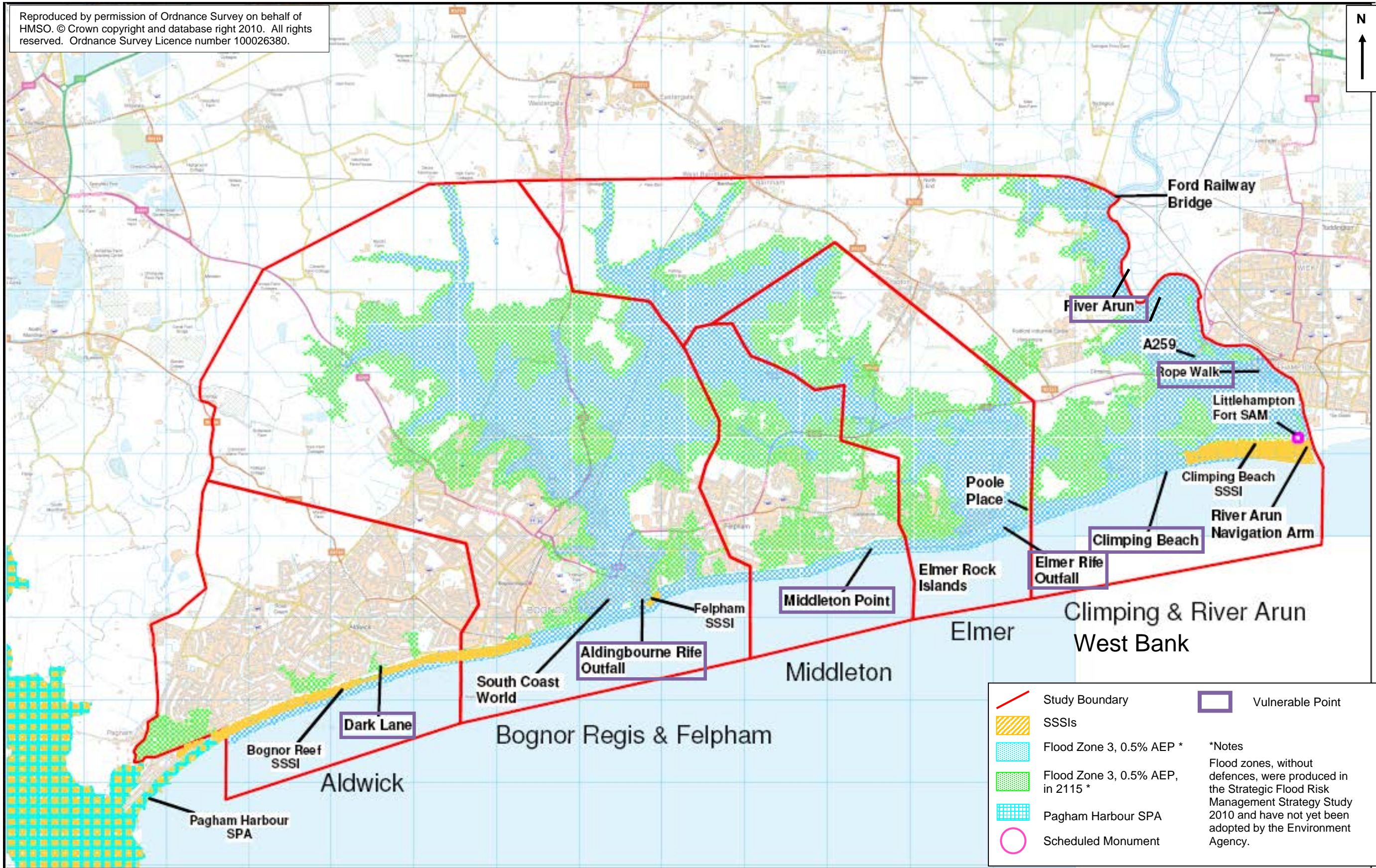
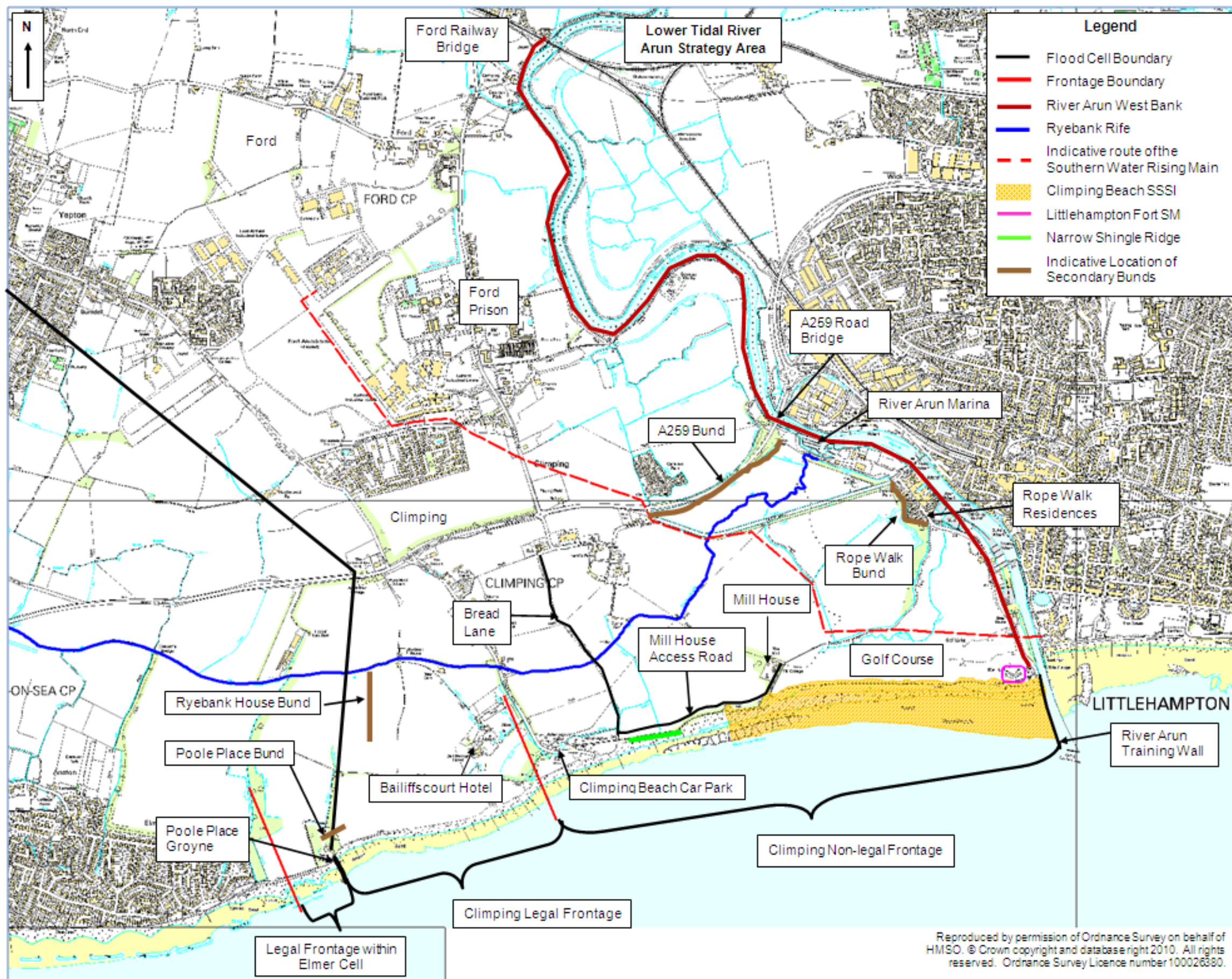


Figure 1.2 Strategy Key Plan 2 – Climping and River Arun West Bank



2. Introduction and Background

2.1 Purpose of this Report

- 2.1.1 This Strategy Appraisal Report (StAR) presents a 100 year strategic flood and coastal erosion risk management plan for the coast between the River Arun and Pagham Harbour, including consideration of future funding needs and opportunities.
- 2.1.2 The coastal Strategy is focused on the dominant risks from tidal flooding and coastal erosion and does not consider fluvial flood risk. To avoid double counting of fluvial damages within the area covered by the River Arun and Western Streams Catchment Flood Management Plan (CFMP), we have not included the affects or management of inland flooding from fluvial events or tidal locking (with or without pump failure). The risk from fluvial and surface water flooding is being considered outside this Strategy.
- 2.1.3 Arun District Council, the local district council, is responsible for managing coastal erosion risk for this area. They are our partner in the Strategy.
- 2.1.4 The appraisal has been undertaken in accordance with Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG) and other current guidance and advice.

2.2 Background

Previous Studies

- 2.2.1 In 2004 a Coastal Defence Strategy covering this stretch of coastline was developed on behalf of Arun District Council and the Environment Agency, but was not fully concluded due to the new requirement for a Strategic Environmental Assessment (SEA) and other changes in guidance. This StAR updates and concludes this earlier work.
- 2.2.2 The 2004 Strategy was updated and completed and presented to the Environment Agency Large Projects Review Group in January 2010. Before the review was completed, the project was subject to a legal challenge that resulted in a Judicial Review hearing in March 2011. Following this we investigated engineering options and economic case in greater detail, for the Strategy's frontage that originally prompted the challenge. In this report we have updated and completed the Strategy, including revisions made as a result of the more detailed work.
- 2.2.3 There are three adjoining FCERM strategies that form the boundaries of this study;
- To the east, the Rivers Arun to Adur Flood and Erosion Management Strategy (approved 2009).
 - To the west, the Pagham to East Head Coastal Defence Strategy (PEHCDS, approved 2009). The current study meets the completed PEHCDS at Aldwick. The coast at Pagham Beach was addressed by PEHCDS. We have taken account of PEHCDS findings in this study. Shingle generally drifts eastwards from Pagham towards the River Arun. The effect on Pagham Beach of management options down-drift in our current study area will therefore be minimal.
 - On the River Arun, the Lower Tidal River Arun Flood Risk Management Strategy was approved in 2013. The Lower Tidal River Arun Strategy has taken into account findings and draft recommendations from our current study and likewise we have considered the upstream Strategy's findings.

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- 2.2.4 A number of watercourses, locally termed rifes, drain inland areas between Bognor Regis and Climping. In this Strategy we do not consider flood risk from inland sources. In June 2012, around 200 properties within the Strategy area suffered surface water flooding following exceptional rainfall. Risk management options for sources including surface water, fluvial, groundwater and drainage are being considered in a separate multi-agency project outside of this Strategy. Information from this Strategy's preparation is being used to ensure that economic benefits are not double-counted.

Policy Framework

- 2.2.5 The **Beachy Head to Selsey Bill Shoreline Management Plan** (SMP2) was adopted in February 2010 and sets the high level policy for this stretch of coastline. This Strategy supports the SMP2 Hold the Line policy for all frontages except at Climping, which had a managed realignment policy. This is discussed further in Chapter 4.
- 2.2.6 The **River Arun and Western Streams Catchment Flood Management Plan** (CFMP) was adopted in 2008 and sets the high level policy for the tidal reach of the River Arun within the Strategy area. The CFMP policy that covers this reach is option four - *take further action to sustain the current scale of flood risk into the future*. This Strategy supports the CFMP policy.
- 2.2.7 There are two local Surface Water Management Plan (SWMP) studies ongoing (at Elmer and Barnham). West Sussex County Council, as Lead Local Flood Authority (LLFA) under the Flood and Water Management Act 2010, completed its Local Flood Risk Management Strategy in May 2014. The Environment Agency completed the draft Flood Risk Management Plan (FRMP) for this area in October 2014. Consultation on this draft closed in January 2015.
- 2.2.8 The Strategy area falls within the South East River Basin District. The current **South East River Basin Management Plan** (RBMP) was published in December 2009. The next SE RBMP is currently out for consultation and will be finalised and submitted for approval in autumn 2015. In accordance with the Water Framework Directive, the RBMP sets out environmental objectives for the ground and surface water bodies within the river basin district and a programme of measures and actions required to achieve these objectives. The relevant waterbodies in the Strategy area are the Sussex Coastal and Arun Transitional.

Location and Designations

- 2.2.9 The Strategy area covers the West Sussex coast from the western bank of the River Arun to the boundary between Pagham and Aldwick (10.5km) in the west and up the River Arun to the Ford railway bridge (5.1km), as shown in Key Plan 1.
- 2.2.10 Much of the coast is highly developed with both residential and commercial properties. The main population centre is at Bognor Regis although there are also adjoining communities at Aldwick, Felpham, Elmer and Middleton. At Climping, the land use is mainly agricultural with limited residential property. The main transport route through the area is the A259. Land use behind the west bank of the river, north of the A259, comprises a residential caravan park and agricultural land. South of the A259 land use comprises a golf course, residential property and a marina with associated commercial development.
- 2.2.11 The majority of the coastline throughout the Strategy area is made up of sand and shingle beaches. These are extensively used for recreation and leisure purposes.
- 2.2.12 There are a number of environmentally designated sites along the Strategy frontage. These include Climping Beach Site of Special Scientific Interest (SSSI), Felpham SSSI and Bognor Reef geological SSSI, as shown in the Strategy Key Plan 1. The Strategy boundary lies outside, but adjacent to, the boundary of the Pagham Harbour Special Protection Area (SPA) and Ramsar site. There is also one Scheduled Monument (SM), Littlehampton Fort, and some Listed Buildings in the Strategy area. More information about these sites and impact of the Strategy appraisal is included in the Environmental Constraints section of this document. A full list and consideration of the environmental sites is included in the 2009 SEA Environmental Report and 2014 Addendum, Appendix C.

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Risk Management Authorities

2.2.13 The management of the river and coastal assets in the Strategy area is split between the Environment Agency, Arun District Council, Littlehampton Harbour Board (LHB) and private landowners (refer to Figures O.3.1 to O.3.8 in Appendix O). LHB has duties and powers under marine legislation and works in accordance with the Port Marine Safety Code to ensure the safe management of the harbour. As a riparian owner of riverside assets, LHB is also subject to the duties placed on it by the Land Drainage Act (1991) and the Water Resources Act (1991).

2.2.14 The proposed works will be promoted under the relevant terms of the Water Resources Act 1991 and the Coast Protection Act 1949.

Strategy Frontages



2.2.15 The coast and hinterland at risk of flooding has been divided into five flood cells, each with a coastal and/or estuarine frontage as follows (Key Plan 1):



- **Climping and River Arun West Bank:** Railway bridge at Ford to Poole Place Groyne (including the Legal and non-Legal coastal frontage at Climping);
- **Elmer:** Poole Place Groyne to Southdean Close;
- **Middleton:** Southdean Close to Middleton Ledge;
- **Bognor Regis and Felpham:** Middleton Ledge to Nyewood Lane, Felpham;
- **Aldwick:** Nyewood Lane to western Strategy boundary at the Aldwick Parish boundary.


2.2.16 The frontage maps are provided in Appendix O and Key Plan 1. This information is summarised in Table 2-1.

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Table 2-1 Strategy Frontages

| Frontage | Existing Defences | *All properties currently at risk 0.5% AEP (1 in 200) event | All properties risk in 100yrs Do-Nothing | All properties at erosion risk 100 yrs Do-Nothing | Property written off /capped (flood and erosion) by 100 yrs | Current Minimum Still Water SoP with wave overtopping %AEP (Return Period) | |
|---|---|---|--|---|---|---|--|
| Climping and River Arun West Bank Environment Agency Littlehampton Harbour Board |  <ul style="list-style-type: none"> • 5.15km of river defences comprising tidal bunds, ad hoc riparian walls and natural ground. • 3.66km of beach defences comprising natural dunes, walls and high ground • 36 timber groynes • 3.66km of beach, of which 1.15km relates to the Climping Legal frontage. | 188 | 230 | 0 | 192 | **Climping: 50% (1 in 2) Minor Breach 0.5%(1in200) Major breach River Arun 10% (1 in 10) | |
| | | | | | | <p>Defence Residual Life (range of years across the frontage)</p> River defences 5 to 20 years. Backshore defences 0 to 20 years. Groynes 0 to 20 years+. Shingle ridge 5 to 10 years. <p>NFCDD Defence Condition Grade</p> River Arun West Bank defences: Condition Grade 2 (Good) to 4 (poor). Climping defences: Mostly Condition Grade 3 (Fair), but varies Grade 2 (Good) to Condition Grade 4 (Poor). | |
| | <p>Other assets at risk:</p> <ul style="list-style-type: none"> • Ford Prison sewage treatment plant • A259 | <ul style="list-style-type: none"> • Up to 590 ha agricultural land • Climping Beach SSSI • Southern Water Rising Main Pipelines | <ul style="list-style-type: none"> • Littlehampton Fort SM • Littlehampton Golf Course • Marina Facilities • Leisure use of the beach – for both legal and non legal frontages | | | | |
| Elmer Environment Agency Arun District Council |  <ul style="list-style-type: none"> • 1.85km of backshore defences comprising varied walls, rock revetment and high ground • 8 rock islands • 1 terminal rock groyne • 1.85km of beach • Redundant groynes that predate the rock islands | 14 | 668 | 3 | 186 | 0.2% (1 in 500) | |
| | | There are currently 18 properties at risk from erosion | | | | | |
| | | <p>Defence Residual Life (range of years across the frontage)</p> Backshore defences 0 to 20 years. Rock Islands 50 years. <p>NFCDD Defence Condition Grade</p> Backshore defences: Condition varies, mostly) Grade 2 and 3 (Good/Fair) but isolated places its 4 (poor) Rock Islands: Condition Grade 1 (Excellent). Timber groynes: Condition Grade 1 (Excellent) and 2 (Good). | | | | | |
| | <p>Other assets at risk:</p> <ul style="list-style-type: none"> • Leisure use of the beach • Elmer Rife Outfall | | | | | | |

| Frontage Operating Authorities | Existing Defences | *All properties currently at risk 0.5% AEP (1 in 200) event | All properties risk in 100yrs Do-Nothing | All properties at erosion risk 100 yrs Do-Nothing | Property written off /capped (flood and erosion) by 100 yrs | Current Minimum Still Water SoP with wave overtopping %AEP (Return Period) |
|--|--|---|--|---|---|--|
| Middleton Arun District Council |  <ul style="list-style-type: none"> • 1.94km of backshore defences comprising walls and timber breastwork • 20 timber groynes and 1.94km of beach | 286 | 938 | 122 | 264*** | 20% (1 in 5)+ |
| | | There are currently 246 properties at risk from erosion | | | | |
| | | Defence Residual Life (range of years across the frontage) Backshore defences 0 to 20 years. Groynes 5 to more than 20 years. NFCDD Defence Condition Grade Backshore defences: Condition Grade 3 (Fair), 4 (Poor) and 5 (Very Poor). Groynes: Condition Grade 2 (Good) and 3 (Fair). | | | | |
| | | Other assets at risk: <ul style="list-style-type: none"> • Leisure use of the beach • Greensward approx 500m x 20m | | | | |
| Bognor Regis & Felpham Environment Agency Arun District Council |  <ul style="list-style-type: none"> • 3.71km backshore defences (walls and breastwork) • 92 timber groynes, 8 rock groynes and 3.71km of beach | 3 | 888 | 114 | 525 | 0.2% (1 in 500) |
| | | There are currently 342 properties at risk from erosion | | | | |
| | | Defence Residual Life (range of years across frontage) Backshore defences 10 to 20 years. Groynes 5 to more than 20 years. NFCDD Defence Condition Grade Majority of timber groynes: Condition Grade 1 (Excellent) or Grade 2 (Good). Small minority at Bognor Regis are Grade 3 (Fair). Rock groynes: Condition Grade 1 (Excellent) Backshore defences: Condition Grade 2 (Good) & 3 | | | | |
| | | Other assets at risk: <ul style="list-style-type: none"> • Aldingbourne Rife outfall • Bognor Reef and Felpham SSSI • Leisure use of the beach and Butlins South Coast | | | | |

| Frontage | Existing Defences | *All properties currently at risk 0.5% AEP (1 in 200) event | All properties risk in 100yrs Do-Nothing | All properties at erosion risk 100 yrs Do-Nothing | Property written off /capped (flood and erosion) by 100 yrs | Current Minimum Still Water SoP with wave overtopping %AEP (Return Period) |
|---|---|--|--|---|---|--|
| Aldwick |  <ul style="list-style-type: none"> • Backshore defences 1.3km walls (east of Dark Lane) occasional riparian walls west of Dark Lane • 31 timber groynes and 2.99km of beach | 70 | 310 | 80 | 6*** | 12% (1 in 8)+ |
| Private Landowners | | There are currently 198 properties at risk from erosion | | | | |
| Arun District Council | | Defence Residual Life (range of years across the frontage) Backshore defences generally greater than 10 years, but 5 years at Dark lane Groynes 0 to 10 years. NFCDD Defence Condition Grade Groynes: Condition Grade 1 (Excellent), Grade 2 (Good) and Grade 3 (Fair). Single groyne at Dark Lane is Condition Grade 4 (Poor). Backshore defences range from Condition Grade 1 (Excellent) to 5 (Very Poor). | | | | |
| | | Other assets at risk: <ul style="list-style-type: none"> • Bognor Reef and Felpham SSSI | | | | |
| Notes *Property counts include those receiving below floor level flooding **Localised over wash reducing the level of the shingle crest. ***No breach scenario for this cell, so value is taken from pre-breach scenario + When flood risk to property starts to occur | | | | | | |

2.2.17 The Annual Exceedance Probability (AEP) used in Table 2-1 is based on still sea water levels. However, where appropriate the impact of wave overtopping has also been incorporated into modelled levels and used in the detailed economic analysis.

Legal Agreements

2.2.18 There are two legal agreements, dated 1967 and 1977, between landowners and the Environment Agency's predecessors along sections of the Climping and Elmer frontages as shown in Figure 1.2. The 1967 Agreement requires the Environment Agency "for ever after to maintain improve and construct such sea defence works as are from time to time reasonably necessary for the protection of the ... estate at Bailiffscourt" between two areas near Poole Place to the west and Atherington car park to the east.

2.2.19 The 1977 agreement requires the Environment Agency to "take over responsibility for sea defences over the Bailiffscourt frontage and maintain the same in a satisfactory state of protection and repair."

2.2.20 Operations on the Climping frontage are subject to restrictions from historical covenants and regulating leases which cover beach management.

Social and Political Background

2.2.21 There are several residents groups within the Strategy area who have been consulted. During the first round of Strategy consultation, people with interests local to the Climping frontage met together with their Member of Parliament to explore options for funding works on the coast.

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- 2.2.22 Arun District Council has produced a publication version of the Local Plan that extends across the area covered by the Strategy. Consultation was completed by Arun District Council in December 2014 and the plan now awaits its inspection in public before it is finalised. The Plan's proposals do not conflict with this Strategy. For Arun West Bank, the Local Plan proposes development that could affect implementation of the Strategy. This is covered in Section 6 and 7.
- 2.2.23 There are private proposals, currently at the "concept stage" for regeneration of Littlehampton Marina area within the Climping and River Arun West Bank frontage. The proposals are being advanced by a private developer, supported but not sponsored by Arun District Council.

2.3 Current Approach to Flood and Erosion Risk Management

- 2.3.1 Historically, the Environment Agency has carried out the following maintenance work in the Strategy area:
- Maintenance and repairs of the River Arun West Bank tidal bunds north of the A259;
 - Beach recycling and timber groyne and breastwork repairs at Climping Beach, to both the legal and non-legal frontages;
 - Maintenance of the Aldingbourne Rife pump and the Elmer Rife outfalls;
 - Monitoring, maintenance and improvement of Environment Agency maintained beaches and assets at Bognor Regis, and the easterly portion of the Elmer flood defence scheme.
- 2.3.2 Arun District Council manages its frontages on a needs basis in accordance with available funding. Works include repairs to sea walls and groynes and responsive beach re-profiling, including the westerly portion of the Elmer flood defence scheme.
- 2.3.3 South of the A259 crossing, no maintenance activities are currently undertaken on the River Arun by the Environment Agency or Arun District Council.
- 2.3.4 The training wall at the mouth of the River Arun is owned and maintained by the Littlehampton Harbour Board, for navigation purposes. A secondary effect is that the upper section of the wall acts as a groyne, retaining beach material. The condition of the training wall, though reasonable at present, is deteriorating. The projected life of the training wall is not a limiting factor for this Strategy appraisal as it will continue to service as a substantial groyne long after it becomes unserviceable as a training wall (Appendix P).
- 2.3.5 The Strategy frontage is included in the Strategic Regional Beach Monitoring Programme. Arun District Council manages beach works using profiles from the 2004 Strategy as a guide. The Environment Agency assets are managed in accordance with the System Asset Management Plan (SAMP).
- 2.3.6 The Environment Agency has a flood warning service in place across the Strategy area. This was promoted throughout the Strategy consultation process. Emergency Incident Plans have been fully developed and published for the urban areas. These include plans for coastal flooding and environmental incidents.

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3. Problem Definition and Objectives

3.1 Outline of the Problem

History of Flooding

- 3.1.1 In the 1980s, flooding from overtopping at Butlins South Coast World at Bognor Regis caused significant levels of damage to the site infrastructure. Subsequently, the Environment Agency and its predecessors constructed a concrete wave wall to the rear of the promenade with toe stabilisation, re-engineered the Aldingbourne Rife outfall arrangements, replaced and refurbished groynes, and undertook re-nourishment of the beach.
- 3.1.2 In the winter of 1988/89, a series of severe storms generated high waves which reduced beach levels and overtopped the defences at Elmer. Approximately 180 properties were flooded. No other properties in the Strategy area were recorded as being flooded at this time. Major works have since been undertaken. This prompted Arun District Council to construct offshore rock island defences at Elmer.
- 3.1.3 At Climping minor breaches of the shingle bank have occurred at frequent intervals, typically every two years, causing localised flooding. These have been repaired to prevent the beach defence becoming exposed to a major failure.
- 3.1.4 In the winter of 2014, there was damage to groynes, breastwork and the top-mark at Middleton. This has been rectified, funded by the winter recovery grant. Beach levels were reduced and defences overtopped at the Elmer and Climping frontages, which led to a repeat of the routine recycling and beach reprofiling activities. Generally all beach levels were lowered and bed rock exposed. The levels have now started to recover.

Outline of the Problem

- 3.1.5 Despite maintenance, the condition of many of the defences is poor and deteriorating (Table 2-1). The defences are also susceptible to being overtopped, especially in areas where beach volumes are low at Middleton (20% AEP) and at Dark Lane, Aldwick (12% AEP). The River Arun West Bank flood defences have a variable SoP between 0.5% AEP and 10% AEP and are at risk from tidal surge in the river overtopping the river banks. Based on recent historical events, the risk of breach at Climping frontage is high (50% AEP) for a minor breach.
- 3.1.6 There are four issues of particular concern through the coastal frontages:
1. There are a number of timber groyne fields and breastwork that have a residual life of less than five years;
 2. The shingle beach volumes have diminished, leading to exposure of some harder coastal defences and increasing the risk of these being undermined;
 3. The Climping frontage (non Legal) has a localised low SoP against breach (50% AEP);
 4. The rock revetment at Elmer requires remedial repairs.
- 3.1.7 There is a significant risk of breach/erosion in several locations, as summarised in Table 3-1. This risk of breach and overtopping is likely to increase with sea level rise.
- 3.1.8 The rate of future landward erosion will increase with continued loss of beach material and subsequent failure of coastal defences.

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Water Framework Directive Objectives

- 3.1.9 Under the Water Framework Directive (WFD), flood risk and coastal erosion risk management measures must not result in the deterioration of any water bodies or prevent these water bodies from achieving their stated WFD objectives. Measures should also strive to positively contribute to meeting objectives.
- 3.1.10 The water bodies affected by the Strategy are the Sussex Coastal (all coastal frontages) and Arun Transitional (River Arun frontage). Sussex Coastal is a heavily-modified water body with a current status of 'moderate ecological potential'. The mitigation measures required for this water body to meet its objective include:
- Operational and structural changes to beach control;
 - Preserve and enhance ecological value of marginal habitat, banks and riparian zone;
 - Managed realignment of the coastal defence;
 - Removal of hard bank reinforcement / replacement with soft engineering solution.
- 3.1.11 Arun Transitional is a heavily-modified water body with a current status of 'moderate ecological' potential. The mitigation measures required for this water body to meet its objective are:
- Indirect / offsite mitigation (offsetting measures);
 - Preserve and enhance ecological value of marginal aquatic habitat, banks and riparian zone;
 - Bank rehabilitation / re-profiling;
 - Removal of hard bank reinforcement or replacement with soft engineering solution.
- 3.1.12 The Strategy is considered in the context of the current approved 2009 RBMP rather than the proposed 2015 RBMP which is currently out for consultation and therefore still subject to change. However, the option for Climping was 'sense-checked' against relevant details in the draft 2015 plan to consider likely future compliance. The Water Framework Directive is discussed in more detail in Chapter 5 and in Appendix M.

3.2 Consequences of Doing Nothing

- 3.2.1 The Do Nothing scenario forms the theoretical baseline for the appraisal and economic comparison with the higher active intervention options. The scenario is based on an assessment of what would happen if all work ceased on the frontages.
- 3.2.2 There are currently 541 residential and 20 commercial properties at risk of flooding from a 0.5% AEP (1 in 200) storm event, and no properties currently at risk of erosion in the Strategy area. Under the Do Nothing scenario by 100 years time, this would increase to 3,034 total properties at risk from flooding or erosion from the same AEP event (Table 2-1). In addition, by the end of the appraisal period, there would be 319 properties at risk solely from erosion.

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Table 3-1 Vulnerable Points, Primary Risk and Consequences of Doing Nothing

| Frontage | Location of Vulnerable Point* | Primary Risk | Do Nothing Timescales and Consequences |
|-------------------------------------|--|----------------|--|
| Climping and River Arun West Bank** | Climping Beach | Breach | <ul style="list-style-type: none"> The shingle ridge is likely to have breached within ten years. Once established and with sea level rise this breach would allow a progressive increase in flood risk to the agricultural hinterland and some residential properties. Following the breach low lying land at Climping will be at greater risk of tidal inundation. The extent and frequency will depend on the top (sill) level of the beach. There is uncertainty what level will naturally develop. Flooding would also be affected by rising sea levels, such that regular annual inundation would occur in 2014 for a 3.3m AOD sill and by 2060 similar flooding would occur with a 3.7m AOD sill. Our analysis looked at a range of sill levels and outcomes, please refer to Appendix P. The floodplain between Climping and the River Arun is hydraulically linked with a common low point at Rope Walk. This means that from the breach point at Climping, tidal waters would flow across the floodplain towards Rope Walk. |
| | Bunds north of A259 and Rope Walk | Breach | <ul style="list-style-type: none"> Breach of the River Arun West Bank frontage is likely to occur within ten years. Do Nothing would result in an increase in flood risk with sea level rise resulting in predicted annual tidal inundation by 2060. |
| Elmer | Elmer Revetment and Elmer Rife outfall | Breach | <ul style="list-style-type: none"> Though protected by the 50 year residual life of the rock islands, complete failure of the backshore rock revetment is likely in the next 5 to 10 years leading to an increased risk of overtopping, and erosion of the hinterland. Failure and breach of the outfall is possible within 20 years, if not maintained, and would provide a route for floodwater outflanking the breakwater and beach defences. |
| Middleton | The Greensward & Old Point | Erosion | <ul style="list-style-type: none"> The toe of the linear defences has already failed and been repaired. Ongoing exposure would lead to final failure, erosion of the hinterland and an increase in flood risk from overtopping. |
| Bognor Regis and Felpham | Aldingbourne Rife Outfall | Breach | <ul style="list-style-type: none"> Failure and loss of the outfall structure and undermining of the adjacent linear defences would provide a flood route along the rife to the low-lying hinterland. Pre-breach loss of beach material would lead to low to moderate risk of flooding from overtopping. Breach is likely to occur within 30 years. |
| Aldwick | Dark Lane | Erosion | <ul style="list-style-type: none"> Continued loss of the volatile beach and exposure and failure of the rock armour and concrete seawall would lead to an increase in flood risk from overtopping and the onset of erosion of the hinterland with properties at risk within 20 years |

Note: * Key Plan 1; ** relates to non legal frontage only.

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3.3 Key Constraints

3.3.1 The key constraints on future coastal and flood risk management for the Strategy frontages are described below.

Environmental

3.3.2 There are a number of sites designated for wildlife conservation that lie along the Strategy frontage. The key designations are Climping Beach SSSI, Felpham SSSI and Bognor Reef geological SSSI. Beach management activities and flooding could affect the interest features of these sites, in particular coastal habitats and bird populations.

3.3.3 The Strategy boundary lies outside, but adjacent to, the boundary of the Pagham Harbour SPA and Ramsar site. Consequently, Regulation 48 of the Conservation (Natural Habitats and c.) Regulations 1994 applies to ensure that the integrity of the European site is maintained.

3.3.4 There is one Scheduled Monument; Littlehampton Fort, and several listed buildings in the Strategy area, which could be affected by flooding.

3.3.5 The beach along the Strategy frontages, especially at Climping, is a popular leisure facility. Amenity value and public access could be affected by beach management activities or changes in beach characteristics.

Legal

3.3.6 Two legal agreements exist between the Environment Agency and landowners at the Climping frontage (Section 2.2.18).

3.4 Objectives

3.4.1 The Strategy objectives are to:

- a) Develop a strategic approach to sustainably manage flood and coastal erosion risk to people, property and other assets over the next 100 years;
- b) Seek ways of enhancing the environmental, amenity and recreational value of the Strategy area;
- c) Provide an Implementation Plan which allows Risk Management Authorities to work with local communities to prioritise flood and coastal erosion risk interventions ensuring the best use of money;
- d) Ensure compliance with and contribute, where possible, to the objectives of the Water Framework Directive.

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4. Options for Managing Flood and Coastal Erosion Risk

4.1 Long List of Options

4.1.1 In addition to do nothing we identified a long list of high level flood and erosion risk management options:

- a) Do Minimum;
- b) Managed Realignment;
- c) Maintain;
- d) Sustain;
- e) Improve.

4.1.2 These options may include engineering interventions for beach management, timber and rock works, sea walls, and managed realignment. A full description of the scope of works can be found in the Options Appraisal Report in Appendix E, and can be summarised as:

- a) Periodic shingle recycling and recharge;
- b) Direct timber groyne and breastwork replacement;
- c) Replacement of timber groynes with rock groynes;
- d) Construction of rock revetments;
- e) Wall raising;
- f) Construction of bunds;
- g) Resistance and resilience measures (property level protection).

4.1.3 Within the long list we considered a number of sub-options where different combinations of engineering responses could achieve the same economic outcome.

4.1.4 An internal workshop was held where the long list of options was assessed. Each option was scored against its technical, economic, environmental and health and safety viability and on its potential impact upon the coastal or estuarine processes for each frontage. This enabled the original long list and sub-options to be reduced to a short list which was then subject to more detailed appraisal.

Improve

4.1.5 For all the coastal frontages an Improve option was not short listed, either because the existing SoP is already very high (for example, at Elmer) or because the Maintain and Sustain options capture virtually all the benefits available, and the incremental benefit cost ratio is not sufficient.

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Managed Realignment at Climping

- 4.1.6 The Managed Realignment (MR) policy at Climping proposed in the SMP2 was investigated at the long list stage. This policy would allow development and realignment of the coastal shingle beach at Climping in response to natural coastal processes. The two main purposes of Management Realignment would be to deliver more cost effective flood and coastal risk management and to create new coastal habitat to deliver WFD objectives for the Sussex Coastal water body.
- 4.1.7 We looked at three potential options for Managed Realignment at Climping.
- 4.1.8 **Option MR1** – removal of the existing defences and allowing a breach to form and realign back to natural high ground. There would be no planned landscaping works to create specific habitats and no provision of new inland flood defences.
- 4.1.9 **Option MR2** – similar to option MR1, but including active habitat creation. We considered Economic Evaluation of Environmental Effects (EVEE) benefit values for mudflat habitat as this would cover the vast majority of the new inter-tidal area. Such habitat creation would require extensive earthworks for tidal defences, landscaping and tidal control. It is expected that these new habitats would establish quickly once the required landscaping, control works and breach have been completed.
- 4.1.10 **Option MR3** - construction of a new set back flood defence structure between Poole Place and the dune system in a natural swash alignment to continue to protect agricultural land and property. Annual beach recycling and ten-yearly recharge would be required to ensure that the new structure is protected.
- 4.1.11 None of these Managed Realignment options were short-listed because:
- Option MR1 would not contribute to ecological potential of the water body (in terms of marginal and intertidal ecology) as the gradient of land tilts towards the river, preventing the formation of a basin that would regularly drain through the open coastal frontage;
 - An outline economic analysis to implement MR2 or MR3 options indicates the Benefit Cost Ratio (BCR) is significantly less than 1;
 - There are more cost effective options to manage the frontage in the short to medium term.
- 4.1.12 This issue was examined again when the economic and engineering options for the Climping frontage were appraised in greater detail. A workshop was held with key consultees, which confirmed the earlier finding that, despite the recommendation from the Shoreline Management Plan (SMP2), managed realignment at Climping is not a suitable mitigation measure for the Sussex coastal water body. The findings of our work will feed into the planning of measures to implement the next RBMP.. This is discussed in the Water Framework Directive Addendum, Appendix M.

4.2 Options Short-Listed for Appraisal

- 4.2.1 Do Nothing is required as the theoretical baseline for the economic assessment and was therefore short-listed for all frontages. This assumes that no work is undertaken on the frontage and therefore has zero costs associated with it. Tables 4-1 to 4-5 outline the remaining short-listed options for each frontage.
- 4.2.2 For the Legal frontage at Climping, the 'Do Minimum (Legal)' option assumes works to achieve compliance with the two legal agreements.

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4.2.3 Beach Management Plans will be developed using data from the current beach monitoring programme to inform the future requirement for beach recycling and recharge for all coastal frontages.

Table 4-1 Short listed options: Climping and River Arun West Bank

| Option | Description |
|---|---|
| Climping Legal frontage | |
| Do Minimum (Legal) | Works to achieve compliance with two legal agreements. |
| Climping non-legal frontage and River Arun West Bank | |
| Do Minimum | <ul style="list-style-type: none"> • Patch and repair works as required to the beach and timber groynes on the non legal frontage while economically sustainable. Works to repair a major breach will not be economic. • Patch and repair works to flood and scour damage to the varied river bank protection and defences south of the A259 and to the embankments north of the A259 until breach. |
| Maintain | <ul style="list-style-type: none"> • Maintenance to the Climping and River Arun defences to maintain existing standard of service. To include beach recharge every 10 years and renew structures at Climping. • Refurbishment and formalisation of the river defences south of the A259. The presence of the A259 reduces the flood risk to residential property at Climping Park immediately to the north, generating benefits. • Refurbishment to the river embankments and bank protection north of the A259. |
| Do Minimum Climping and Sustain River Arun West Bank | <ul style="list-style-type: none"> • Patch and repair works at Climping as above. • Secondary A259 and Rope Walk bunds will be required (see Key Plan 2).The timing of the Rope Walk bund is dependent upon how long the assets at Climping last until a major breach is experienced. For the River Arun West bank, construction of new flood walls is required south of the A259 road bridge with works to Sustain the existing tidal defences north of the A259 to Ford Railway Bridge. |
| Sustain | <ul style="list-style-type: none"> • Sustain at Climping would include construction of a new sea wall at Climping Beach to support the narrow shingle ridge with periodic beach recharge every 10 years (to a greater volume than for Maintain) and annual beach recycling. • For the River Arun West bank, construction of new flood walls is required south of the A259 road bridge, with works to Sustain the existing tidal defences north of the A259 to Ford Railway Bridge. A secondary A259 bund would be required around 2055. |

Table 4-2 Short listed options: Elmer

| Option | Description |
|------------|--|
| Do Minimum | <ul style="list-style-type: none"> • Patch and repair works to the beach and linear defences on an annual basis. • Replacement of dislodged rocks on the rock islands may be required post severe storm events. In consideration of the condition and residual life of the existing defence assets, it is estimated that this option would delay breach of the defences by ten years. |
| Maintain | <ul style="list-style-type: none"> • Works to the beach rock revetment. The existing offshore rock islands effectively reduce the impact of wave overtopping and typically retain the series of beaches between the rock islands. • In the longer term, construct the secondary bund at Poole Place (Key Plan 2). The Poole Place bund is required to cut off a secondary flood route that could outflank the main Elmer defences during a severe storm event. • As climate change increases sea levels there is an increasing likelihood that, given the low 10% AEP (1 in 10) SoP on the river, the floodplain between Elmer and Climping could become hydraulically connected by 2085 during flood events in excess of 0.2% AEP. The Ryebank House bund may be required at this time to prevent this connection and protect Elmer. • Implementation of the Maintain option, and based on predictions in sea level rise though reduced, the SoP would remain in excess of 0.2% AEP in 100 years. |
| Sustain | <ul style="list-style-type: none"> • As for the Maintain option, with the potential for future inclusion of upgrades to the rock islands/backstop defence to account for climate change. • The existing high SoP means that the potential benefits to Sustain the SoP into the future are low, and this option is unlikely to be economic. |

Table 4-3 Short listed options: Middleton

| Option | Description |
|------------|---|
| Do Minimum | <ul style="list-style-type: none"> • Patch and repair works would delay the Do Nothing effects by an estimated ten years. • This option has been short-listed solely as it is the fall back option should the preferred option not be affordable. |
| Maintain | <ul style="list-style-type: none"> • Maintain defence heights at current levels (including significant remedial works to repair current assets), which will prevent beach loss, erosion damages. • Beach recharge and recycle works would be required with a programme of ongoing maintenance and replacement of timber groynes. • Implementation of the Maintain option over the 100 year period will prevent erosion of the frontage. Based on predictions of sea level rise there will be deterioration in SoP to wave over topping such that in 100 years time the onset of below floor level flooding would occur annually. The onset of above floor level flooding would be at 16% AEP |
| Sustain | <ul style="list-style-type: none"> • Works to be concentrated around Sea Lane/Old Point as these are the locations most vulnerable to breach. • The failing timber breastwork would be replaced with rock revetment and the intensity of recharge and recycling would increase over that for the Maintain. |

Table 4-4 Short listed options: Bognor Regis and Felpham

| Option | Description |
|------------|--|
| Do Minimum | <ul style="list-style-type: none"> • Patch and repair works. • In consideration of the condition and residual life of the existing defence assets, and when compared to the Do Nothing, it is estimated that this option would extend the residual life by 20 years, annual probability of breach is improved to 1% AEP (1 in 100) within that same period. |
| Maintain | <ul style="list-style-type: none"> • Maintain defence heights at their current levels (including some significant remedial works to repair current assets), which will prevent beach loss, erosion impacts and damages. • Beach recharge and recycle works would be required with a programme of replacement and ongoing maintenance of timber groynes. • Sea walls would need refurbishment and provision of additional toe protection in the vicinity of Aldingbourne Rife outfall. • Maintain the Aldingbourne Rife outfall. • Implementation of the Maintain option, and based on predictions in sea level rise though reduced, the SoP would remain in excess of 0.5% AEP in 100 years time. |
| Sustain | <ul style="list-style-type: none"> • Works are required to replace the groynes and recharge the beach to raise the beach level to keep up with climate change. • Works to sea walls would be as for Maintain. • The intensity of recharge and recycling would increase over that for the Maintain option and the timber groynes would be replaced by fewer rock groynes in a ratio of 2.5 to 3. Maintain the Aldingbourne Rife outfall. |

Table 4-5 Short listed options: Aldwick

| Option | Description |
|------------|--|
| Do Minimum | <ul style="list-style-type: none"> • Patch and repair of defences and recycling of beach material. • This process will delay the predicted Do Nothing erosion process by up to ten years. • This option has been short-listed solely as it is the fall back option should the preferred option not be affordable. |
| Maintain | <ul style="list-style-type: none"> • Maintain defence heights at current levels (including some significant remedial works to repair current assets), which will prevent beach loss, erosion damages. • Beach recharge and recycle works would be required with a programme of replacement and ongoing maintenance of timber groynes. • The rock revetment toe at Dark Lane would need to be extended. • Implementation of the Maintain option over the 100 year period will prevent erosion of the frontage. The beach management investment will also serve to mitigate the overtopping issues at Dark Lane and provide a more consistent SoP across the whole frontage. Based on predictions in sea level rise, the minimum SoP for the frontage to overtopping would be 5%AEP in 100 years time. |
| Sustain | <ul style="list-style-type: none"> • Generally as for Maintain but with an increased intensity of beach recharge and recycling. Works to ensure a consistent SoP of 0.5% AEP (1 in 200) along the frontage would result in no damage due to overtopping or erosion throughout the appraisal period. |

5. Options Appraisal and Comparison

5.1 Sources of Data and Technical Issues

5.1.1 This Strategy uses data from the following sources:

- a) 2004 HR Wallingford Strategy Study;
- b) Performance Reviews to better understand and provide more detail for assessments along the Elmer and Bognor Regis and Felpham frontages;
- c) Flood zone mapping to determine floodplain connectivity;
- d) Walkover condition survey to determine structure residual life and identify possible work requirements;
- e) National Flood and Coastal Defence Database (NFCDD); and
- f) LiDAR data.

5.1.2 This section provides more details about these sources of data and technical issues considered as part of the options comparison and appraisal. Further details can be found in the Appendices to this document.

5.1.3 This is a coastal Strategy and tidal inundation is the dominant source of flooding. To avoid double counting of fluvial damages within the area covered by the River Arun and Western Streams CFMP, we have not modelled the affects of inland flooding from fluvial events or tide locking (with or without pump failure). Therefore we have not included any future capital or maintenance costs for inland defences on the rife drainage system.

Defence Performance Reviews

5.1.4 We carried out performance reviews of the Elmer breakwater scheme and the Felpham groyne scheme (see Performance Analysis Report, Appendix I). The reviews concluded that both schemes were performing well to design parameters, but that their performance is likely to deteriorate with future sea level rise. The results of the studies were used to inform the development of the strategic options.

5.1.5 We also undertook a study (Elmer Breakwater Study, Atkins, 2010) which looked at historic aerial photographs and beach profile data to investigate the impact of the Elmer rock islands on the beach at Climping. This study concluded that there is no evidence to suggest that the Elmer rock islands have significantly increased the amount of erosion of the Climping beach, as a similar level of erosion was taking place there before the rock islands were built.

Flood Zone Mapping and Floodplain Connectivity

5.1.6 We determined the frontage boundaries based on mapping outputs from the National Flood Risk Assessment (NaFRA) 2008. Using this data Elmer, Climping and the River Arun frontages were treated as one for the Strategy two-dimensional (2D) modelling.

5.1.7 While the River Arun West Bank frontage on its own provides a BCR in excess of one, we concluded that it would not be technically or economically feasible to separate the Climping and River Arun West Bank frontages. The 2D flood risk modelling highlighted that there is floodplain inter-connectivity between the Climping and River Arun West Bank at the 10% AEP (1 in 10) event.

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- 5.1.8 The outputs from the 2010 flood zone mapping indicate that there is no floodplain connectivity between Elmer and Climping even for the extreme 0.1% AEP (1 in 1000) event. However connectivity is established after 2085, taking the upper band predicted sea level rise into account, for the extreme 0.1% flood event.
- 5.1.9 The flood extent information was used during the appraisal process to verify the frontage boundaries. The verification and evaluation has shown that it is technically feasible and economically justifiable to separate Elmer from Climping by construction of inland bunds at Poole Place in the short term, and across the floodplain adjacent to Ryebank House, as shown on Strategy Key Plan 2. Based on the Strategy flood extent modelling and flood risk, the Ryebank House bund would not be required for approximately 60 years. The exact timing of this intervention would depend upon the outcome of future Strategy reviews and actual sea level rise resulting from climate change.
- 5.1.10 There is no evidence to suggest that the presence of the Elmer Breakwaters has caused an increase in erosion downdrift at Climping. The existence of the Legal agreement means that the legal frontage will need to be maintained. The option choice of the Climping legal frontage is not sensitive to the option choice at Elmer thereby confirming separation of the two frontages

Climping Technical Analysis

- 5.1.11 We have undertaken a detailed technical and economic appraisal of FCERM options for the Climping coastal frontage not covered by the legal agreements. The aim of the analysis was to provide a more robust technical basis for recommending options at Climping. As part of this additional analysis we have also considered the costs to comply with the legal agreements.
- 5.1.12 The Climping analysis also investigated the technical uncertainties concerning the option selection for this frontage. This included a detailed review of historic recorded wave events, their damage impact on Climping beach and the extent of the repairs required. A probabilistic matrix of wave climate and the likelihood of minor and major damage to the beach was developed for three indicative breach sill levels. This approach allowed us to estimate the potential duration of the Do Minimum option before it might become uneconomic.
- 5.1.13 A reasonable set of 'mid-range' parameters (e.g. wave or storm conditions) have been selected following a sensitivity analysis. These have been used to generate the associated flood damages, formulate option cost profiles and calculate the BCR presented in this business case. The parameters chosen should not however be interpreted as a prediction of what will actually happen over the coming years.
- 5.1.14 The principal finding of the analysis is that the shingle beach is more resilient to damage than initially considered and that there is an economic case to undertake limited reactive patch and repair to extend the life of the defence. The detailed technical and economic analysis is discussed in Appendix P.

Surface Water

- 5.1.15 The floodplain along the River Arun west bank is drained via a network of rifes that outfall through tidal controls directly into the river. The active Sustain option with early wall raising will not adversely affect the drainage system. Measures to mitigate surface water impacts will need to be fully considered when designing the proposed Rope Walk and A259 bunds.

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Adapting to Climate Change

- 5.1.16 Revised climate change advice was published in September 2011 to be applied to all future appraisals submitted for approval after 01 January 2012. This Strategy was substantially complete at this time so, taking a proportionate approach, we have tested if the 2011 advice could lead to a different preferred option and investment decision. This sensitivity test is included in Section 6.2 and concludes that the investment decisions recommended by this Strategy are robust in the short to medium term.
- 5.1.17 The new advice uses the basis of 'change factors' for key parameters to represent the potential changes anticipated over the next hundred years, compared to a historic baseline. In addition to these change factors, upper and lower estimates of potential change are provided to present the 'range of future risks' and uncertainties in climate change predictions.

Extreme Sea Levels - Coastal Flood Boundaries Dataset

- 5.1.18 Water levels in this study were based on the Environment Agency adopted tidal levels (Extreme Sea Levels Kent, Sussex, Hampshire & Isle of Wight Updated Summary Report, December 2004, JBA Consulting) and altered as necessary for sea level rise.
- 5.1.19 In February 2011, the Environment Agency released new design sea level data for a range of AEP events together with swell wave data. Inclusion of upper and lower confidence bands either side of the baseline to account for uncertainties were issued. A transition period was recommended for projects that were underway, to allow a risk based approach to be applied. This Strategy was substantially complete in February 2011 and has as such adopted a risk based approach.
- 5.1.20 For the risk assessment, a comparison between the previously adopted extreme sea levels (Extreme Sea Levels Kent, Sussex, Hampshire and Isle of Wight Updated Summary Report, December 2004) and the new datasets has been completed. The objective of the comparison was to show if application of the new data sets could significantly affect the options appraisal.
- 5.1.21 The new dataset baseline is marginally lower than the previous 2004 data, with the greatest difference of 0.24m in the estimated 0.67% AEP (1 in 150) event. Application of the upper confidence interval indicates that there is a difference of 0.1m at limited AEP events, and no difference with other events.
- 5.1.22 This difference is considered negligible in light of the tolerances of modelling and data applied to a strategy level project, and the use of the 2004 dataset over the 2011 dataset is not expected to have any effect on the choice of preferred options.

5.2 Environmental Assessment

- 5.2.1 We undertook a Strategic Environmental Assessment (SEA) and produced an Environmental Report (Appendix C) to assess the environmental impacts of the short-listed options on all of the relevant receptors for each of the Strategy frontages. We produced an Addendum to the SEA Environmental Report to consider the revised options for Climping (Appendix C).
- 5.2.2 Within the SEA, each short-listed option was assessed for impacts on the SEA objectives. The impacts were assessed by their 'significance of impact' on the objectives to determine their environmental ranking. The option with the lowest ranked score is the SEA preferred option. The summary of this assessment is shown in Table 5-1. The Elmer Sustain option was not assessed by the SEA as it had been discounted in the early stages of the economic appraisal (see Tables 4-2 and 6-2).

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- 5.2.3 The SEA preferred option is to Sustain for Climping, Middleton, Bognor Regis and Felpham and Aldwick. For the River Arun West Bank it is Improve and for Elmer it is Maintain. The main determining factor was the retention of the current level of flood risk to life and property into the future under these options. The Strategy's economic appraisal, however, found that the level of capital investment required to deliver the SEA preferred options may not be economically justified in every frontage.
- 5.2.4 In May 2010 we completed an assessment for compliance with the Water Framework Directive (WFD) (Appendix M) and this was subsequently updated in April 2012 to consider the revised Climping options appraisal. The WFD compliance of each option is described in Chapter 6.

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Table 5-1 Summary SEA Ranking Assessment of Short Listed Options

| CoM = Cessation of Maintenance: DM = Do Minimum; M = Maintain; S = Sustain | Option by Frontage | | | | | | | | | | | | | | | | | | | |
|--|----------------------|----------|-------------------|----------|-----------|----------------|----------------|----------|-------------------------------------|----------|----------|----------------|----------|----------|------------------------|----------|----------|----------------|----------|--|
| | River Arun West Bank | | | Climping | | | | | | Elmer | | Middleton | | | Bognor Regis & Felpham | | | Aldwick | | |
| | | | | Legal | Non-legal | | Whole frontage | | | | | | | | | | | | | |
| Objective | DM | M | S | DM | CoM | DM | M | S | DM | M | DM | M | S | DM | M | S | DM | M | S | |
| 1. Provide opportunities to improve human health and avoid adverse effects on population | | | | | | | | | | | | | | | | | | | | |
| 2. Protect and enhance biodiversity | | | | | | | | | | | | | | | | | | | | |
| 3. Protect and enhance land quality | | | | | | | | | | | | | | | | | | | | |
| 4. Protect and enhance water | | | | | | | | | | | | | | | | | | | | |
| 5. Reduce flood risk to people and property | | | | | | | | | | | | | | | | | | | | |
| 6. Protect and enhance air quality | | | | | | | | | | | | | | | | | | | | |
| 7. Mitigate impacts from climate change and reduce contribution to green house effect | | | | | | | | | | | | | | | | | | | | |
| 8. Protect existing infrastructure | | | | | | | | | | | | | | | | | | | | |
| 9. Protect and improve existing economic assets | | | | | | | | | | | | | | | | | | | | |
| 10. Protect and enhance cultural heritage features | | | | | | | | | | | | | | | | | | | | |
| 11. Protect and enhance landscape character / visual amenity | | | | | | | | | | | | | | | | | | | | |
| ENVIRONMENTAL RANKING | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 5 | 2 | 1 | 3 | 2 | 1 | 3 | 2 | 1 | |
| Key to the table: significance of impacts | | | | | | | | | | | | | | | | | | | | |
| Major positive | | | Moderate Positive | | | Minor Positive | | | Negligible/ neutral/ not applicable | | | Minor negative | | | Moderate Negative | | | Major negative | | |

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SEA Consultation

- 5.2.5 We undertook consultation with internal and external stakeholders at the SEA Scoping stage between March and June 2008. The main consultees are listed in Section four of the SEA Environmental report along with the comments received and actions taken.
- 5.2.6 We carried out consultation on the draft Strategy recommendations between June 2009 and January 2010. Further consultation, targeted at areas where the recommended option has changed, on the Climping and River Arun West bank frontage, was completed by January 2015.
- 5.2.7 Natural England has participated in the Strategy throughout its development. An initial letter of support for the Strategy was provided following the first round of consultation in 2009. A further letter of support concerning the Climping and River Arun Frontage was provided following the consultation period completed in January 2015.

5.3 Social and Community Impacts

- 5.3.1 Comments received during the SEA consultation from the Member of Parliament and communities have highlighted the following concerns regarding Do Minimum options:
- a) Increased risk of flooding to residential properties;
 - b) A deterioration of the marine commercial activities on the west bank of the River Arun;
 - c) An increased risk to road and utility infrastructure;
 - d) A reduction in the local tourism economy as beaches decline;
 - e) An increased risk to the viability of the Climping links golf course should West Beach dunes roll back;
 - f) A reduction in local commercial investment.
- 5.3.2 Further detail on the feedback received during the SEA consultation in 2009/10 and in 2014/15 is in Appendix K. None of the feedback resulted in a change to the environmental assessment results or a change in preferred option for environmental reasons. However, responses will inform how preferred options can be best implemented to protect people and the environment.

5.4 Option Costs

- 5.4.1 This section contains a summary of the general approach for costing the short-listed options over the 100 year appraisal period. Appendix N contains the more detailed cost breakdowns for these options. Proposed maintenance activities and capital works were identified and quantified in the following ways:
- a) Beach recycling and recharge material volumes were calculated based on the HR Wallingford Critical Beach Profile and coastal process reports;
 - b) The number, length and height of new groynes were listed assuming direct replacement of existing groynes on a like-for-like basis;
 - c) Model results were used to establish the height and length of wall raising required to keep pace with climate change;
 - d) The type and frequency of maintenance activities was based on existing practices, defence condition survey and coastal process studies.

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- 5.4.2 During the Strategy development, we worked closely with an experienced local Water and Environment Management (WEM) framework contractor. The engagement of Team Van Oord in Early Supplier Engagement (ESE) enabled us to cross check construction costs against those within the Unit Cost Database. Costs for all short-listed options have a price date of Q4 2008.
- 5.4.3 The changes to Construction Price Index (Department for Business, Innovation and Skills June 2014) for the period up to 2014 have been monitored and only show minor change over the period since 2008. The Q4 2008 prices therefore remain valid and have not been changed.
- 5.4.4 For each option, we have included the future cost for capital expenditure and maintenance and these have been optimised over the 100 year appraisal period of the Strategy.
- 5.4.5 Where applicable, costs for professional fees and pre-contract costs have been included as a percentage of the construction cost.
- 5.4.6 The Present Value (PV) costs have been determined using a 3.5% discount rate – reducing to 3.0% for years 31-75 and 2.5% thereafter. This is in line with current guidance.

Optimism Bias

- 5.4.7 The FCERM-AG describes Optimism Bias (OB) as “the tendency for appraisers to be overly optimistic in early assessments of project costs, time scales and benefits in comparison to the final values.” To counter this, HM Treasury recommends the use of an OB percentage that increases the costs by an amount that reflects the uncertainty surrounding the estimates. It is usual to apply an OB of 60% to costs in a project at an early stage of consideration, including strategies.
- 5.4.8 The FCERM-AG supplementary guidance on OB sets out key components of risk. For each option, it can be assessed whether the contributions of these components should be higher or lower. In some cases, action can be taken to minimise an individual risk. Conversely, the contribution from a specific risk component may need to be increased. Following this assessment, a revised OB percentage can be set.
- 5.4.9 OB was reduced from the standard 60% for the majority of the Strategy frontages because of increased confidence in the costings for three reasons:
 - a) Early contractor involvement;
 - b) Use of information from recent, local, similar construction projects;
 - c) Relatively low technical challenge for the construction works.
- 5.4.10 In this Strategy we had access to the construction rates for recent local projects of a similar nature. In addition the types of construction proposed by the Strategy are well understood, delivered regularly along these frontages by the Environment Agency and are not overly complex. Consequently, we have been able to reduce the OB allowance from 60% to 40% (50% for Aldwick) for the costing of the options. A full breakdown of OB allowances is described in Appendix N.

5.5 Option Benefits

- 5.5.1 All benefits have been assessed in accordance with Flood and Coastal Defence Project Appraisal Guidance (FCDPAG) and Supplementary Guidance issued by Defra and amended as appropriate to FCERM-AG. Flood damages have been calculated using the Multi Coloured Manual (MCM) (Middlesex Flood Hazard Research Centre (FHRC) 2005). Further detail and explanation of the applied methodology and assessment of the damages and benefits for the various options is included in the Economic Appraisal for Elmer to Aldwick in Appendix F and in Appendix P for Climping and the River Arun West Bank. A summary is provided in this section.

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- 5.5.2 Risk to life has been calculated for all cells and included in the summary tables. We have completed the assessment to Defra supplementary guidance¹ and, under the Do Nothing scenario, fatalities are estimated at 0.3 per year in 2009 rising to 6.8 per year in 2109 across the Strategy area.
- 5.5.3 For the Climping and River Arun West Bank frontage we have valued agricultural losses in accordance with Defra guidance². Using the 'Farm Management Pocketbook' (John Nix) 2005 MCM and land registry regional records for sale of farmland, we have used the highest reasonably justifiable land valuation. There is no significant agricultural land use behind the other frontages.
- 5.5.4 The property list came from the National Property Dataset (NPD) 2005, adjusted through both GIS verification and ground truthing. Missing property types were investigated and added.
- 5.5.5 All damages were originally assessed to an August 2008 price date by using the 'All Items' Retail Price Index (RPI). Properties have been valued in accordance with guidance³ and adjusted by the Distributional Index Factor. Based on National Statistics Consumer Price Index (CPI), the economic damages and benefits have been increased by a factor of 16.7% for the period from August 2008 to June 2014.
- 5.5.6 Traffic damages as a result of diversion costs were calculated based on the Department for Transport guidance⁴. We have calculated traffic counts for two locations, Middleton Road in 'Middleton' and the A259 Bridge Road in 'Climping and River Arun West Bank' using data supplied by Arun District Council and West Sussex County Council (WSSCC), which we have used in our appraisal.

¹ 'Supplementary Note to Operating Authorities: Assessing and Valuing the Risk to Life from Flooding for Use in Appraisal of Risk Management Measures', Defra, May 2008.

² 'Valuation of Agricultural land and Output for Appraisal Purposes', May 2008.

³ 'Economic evaluation of Damages for Flood Risk management Projects' by the Environment Agency, May 2008. Document Ref 412_07

⁴ 'Values of Time and Operating Costs' (TAG Unit 3.5.6, Department for Transport, July 2008).

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6. Selection and Details of the Preferred Option

6.1 Selecting the Preferred Option

6.1.1 The assessment of options for each reach was undertaken as follows:

- a) The technical viability of alternative options was considered and the long-list of options reduced to provide a short-list (refer to Section 4-2);
- b) Comparison with strategic environmental objectives was considered in the SEA using an evaluation matrix (refer to Table 5-1);
- c) The economic consequences of each short-listed option were established and tabulated using FCERM-AG spreadsheets and a preferred economic option was defined for each frontage;
- d) The environmentally preferred option for each frontage was defined from the SEA and compared against the economic preferred option to identify any conflicts. Compliance and contribution towards WFD objectives was also considered;
- e) A Strategy preferred option was chosen for each frontage, and mitigation proposed where this conflicted with the environmentally-preferred option. WFD compliance was assured and contributions to WFD objectives included where technically feasible or not disproportionately costly;
- f) A review of the existing assets so that their residual life would be appropriately managed by maintenance or replacement works through the Strategy appraisal period;

6.1.2 The following sections present the preferred option for each of the Strategy's flood cells. The benefit cost assessment is summarised in Tables 6-1 to 6-6.

Climping and River Arun West Bank

Table 6-1 Climping and River Arun West Bank Benefit-Cost Assessment

| | PV Damages (£K) | PV Costs (£K) | PV Benefits (£K) | Av. Benefit/Cost Ratio | Incremental BCR |
|--|--------------------|------------------|---------------------|------------------------------|--|
| Climping and River Arun West Bank – Legal Frontage only | | | | | |
| Do Minimum (Legal) | 0 | 6,070 | - | - | - |
| Climping non-legal frontage and River Arun West Bank | | | | | |
| Do Nothing | 47,737 | - | - | - | - |
| Do Minimum | 36,731 | 1,513 | 11,276 | 7.45 | - |
| Maintain | 31,959 | 17,068 | 16,119 | 0.94 | 0.3 against Do Minimum |
| Cessation at Climping and Sustain River Arun | 7,303 | 12,565 | 40,538 | 3.23 | 2.7 against Do Minimum |
| Do Minimum Climping and Sustain River Arun West Bank | 6,435 | 12,306 | 41,856 | 3.40 | 2.8 against Do Minimum |
| Sustain | 3,453 | 27,522 | 44,801 | 1.63 | 0.2 against Do Minimum Climping and Sustain Arun West Bank |

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- 6.1.3 At the Climping legal frontage, we will continue to comply with the legal agreements, working with Natural England to ensure continued assent to recycle shingle material from the beach in front of the Climping Beach SSSI. The legal frontage is generally on high ground, and is primarily at risk of erosion, with overtopping in excess of a current 1 in 100 year order event: economic benefits are negligible from the works along this frontage. There remains the risk that land further inland behind the legal frontage will flood from a breach at the non-legal frontage.
- 6.1.4 Environment Agency teams will continue to engage with the landowners concerning the requirements of the legal agreements, future management of the affected coastline and potential changes to the legal agreements.
- 6.1.5 The economic preferred option for the remainder of the flood cell is Do Minimum at Climping and Sustain for the River Arun West Bank. This option has a BCR of 3.4 and an iBCR of 2.8 with respect to Do Minimum, and can therefore be selected as the preferred option since the SoP for Do Minimum is considerably less than 1.3% AEP. The additional investment needed to Sustain the whole frontage cannot be selected since the iBCR, with respect to the preferred option, is only 0.2.
- 6.1.6 The flood mechanism for this cell prevents us from fully separating out benefits and costs between the coastal Climping frontage and the River Arun West Bank frontage. The receptors that generate the benefits are concentrated in the residential and commercial property alongside the River Arun and at Climping Park, immediately north of the A259. Based on the detailed technical analysis for the flood cell presented in Appendix P, it is concluded that about 97% of the damages are attributable to tidal flooding from the River Arun and about 3% from the properties at Atherington close to the coast.
- 6.1.7 To test the robustness of Do Minimum at Climping, the option of ceasing maintenance now (Year 0) at Climping and Sustain for the River Arun is presented in Appendix P. This option determined a BCR of 3.2, marginally lower than Do Minimum at Climping and Sustain at River Arun. This therefore supports the selection of Do Minimum at Climping as the preferred option.
- 6.1.8 The Implementation Plan given in Chapter 7 describes at what point the Do Minimum option for the non-legal Climping frontage would no longer be viable, leading to the necessity to cease further maintenance.
- 6.1.9 If the legal and non-legal frontage costs were combined, there would be a relative decrease in BCR across all the options. However the Do Minimum and Sustain option remains the leading option, as shown in Table 6.2. As the legal frontage does not contribute further benefits, the benefits remain unchanged from those in Table 6.1.

Table 6-2 Climping and River Arun West Bank Benefit-Cost Assessment Including Legal costs

| | PV Damages (£K) | PV Costs (£K) | PV Benefits (£K) | Av. Benefit/Cost Ratio | Incremental BCR |
|---|--------------------|------------------|---------------------|------------------------------|--|
| Climping whole frontage and River Arun West Bank | | | | | |
| Do Nothing | 47,737 | - | - | - | - |
| Do Minimum | 36,731 | 7,583 | 11,276 | 1.5 | - |
| Maintain | 31,959 | 23,138 | 16,119 | 0.7 | 0.3 against Do Minimum |
| Do Minimum and Sustain | 6,435 | 18,376 | 41,856 | 2.3 | 2.4 against Do Minimum |
| Sustain | 3,453 | 33,592 | 44,801 | 1.3 | 0.2 against Do Minimum Climping and Sustain Arun West Bank |

- 6.1.10 The environmentally preferred option for Climping was Sustain, due to the standard of protection afforded to receptors and the opportunity to allow some local landward expansion of coastal habitats such as vegetated shingle and sand dunes. This option would also contribute most to Sussex Coastal water body meeting its WFD objectives. However, the high capital cost of implementing this option was found to be disproportionate to the potential ecological and economic benefits and therefore this option was not taken forward.
- 6.1.11 During the further appraisal of the Climping frontage, we held a workshop to examine WFD compliance in more detail. As well as confirming the unsuitability of Managed Realignment as a mitigation measure in this location, it also provided an assessment of the Do Minimum option, compared to a Do Nothing (Cessation of Maintenance) scenario. The assessment found that while Do Minimum would maintain an artificial beach alignment and profile, the ecological negatives from coastal squeeze would be minimal since at this location the shingle beach has low ecological value and the coast would not naturally form a wider foreshore if left to natural processes. Therefore the Do Minimum option was considered compliant with WFD objectives.
- 6.1.12 The environmentally preferred option along the River Arun West Bank is Improve to minimise the impact of flooding on a number of receptors within the cell. Sustain was the next environmentally favoured option, as this would ensure flood protection is sustained, although at a lower standard for the duration of the Strategy.
- 6.1.13 The SEA and WFD assessments identified opportunities for contribution to WFD objectives for the Arun transitional water body through localised realignments and tidal exchange schemes under the Sustain option. These would not be economically justifiable for purely flood risk management purposes and would require contributions from other sources. The preferred option is therefore considered compliant with WFD requirements.

Elmer

Table 6-3 Elmer Benefit-Cost Assessment

| | PV Damages (£K) | PV Costs (£K) | PV Benefits (£K) | Av. Benefit/Cost Ratio | Incremental BCR |
|------------|-----------------|---------------|------------------|------------------------|-----------------|
| Do Nothing | 77,052 | 0 | 0 | - | - |
| Do Minimum | 67,503 | 2,627 | 9,549 | 3.6 | - |
| Maintain | 140 | 4,834 | 77,978 | 16.1 | 31.0 |
| Sustain | 40 | 8,777 | 78,079 | 8.9 | 0.0 |

- 6.1.14 The economic preferred option is Maintain for the Elmer frontage as this has the highest BCR. The next highest option of Sustain cannot be selected since the IBCR is zero.
- 6.1.15 For the frontage at Elmer, the environmentally preferred option is the same as the economic preferred option of Maintain. This is environmentally preferred as it maintains a high standard flood and erosion risk protection and minimises adverse effects on the amenity value of the beach and its character.
- 6.1.16 The WFD assessment concluded that this option would not cause deterioration in the status of any water bodies, and that hydro-morphological mitigation measures for Sussex Coastal relating to beach control and preserving habitats could be delivered through sensitive beach management practices.

Middleton

Table 6-4 Middleton Benefit-Cost Assessment

| | PV Damages (£K) | PV Costs (£K) | PV Benefits (£K) | Av. Benefit/Cost Ratio | Incremental BCR |
|------------|-----------------|---------------|------------------|------------------------|-----------------|
| Do Nothing | 44,682 | 0 | - | - | - |
| Do Minimum | 35,881 | 3,657 | 9,053 | 2.5 | - |
| Maintain | 904 | 16,003 | 46,238 | 2.9 | 3.0 |
| Sustain | 377 | 21,088 | 46,776 | 2.2 | 0.1 |

6.1.17 The economically preferred option is to Maintain the Middleton frontage. The IBCR is not high enough to step up to Sustain.

6.1.18 The environmentally preferred option for the Middleton frontage is Sustain, since this protects the highest number of receptors from flood and erosion risk over time. Maintain is still considered to provide adequate protection over the short term. Of the three possible Maintain sub options in the long list (Section 4.1.2), the most environmentally preferred was selected which minimises adverse effects on coastal habitats, beach amenity and character and safety.

6.1.19 The WFD assessment concluded that this option would not cause a deterioration in status of any water bodies, and that hydro-morphological mitigation measures for Sussex Coastal relating to beach control and preserving habitats could be delivered through sensitive beach management practices.

Bognor Regis and Felpham

Table 6-5 Bognor Regis and Felpham Benefit-Cost Assessment

| | PV Damages (£K) | PV Costs (£K) | PV Benefits (£K) | Av. Benefit/Cost Ratio | Incremental BCR |
|------------|-----------------|---------------|------------------|------------------------|-----------------|
| Do Nothing | 44,790 | 0 | 0 | - | - |
| Do Minimum | 29,545 | 5,879 | 15,245 | 2.6 | - |
| Maintain | 0 | 17,503 | 46,046 | 2.6 | 2.6 |
| Sustain | 0 | 22,389 | 46,046 | 2.1 | 0 |

6.1.20 The economically preferred option is to Maintain the frontage at Bognor Regis and Felpham. This option has the highest BCR. It is not possible to step up to Sustain since the IBCR is zero. The benefits for Sustain and Maintain are the same since the SoP is already very high.

6.1.21 The environmentally preferred option for the frontage is Sustain. Maintain is still considered to provide adequate protection. Of the possible Maintain sub options in the long list (Section 4.1.2) which does not involve rock structures, has been selected as it minimises adverse effects on the beach character and habitat and maintains amenity and safety.

6.1.22 The WFD assessment concluded that this option would not cause a deterioration in status of any water bodies, and that hydromorphological mitigation measures for Sussex Coastal relating to beach control and preserving habitats could be delivered through sensitive beach management practices.

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Aldwick

Table 6-6 Aldwick Benefit-Cost Assessment

| | PV Damages (£K) | PV Costs (£K) | PV Benefits (£K) | Av. Benefit/Cost Ratio | Incremental BCR |
|------------|--------------------|------------------|---------------------|---------------------------|-----------------|
| Do Nothing | 18,222 | 0 | - | - | - |
| Do Minimum | 13,627 | 2,450 | 4,653 | 1.9 | - |
| Maintain | 57 | 5,550 | 18,765 | 3.4 | 4.6 |
| Sustain | 12 | 13,994 | 18,811 | 1.3 | 0.0 |

6.1.23 The economically preferred option is to Maintain the Aldwick frontage. This option has the highest BCR. It is not possible to step up to Sustain since the IBCR is zero.

6.1.24 The environmentally preferred option for Aldwick is Sustain since this protects the highest number of receptors from flood and erosion risk over time. Maintain is still considered to provide adequate protection over the short term and was preferred over Do Minimum since beach profiles would be maintained protecting amenity value and habitats.

6.1.25 The WFD assessment concluded that this option would not cause a deterioration in status of any water bodies, and that hydro-morphological mitigation measures for Sussex Coastal relating to beach control and preserving habitats could be delivered through sensitive beach management practices.

6.2 Sensitivity Testing

6.2.1 A wide range of economic sensitivity tests were undertaken to assess the most uncertain assumptions for each frontage. In each case we tested the impact of the following elements of the economic appraisal:

- a) Delaying the breach.
- b) Removing risk to life.
- c) Raising property threshold levels and increasing costs.
- d) Increasing Optimism Bias to 60%.

6.2.2 These elements were chosen because individually they provide a significant contribution to the economic analysis and any variation could have a proportional impact on the BCR. The sections below summarise the results of the sensitivity testing and whether the decision rule changes the preferred option for each frontage.

6.2.3 For each frontage, a table shows the impacts of the changes on the BCR for the preferred option. For each, we have completed a further test reported in the table, whether the outcome of the decision rule with FCERM –AG would be altered.

Climping (non-legal) and River Arun West Bank

6.2.4 As presented in Table 6-7, the preferred option remains the same for each test and the BCR and incremental BCR remain above unity. These tests give confidence in the selection of the preferred option for the frontage at Arun West Bank and the non-legal section of the Climping coast. However, we recognise that the point when do minimum maintenance at Climping ceases to be economically viable, will be sensitive to the BCR. This is considered further in the sections below.

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Table 6-7 Climping and River Arun Sensitivity Testing

| Sensitivity Test | Benefits £k | Costs £k | Benefit Cost Ratio | Does the preferred option still pass the decision rule? |
|---|----------------|-------------|-----------------------|---|
| Baseline | £41,856 | £12,306 | 3.4 | n/a |
| Double Do Nothing Agricultural damages | £42,226 | £12,320 | 3.43 | Yes |
| Double traffic losses | £44,268 | £12,333 | 3.59 | Yes |
| Economic decision delayed to Yr 52 (probability that breach not yet occurred = 0.2) | £41,856 | £12,190 | 3.43 | Yes |
| Optimism Bias at 60% | £41,856 | £14,079 | 2.97 | Yes |

Elmer to Aldwick

6.2.5 Table 6-8 presents a summary of the sensitivity testing carried out for the Elmer to Aldwick frontages. Further details are provided in Appendix F.

Table 6-8 Elmer to Aldwick Sensitivity Testing

| Frontage | Baseline BCR | Sensitivity Test with the largest impact (and associated BCR and additional commentary) | BCR range for all other sensitivity tests | Same Preferred Option? |
|--------------------------------|-----------------|--|--|---------------------------|
| Elmer | 16.1 | Delayed Breach (BCR 15.5) Risk to life removed (BCR 9.8) Not reasonable to remove risk to life because of flood depth and high density of residential properties. | 9.8 – 16.36 | Yes |
| Middleton | 2.9 | Human intangibles removed (BCR 2.7) Risk to life removed (BCR 2.4) | 2.4 – 3.3 | Yes |
| Bognor Regis and Felpham | 2.6 | Risk to life removed (BCR 2.1) 60% Optimism Bias (BCR 2.3) Delaying breach by 20 years brought the BCR to be the same as Do Minimum (2.4). The frontage, however, protects the urban centre of Bognor Regis and the Butlins South Coast World. These additional non-valued elements provide justification for the preferred option to remain as Maintain. | 2.1 – 2.9 | Yes |
| Aldwick | 3.4 | Risk to life removed (BCR 2.8) | 2.8 – 3.6 | Yes |

Climate Change Uncertainty

6.2.6 The application of the 2011 Climate Change advice is addressed in Section 5.1. Specific impacts are described below.

6.2.7 The Sustain element of the preferred option for the River Arun frontage is where application of the Lower scenario curve may have the most impact on the economic analysis. The damages for all options will be reduced most likely in proportion to each other. For the Sustain option, the costs will reduce as defences can be built lower and future interventions can be delayed or may no longer be required. The effect of climate change on the Climping frontage is likely to be small, due to the short residual life of defences under the do minimum recommendation.

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- 6.2.8 For the remaining four coastal flood cells at Elmer, Middleton, Bognor and Felpham and Aldwick, the draft Strategy recommends to 'Maintain' the existing defences. Based on trends of the Central and Upper estimate 2011 climate change data compared to the 2006 data used by this Strategy, it is considered there is unlikely to be enough difference to change the draft Strategy recommendations in the short to medium term. The Lower estimate scenario prediction starts to diverge away from the current trends from around 2025. The application of this lower estimate is highly unlikely to change the preferred Maintain option for the coastal frontages, but may delay the need for certain capital works. Under this option, no work is currently being proposed which will prevent any changes in management of flood and coastal risks in the future, should the Lower estimate prediction of climate change be realised.
- 6.2.9 We conclude that the new Adapting to Climate Change Advice does not influence the investment decision recommended by this Strategy in the short to medium term.

6.3 Consultation Feedback 2015

- 6.3.1 Consultation on the full strategy was completed in 2009-2010. Since then, further assessments caused a change in preferred option for one Strategy frontage: Climping and Arun West Bank. Here, the preferred option changed from cessation of maintenance to Do Minimum. A re-consultation exercise was completed between November 2014 and January 2015 focusing only on this one Strategy area.
- 6.3.2 The economic benefits at Climping were subject to particular scrutiny and comment by consultees because the benefits value can affect the implementation of the do minimum option. We made people aware through the consultation that the point at which further maintenance is no longer economically justified is subject to change if the benefits are raised or lowered.
- 6.3.3 Two points of clarification were raised which influence the economic benefit calculation for the Climping non-legal frontage. Feedback from Southern Water indicated that we had undervalued costs due to the impact of flooding on the wastewater pipeline that crosses the tidal floodplain. We were also prompted to re-assess the number of properties at Climping Park, which increased from 88 to 102. Remaining feedback did not alter our previous assessments.
- 6.3.4 We have assessed the effect of benefits changes as shown in Table 6-9 below. This influences recommendations for implementing the Do Minimum Climping and Sustain River Arun West Bank option and has been used by us in updating the implementation section below. We have also considered whether the benefit changes could influence the Strategy recommendations by considering incremental BCR for the decision rule. Table 6-9 presents the Strategy's final economic position for the Climping and River Arun West Bank frontage, and updates the information given in earlier tables and Appendix P.

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Table 6-9 Climping and River Arun West Bank Benefit-Cost Assessment (post-Consultation Economic Benefit Update)

| | PV Damages (£K) | PV Costs (£K) | PV Benefits (£K) | Av. Benefit/Cost Ratio | Incremental BCR |
|--|--------------------|------------------|---------------------|------------------------------|--|
| Climping and River Arun West Bank – Legal Frontage only | | | | | |
| Do Minimum (Legal) | 0 | 6,070 | - | - | - |
| Climping non-legal frontage and River Arun West Bank | | | | | |
| Do Nothing | 50,827 | - | - | - | - |
| Do Minimum | 38,995 | 1,403 | 12,083 | 8.61 | - |
| Maintain | 31,882 | 17,068 | 19,285 | 1.13 | 0.5 against Do Minimum |
| Cessation at Climping and Sustain River Arun | 9,039 | 12,565 | 41,788 | 3.33 | 2.7 against Do Minimum |
| Do Minimum Climping and Sustain River Arun West Bank | 7,179 | 12,337 | 43,648 | 3.54 | 2.9 against Do Minimum |
| Sustain | 3,628 | 27,522 | 47,715 | 1.73 | 0.3 against Do Minimum Climping and Sustain Arun West Bank |

6.3.5 We have completed a further sensitivity test increasing the replacement cost for the rising main sewer to £9,000k based on the feedback received from Southern Water, as shown in Table 6-10 below. This test, and the sensitivity tests in Section 6.2 highlight our confidence of preferred option, and that there will not be sufficient benefits to justify a Sustain option.

Table 6-10 Climping and River Arun Southern Water Rising Main Sensitivity Test

| Sensitivity Test | Benefits £k | Costs £k | Benefit Cost Ratio | Does the preferred option still pass the decision rule? |
|--|----------------|-------------|-----------------------|---|
| Southern Water rising main full replacement cost of £9,000k included | £47,459 | £12,337 | 3.85 | Yes |

6.3.6 Consultation correspondence raised additional issues including further points regarding costs and benefits. Among the issues were questions over the viability, extent and economic effect of the Climping Legal frontage. People also asked about implications to the Strategy of the Local Plan and proposed development of the River Arun West bank. The Local Plan recognises the need for regeneration and reducing flood risk on the River Arun West Bank, and proposes development through an Area Action Plan.

6.3.7 Other issues raised during the re-consultation are covered in the Climping and Arun West Bank Consultation Summary Report (March 2015). Their impact on the Strategy has been considered where appropriate.

6.3.8 None of the matters raised during the targeted re-consultation change the recommendation of the Strategy for Do Minimum/Do Minimum Legal at Climping and Sustain River Arun West Bank. The sensitivity tests confirm the robustness of this decision.

6.4 Details of the Preferred Options

6.4.1 Table 6-11 provides a summary of the preferred option and outcome measure score for each frontage. The implementation of these options is subject to funding availability, which is discussed in the subsequent implementation section.

Table 6-11 Preferred Options for Strategy Implementation

| Frontage | Preferred Option | Description | BCR |
|---------------------------------------|--------------------|---|------|
| Climping Legal Frontage | Do Minimum (Legal) | Compliance with legal obligation (see Table 4.1). | - |
| Climping and the River Arun West Bank | Do Minimum | Climping Non-legal Implementation of a reactive patch and repair regime for as long as it remains economically sustainable and technically practical. | 3.5 |
| | Sustain | River Arun West Bank Works to raise existing defences to a standard of 0.2% AEP (1 in 500) With climate change this will degrade to a 10% AEP (1 in 10) requiring further raising in year 2085. From the A259 to the Ford railway bridge we can maintain the river bunds to their existing level providing a current 0.5% AEP (1 in 200) SoP, reducing to a 1.5% AEP (1 in 67) by 2085. From this point this SoP will be sustained. Construction of a new bund along the south side of the A259 will contain flood waters from the river and Climping, and a new low bund to reduce the 'back door' flood risk to Rope Walk in future years. | |
| Elmer | Maintain | An immediate programme of beach management with periodic beach recycling, recharge and reinforcement of the rock revetment to mitigate the risk of erosion and potential breach of the defences. In future years, construction of two new secondary bunds at Poole Place and Ryebank House to reduce the risk of future 'back door' flooding from Climping. | 16.1 |
| Middleton | Maintain | An immediate programme of maintenance and replacement of the timber groynes along with beach management with periodic beach recycling and recharge, typically every ten years which will help to prevent erosion and manage the risk of flooding from wave overtopping . | 2.9 |
| Bognor Regis and Felpham | Maintain | An immediate programme of maintenance and replacement of the timber groynes along with beach management through periodic beach recycling and recharge, typically every ten years which will help to prevent erosion manage the risk of flooding from wave overtopping and reduce the risk of breach. | 2.6 |
| Aldwick | Maintain | An immediate programme of maintenance and replacement of the timber groynes along with beach management through periodic beach recycling and recharge typically every ten years which will help to prevent erosion and manage the risk of flooding from wave overtopping. | 3.4 |

Costs of the Preferred Options

6.4.2 Table 6-12 provides a summary of the 'needs based' capital cost items recommended for the preferred options for all frontages and the non capital expenditure for maintenance to comply with the legal agreements. This investment profile of capital works is based on an optimised SoP, termed 'needs based'.

6.4.3 The cost for a Beach Management Plan is included within the PV costs for each option.

Table 6-12 'Needs Based' Cash Costs of Preferred Options (Including OB, excluding inflation)

| Cost | 2015/16 (£k) | 2016/17 (£k) | 2017/18 (£k) | 2018/19 (£k) | 2019/20 (£k) | Future years (£k) | Total (£k) |
|--|--------------|--------------|--------------|--------------|--------------|-------------------|------------|
| Climping Legal Frontage: Do Minimum (Legal) | | | | | | | |
| Capital | - | - | - | - | - | 4,158 | 4,158 |
| Non-capital | 166 | 166 | 166 | 166 | 166 | 15,812 | 16,641 |
| Total | 166 | 166 | 166 | 166 | 166 | 19,970 | 20,799 |
| Climping and River Arun West Bank: Do Minimum Climping and Sustain River Arun West Bank | | | | | | | |
| Capital | 210 | 245 | 2,800 | 2,800 | - | 13,216 | 19,271 |
| Non-capital | 97 | 97 | 97 | 97 | 97 | 7,271 | 7,757 |
| Total | 321 | 342 | 2,897 | 2,897 | 97 | 20,487 | 27,028 |
| Elmer: Maintain | | | | | | | |
| Capital | 210 | 140 | 1,316 | - | - | 7,154 | 8,820 |
| Non-capital | 62 | 45 | 63 | 63 | 63 | 6,137 | 6,433 |
| Total | 272 | 185 | 1,379 | 63 | 63 | 13,291 | 15,253 |
| Middleton: Maintain | | | | | | | |
| Capital | 140 | 140 | 2,002 | 1,789 | - | 23,148 | 27,219 |
| Non-capital | 238 | 238 | 238 | 238 | 238 | 22,610 | 23,800 |
| Total | 378 | 378 | 2,240 | 2,027 | 238 | 45,758 | 51,019 |
| Bognor Regis and Felpham: Maintain | | | | | | | |
| Capital | 70 | 70 | 1,176 | 662 | - | 20,334 | 22,312 |
| Non-capital | 336 | 336 | 336 | 336 | 336 | 31,920 | 33,600 |
| Total | 406 | 406 | 1,512 | 998 | 336 | 52,254 | 55,912 |
| Aldwick: Maintain | | | | | | | |
| Capital | 8 | 45 | - | - | 75 | 15,870 | 15,998 |
| Non-capital | 50 | 35 | 35 | 23 | 35 | 3,289 | 3,467 |
| Total | 58 | 80 | 35 | 23 | 110 | 19,159 | 19,464 |

6.4.4 Table 6-13 summarises the activities required, costs and timescales for the preferred Do Minimum at Climping and Sustain River Arun option.

Table 6-13 Climping and River Arun Activities, Indicative Costs (exc Optimism Bias) and Timescales

| Description | Indicative Costs £(k) | Indicative Timescales (subject to funding) |
|--|--------------------------|---|
| Climping (non legal) | | |
| Implementation of a reactive patch and repair regime for as long as it remains economically sustainable and technically practical. | Up to 20.0 | Annual (whilst available & sustainable) |
| River Arun West Bank | | |
| Scheme appraisal: PAR preparation, design and contract management | 325 | Years 1 - 2 |
| Construction of linear defences from the river mouth to footbridge | 4,000 | Years 3 - 4 |
| Construction of linear defences from the footbridge to A259 | 3,500 | Year 15 |
| Raising of the river defences | 1,100 | Year 2085 |
| Construct a low secondary bund at the western side of Rope Walk, to reduce the risk of 'back door' flooding | 220 | Forecast for Year 31 Refurbishment year 50 (Timing is dependent upon the continued sustainability of the Do Minimum at Climping (non-legal), refer to section 7.2). |
| Refurbishment of tidal banks north of A259 | 1,700 | Year 32 |
| Refurbishment of tidal banks north of A259 | 1,000 | Year 62 |
| Construct secondary bund along the A259 | 850 | Forecast for Year 31 and refurbishment in year 50 |
| Maintenance of existing river defences and new bunds. | 50 | Annual |

6.4.5 Tables 6-14 to 6-17 summarise the activities required, costs and timescales for the preferred Maintain option for the remaining coastal frontages.

Table 6-14 Elmer Activities, Indicative Costs (exc Optimism Bias) and Timescales

| Description | Indicative Costs (£k) | Indicative Timescales (subject to funding) |
|---|--------------------------|---|
| Scheme PAR preparation, design and contract management | 250 | Year 1 - 2 |
| Beach recharge by rainbow dredger | 365 | Year 3, then every 10 |
| Rock toe improvements at Environment Agency revetment (Alleyne Way) | 375 | Year 3 and year 50 |
| Back defence at Poole Place - bund 4m AOD 1.5m high | 200 | Year 3 and year 50 |
| Back defence in the vicinity of Ryebank House - bund 4m AOD 1.5m high | 1,250 | Year 2085 |
| Beach Management Plan | 10 | - |
| Annual Maintenance for beaches and rock works | 34 | Annual |
| Maintenance to Poole Place and Ryebank bunds | 5 | Annual post construction |

Table 6-15 Middleton Activities, Indicative Costs (exc Optimism Bias) and Timescales

| Description | Indicative Costs (£k) | Indicative Timescales (subject to funding) |
|--|-----------------------|--|
| PAR preparation, design and contract management | 200 | Over years 2 to 3 |
| Beach recharge by rainbow dredger | 1,278 | Year 5 and every 10 years |
| Timber groyne replacement extension/raising | 350 | Year 20 then every 40 years |
| Timber groyne replacement 50m long, extension/raising | 1,430 | Year 4 then every 40 years |
| Timber groyne mid life refurbishment | 50 | 20 years after construction |
| Beach recycling | 60 | Annual |
| Beach Management Plan | 10 | - |
| Maintain wall condition including promenade/splashwall maintenance | 60 | Annual |
| Maintain timber groynes/breastwork | 40 | Annual |

Table 6-16 Bognor Regis and Felpham Activities, Indicative Costs (exc Optimism Bias) and Timescales

| Description | Indicative Costs (£k) | Indicative Timescales (subject to funding) |
|--|-----------------------|--|
| PAR preparation, design and contract management | 100 | Over years 2 to 3 |
| Beach recharge (rainbow dredger) | 472 | Year 4 then every 10 |
| Extend the sea wall rock toe protection at Canning Rd (800m) | 840 | Year 3 |
| Replacement of groyne field 1 | 1,980 | Year 10 then every 40 |
| Replacement of groyne field 2 | 1,870 | Year 20 then every 40 |
| Groyne mid life refurbishment | 80 | 20 Years after construction |
| Sea wall refurbishment including promenade/splashwall | 108 | Every 20 years |
| Beach recycling | 38 | Annual |
| Beach Management Plan | 10 | - |
| Maintenance of outfalls (flaps/pumps etc) walls and groynes | 193 | Annual |

Table 6-17 Aldwick Activities, Indicative Costs (exc Optimism Bias) and Timescales

| Description | Indicative Costs (£k) | Indicative Timescales (subject to funding) |
|---|-----------------------|--|
| Design and contract management | 5 | Year 1 |
| Beach recharge | 725 | Year 15 then every 15 |
| Beach recycling | 50 | Year 5 then every 5 |
| Replace the timber groyne field 1 east of Dark Lane | 1,320 | Year 10 then every 40 |
| Replace the timber groyne field 2 | 440 | Year 15 then every 40 |
| Extension of the rock toe at Dark Lane | 30 | Year 2 only |
| Dark Lane sea wall repairs | 10 | Year 1 |
| Beach Management Plan | 10 | - |
| Annual maintenance of the sea wall and groynes | 13 | Annual |

Benefits of the Preferred Options

6.4.6 Table 6-18 provides a summary of the benefits for the preferred options for all frontages.

Table 6-18 Summary of benefits for preferred Strategy options

| Frontage | Climping and River Arun West Bank | | Elmer | Middleton | Bognor Regis and Felpham | Aldwick | Total |
|--------------------------------------|-----------------------------------|-------------------------------------|----------|-----------|--------------------------|----------|---------|
| | Legal frontage | Non legal frontage and River Arun | | | | | |
| Preferred option | Do Minimum (Legal) | Do Minimum (coast)/ Sustain (river) | Maintain | Maintain | Maintain | Maintain | - |
| PV property damages avoided (£k) | - | 25,436 | 46,199 | 19,698 | 12,923 | 1,884 | 106,140 |
| PV asset protection benefits (£k) | - | 1,203 | 322 | 16,397 | 22,006 | 13,224 | 53,152 |
| PV traffic benefits (£k) | - | 2,411 | 0 | 16 | 0 | 0 | 2,427 |
| Human intangible benefits (£k) | - | 0 | 1,066 | 2,460 | 1,256 | 601 | 5,383 |
| Agricultural benefits (£k) | - | 338 | - | - | - | - | 338 |
| Risk to life (£k) | - | 14,259 | 30,391 | 7,667 | 9,861 | 3,034 | 65,212 |
| PV benefits to Bognor Reef SSSI (£k) | - | 0 | 0 | 0 | 0 | 23 | 23 |
| Total PV benefits (£k) | - | 43,648 | 77,978 | 46,238 | 46,046 | 18,765 | 232,675 |

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6.5 Summary of (Preferred Strategy) Recommendations

6.5.1 Table 6-19 summarises the PV and cash costs for the preferred options.

Table 6-19 Summary of Preferred Strategy (needs based) (no Inflation)

| Frontage | Climping and River Arun West Bank | | Elmer | Middleton | Bognor Regis and Felpham | Aldwick | Total |
|---|-----------------------------------|-------------------------------------|-----------------|--------------|--------------------------|----------------|---------|
| | Legal frontage | Non legal frontage and River Arun | | | | | |
| Preferred option | Do Minimum (Legal) | Do Minimum (coast)/ Sustain (river) | Maintain | Maintain | Maintain | Maintain | - |
| Current Standard of protection %AEP (return period) | n/a | 10 (1 in 10) | > 0.2 (1in 500) | 20 (1 in 5) | >0.2 (1 in 500) | 12 (1 in 8) | - |
| Future Standard of protection %AEP (return period) | n/a | 10 (1 in 10) | > 0.2 (1in 500) | 100 (1 in 1) | >0.5 (1 in 200) | 5 ** (1 in 20) | - |
| PV costs (£k) | | | | | | | |
| Capital costs | 911 | 7,040 | 2,148 | 6,524 | 5,575 | 3,027 | 25,175 |
| Non Capital costs | 3,425 | 1,772 | 1,304 | 4,907 | 6,927 | 674 | 19,036 |
| Optimism Bias* | 1,734 | 3,525 | 1,381 | 4,572 | 5,001 | 1,850 | 18,054 |
| Total PV costs | 6,070 | 12,337 | 4,834 | 16,003 | 17,503 | 5,550 | 62,266 |
| Cash Costs (£k) | | | | | | | |
| Capital costs | 2,970 | 13,765 | 6,300 | 19,442 | 15,937 | 10,665 | 69,079 |
| Non Capital costs | 11,886 | 5,541 | 4,595 | 17,000 | 24,000 | 2,310 | 65,342 |
| Optimism Bias* | 5,943 | 7,722 | 4,358 | 14,577 | 15,975 | 6,488 | 55,066 |
| Total cash costs | 20,799 | 27,028 | 15,253 | 51,019 | 55,912 | 19,463 | 189,487 |
| Benefits (£k) | | | | | | | |
| PV Benefits | 0 | 43,648 | 77,978 | 46,238 | 46,046 | 18,765 | 232,675 |
| Benefit cost ratio | - | 3.5 | 16.1 | 2.9 | 2.6 | 3.4 | 3.7 |

* Optimism Bias at 50% for Aldwick and 40% for the remainder of the frontages.

** The Maintain option over the 100 year period will prevent erosion of the frontage. The beach management investment will also serve to mitigate the overtopping issues and provide a more consistent SoP across the whole frontage of 5%AEP in 100 years time.

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7. Implementation

7.1 Funding the Strategy

7.1.1 Earlier in this Strategy report, we have recommended preferred options based on technical, economic and environmental assessment without full consideration of affordability or availability of current revenue or capital money. In this section, we investigate the indicative Flood and Coastal Risk Management Grant in Aid (FCRM GiA) that could be available in accordance with Defra's Partnership Funding policy. We define the initial capital investment recommended for each frontage, assess the Partnership Funding Score and determine the range of contribution required for works to progress, depending on the annual threshold.

7.1.2 We have assessed the 'needs based' preferred options using the Partnership Funding calculator (April 2012). Table 7-1 summarises the calculator outputs and provides an indication of the likely contributions needed. In accordance with Defra guidance, the Environment Agency generally prioritises the allocation of FCRM GiA funding to favour schemes with higher partnership funding scores. The score required to secure funding will vary from year to year according to what other projects are proposed on the programme. The last row in the Table indicates a range of contributions that may be required to secure FCRM GiA funding if the threshold is set at 100% or 150% but it is important to note that the threshold could be higher than 150%.

7.1.3 Unlike the property counts in Table 2.1, the OM2 and OM3 household counts in Table 7-1 are for residential property only and, for OM2, with above floor level flooding only. The Partnership Funding score for Elmer has been capped at 45% to account for the already approved construction funding for the Elmer Sands Surface Water Management Plan. The detailed assessments are presented in Appendix F for Elmer to Aldwick and Appendix P for Climping and the River Arun West Bank.

Table 7-1 Partnership Funding Summary

| Calculator Outputs | Climping and River Arun West Bank | Elmer | Middleton | Bognor Regis & Felpham | Aldwick |
|--|-----------------------------------|----------------|---------------|------------------------|---------|
| Duration of Benefits (Period of intervention; years) | 14 | 11 | 14 | 9 | 9 |
| PV Costs for duration of benefits (£k) | 6,457 | 2,086 | 6,107 | 4,326 | 389 |
| PV Costs for just the construction element (£k) | 5,397 | 1,521 | 3,509 | 1,770 | 112 |
| PV Benefit for duration of benefits (£k) | 13,142 | 22,350 | 7,331 | 4,959 | 1,495 |
| OM2 Total households with reduced flood risk | 166 | 106 | 124 | 0 | 8 |
| OM3 Total households with reduced erosion risk | 0 | 18 | 246 | 342 | 198 |
| OM4 Environmental benefits | 0 | 0 | 0 | 0 | 0 |
| Calculated "FCRM GiA Contribution" (£k) | 944 | 1,417 | 1,006 | 779 | 112 |
| "FCERM GiA Partnership Funding Score" (%) | 18 | 31 (45 capped) | 16 | 18 | 116 |
| Range of contributions (£k) required 100% to 150% (* or up to the maximum PV Cost) | 5,299 - 5,683 | 1,056 - 1,820 | 2,931 - 4,700 | 1,451 - 2,330 | 0 - 39 |

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- 7.1.4 Using the Partnership Funding calculator (April 2012) we have assessed the effect of the benefit changes presented in Table 6-9 on the likely contributions needed. The implication is an increase in the Partnership Funding Score to 18%, and an adjustment in the contributions required to achieve an adjusted score of 100% to £5,299k.
- 7.1.5 The period of intervention for River Arun West Bank is 14 years. During this time we recommend constructing linear defences from the river mouth to the footbridge in years three to four.
- 7.1.6 The proposed works on the Elmer frontage have an intervention period of 11 years. This includes rock revetment works and beach recharge in year three, and consideration of the need for the bund at Poole Place.
- 7.1.7 For the remaining frontages between Middleton and Aldwick, the period of intervention is 14 and nine years respectively. Works recommended in this period are replacement of the timber groynes at Middleton (year five), and extension of the sea wall at Bognor Regis (year four) and the rock toe at Aldwick (year two). Beach recharge is proposed at all these frontages.
- 7.1.8 Where the preferred economic and environmental option for a frontage has a PF score of less than 100%, the proposed works will be ineligible for FCRM GiA funding unless additional contributions are secured or cost reductions made. The Strategy appraisal has been unable to identify any alternative options that would attract greater funding. Therefore for many of the frontages, without significant contributions (around 85% of the cost of the works), implementation of the preferred option will be unaffordable, making adoption of a 'do minimum' approach to management of the frontage the only feasible outcome. Should external contributions subsequently be secured then this position can be reviewed.
- 7.1.9 The projects recommended by the Strategy are included in the Environment Agency's draft programme of flood and coastal erosion risk management schemes. For non-legal works, the timing of schemes is likely to depend on external contributions.

Approach to securing contributions

- 7.1.10 We considered potential sources for external contributions throughout the Strategy area. The residential nature of the frontages means that there are few major beneficiaries. The economic appraisal highlighted no single commercial beneficiary gaining more than 6% of the total benefits in any one flood cell. Local FCERM authorities will continue to seek funding opportunities to implement Strategy recommendations. Potential sources include local holiday parks and other businesses, relevant flood risk management authorities and private developers.
- 7.1.11 During the development of the Strategy, collaborative funding meetings were held with local residents at Climping. These meetings were instigated and chaired by the local MP. They discussed options and routes to source local contributions towards capital works.
- 7.1.12 We chose the best option for each frontage on the basis of the technical, economic and environmental appraisal. We then prepared and reviewed the partnership funding scores to identify a potential FCERM GiA eligibility and the amount of partnership funding required.
- 7.1.13 The funding implications of these options are presented in Table 7-1. Section 7.2.7 sets out the default position if the required partnership funding is not secured. This enables the Environment Agency (for Climping and River Arun West Bank), and our partners, Arun District Council (for all remaining frontages), to define and implement plans to gain funding.
- 7.1.14 The cash sums required, in 2015 prices, are summarised in Table 6-12 - 6-17 and given in present value in Table 7-1. Appendix Q sets out the cash sums required. The cash sums required will form the basis of the investment development plans, which will be pursued by the Environment Agency and Arun District Council under guidance from the Solent and South Downs Programme and Strategic Overview Team.

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7.1.15 The following funding sources are being pursued by the Environment Agency and Arun District Council:

- (i) Arun District Council within their Capital Programme;
- (ii) other national and local public funds including West Sussex County Council and Local Enterprise Partnership (Arun District Council are leading on this with support from the Environment Agency);
- (iii) Parish, District and Borough Councils who have begun precepts to accrue funds for Partnership Funding; and
- (iv) residents associations, landowners and the relatively few large businesses (mainly holiday parks) along the Arun to Pagham frontage.

7.1.16 Discussions regarding external funding opportunities between Risk Management Authorities and Environment Agency Area Management have taken place. These will be maintained and joint plans developed to secure contributions. Some details are included in the implementation plan section below.

7.2 Implementation Plan

7.2.1 We recommend that Beach Management Plans (BMPs) are initiated at the earliest opportunity, after approval of the Strategy to inform and assist in its implementation. The objective of the BMPs will be to improve the efficiency of planned investment by better determination of the extent and timing of future maintenance and scheme works required. BMPs will also act as a tool to monitor the environmental effects and implement mitigation measures of any adverse impacts of the work.

7.2.2 BMPs should consider management of beach materials and structures for the frontages defined in this Strategy, but should also take into account wider scale monitoring and management of beach (shingle) material. The highest priority for BMP production exists at Climping where works to meet the legal requirement and details of management actions on the 'Do Minimum', non-legal section should be defined.

7.2.3 We will analyse existing coastal process and annual monitoring data and seek to identify and programme works across the coastal frontages to include maintenance works to sea walls and groynes and re-profiling and recycling of the beach materials. In parallel to this, outputs from the BMP will be used to confirm the extent and timing of the Strategy recommended capital works over the next ten years including beach recharge for Elmer, Middleton, Bognor Regis and Felpham and Aldwick and for groyne works at Middleton.

7.2.4 Each BMP should consider how to engage local people, companies and organisations with interests in the plan. Where appropriate, interactions with other sources of flooding should be considered, with communication between all relevant flood and coastal risk management authorities. To ensure that local interests are represented and information can be sent to the right people at the right time, we encourage community forums such as flood action groups.

7.2.5 Each BMP should take into account effects of any legal restrictions or constraints on management practices. These may include environmental restrictions, historical covenants, regulating leases, and other legal requirements.

7.2.6 The Environment Agency will work in partnership with Arun District Council (with support and data from the Channel Coast Observatory) to initiate the BMPs. These Beach Management Plans are included in the Environment Agency's draft programme of flood and coastal erosion risk management work.

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Measures planned if schemes cannot be funded

- 7.2.7 If sufficient funding cannot be gained to implement the recommended 'needs based' schemes, maintenance works should continue subject to money being available for this. We must note here that funding for maintenance expenditure is also limited and may not be available if there are higher priority requirements elsewhere. Continued maintenance equates to the 'Do Minimum' options works described for each frontage.
- 7.2.8 In general, application of the Do Minimum option will have the greatest adverse impact at the existing vulnerable points along the Strategy frontages, where the defences are already deteriorating. Prolonged delays in investment will increase the flood risk from overtopping and failure of the defences leading to breach and flood inundation or erosion.
- 7.2.9 The wider impact of not implementing the schemes is that Environment Agency, Arun District Council and West Sussex County Council (as the Lead Local Flood Authority) will need to continue to raise public awareness of the flood risk and emergency planning issues, the benefits of registering with the Flood Warning Service and on self-help flood resilience measures. The 'needs based' implementation plan is described below for each frontage, and includes estimates of the impact of doing Minimum in the short term.

Climping and River Arun West Bank

- 7.2.10 For the Climping Legal frontage, Do Minimum (Legal) includes works to comply with the legal agreements.
- 7.2.11 For Climping non legal frontage, Do Minimum is the option recommended by the Strategy. This includes reactive 'patch and repair' maintenance works to the groynes, breastwork and beach crest to prolong the residual life, subject to maintenance funding being available. The Environment Agency will continue to engage with Natural England regarding any works undertaken on the Climping Frontage due to the presence of the Climping Beach SSSI.
- 7.2.12 At Climping, our work (Appendix P) has shown that successive storms in a single year can critically damage the existing defences. Once damaged, the defence becomes increasingly vulnerable and restorative action is required within a short timescale if the defences are to continue to be effective. The number of (damaging) cycles in a given year cannot be predicted with any certainty as it depends entirely on the occurrence and severity of storm activity.
- 7.2.13 Do Minimum will prolong the life of current defences, but will not include works to renew groynes and breastwork structures as they eventually wear out. The timing is as yet uncertain depending on the condition of the defence structures as well as the storm activity experienced. Our work has suggested that the remaining life of defences could be between 10 and 35 years, but could be significantly less.
- 7.2.14 We expect maintenance requirements at Climping to increase over time as the structures deteriorate. At some point, when the costs of maintenance outweigh the calculated economic benefits, or if there is a significant breach in the defences that makes the work no longer viable, the Environment Agency will not be able to commit further funds. At this point the Environment Agency will have to cease maintenance for the non-legal frontage at Climping.
- 7.2.15 This Strategy has prompted discussions with key stakeholders considering the future of the Climping coastal frontage. Suggestions have been made that the future of ongoing maintenance could be supported or influenced by;
- a) the future of the legal requirements on Climping legal frontage if this were to change;
 - b) the effect of development of River Arun West Bank recommended by the Local Plan which will require improvement of protection against coastal flood risk. The position of any new defences between Rope Walk and the coast will need to be considered;

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- c) any local contributions which could assist in prolonging the life of existing defences;
- d) Southern Water who will need to consider the optimum solution for protection of their assets, working with other FCERM authorities.

7.2.16 As the defences at Climping deteriorate, the Environment Agency will follow policy guidance on maintenance that is current and in force. Currently, this guidance is contained in the document titled 'How we review the maintenance of flood risk management assets'⁵. This incorporates current policy advice from Defra. Specifically it describes how we will engage with landowners and other affected parties where we have decided to stop maintaining uneconomic flood defences for the long term. Where we conclude that continued maintenance is no longer economically justified we will include our intent to stop maintenance in our regional maintenance programme. As required under Section 23 (1) of the Flood and Water Management Act 2010 we will consult the Southern Regional Flood and Coastal Committee (RFCC) and take into account any representations made by the Committee.

7.2.17 The Environment Agency's protocol for the maintenance of flood and coastal risk management assets sets out the process we will follow when we decide to stop, formally and permanently, our maintenance work. The points set out below illustrate how this point may be reached if work continues on an as-needs basis where maintenance funding availability doesn't constrain work done to meet the increasing requirement.

- a) The annual costs and benefits for work on the Climping and Arun West Bank flood cell can be considered using the Do Minimum option's BCR which is 3.5. The costs for this option of £20k p.a. are based on assessed historic maintenance practice. The BCR multiplied by the annual maintenance cost on the Climping non-legal frontage is approximately £70k.
- b) If the annual maintenance requirement rises and additional FCRM GiA funding is available, to a point where £70k is exceeded on a two year rolling basis, the BCR would be expected to fall below unity. This could trigger the point where it would become uneconomic for the Environment Agency to continue their maintenance works. The Environment Agency would then give notice to cease maintenance on the Climping beach non-legal frontage.
- c) The Environment Agency will stop maintaining the assets at the end of the notice period, which will be determined subject to site conditions, allowing a reasonable period for land and property owners to adapt and put alternative arrangements in place.
- d) Even in this case where maintenance increases are not limited by funding availability, there are potential circumstances in which the Environment Agency could not provide reasonable notice. This would happen if the defences fail unexpectedly (such as during a major storm) and it would be uneconomic for us to repair them. It is important that people who would be affected in case of such failure are aware that this situation could develop quickly.

7.2.18 The Environment Agency will keep people whose properties and land will be affected by the decision that further maintenance can no longer be justified, informed of ongoing maintenance expenditure and significant changes to the beach and defence structures. The effects and ongoing likelihood of defence failures (sudden and/or gradual) should be explored with owners and if appropriate, emergency plans agreed through Arun District Council.

7.2.19 The recommended Sustain option on the River Arun West Bank includes the construction and ongoing maintenance of raised linear defences from the river mouth to the A259. Two inland bunds at Rope Walk and along the south side of the A259 are also recommended to reduce the risk of outflanking, as shown in Strategy Key Plan 2. The appraisal for these works should also investigate opportunities for local realignments and tidal exchange schemes.

⁵ Protocol for the maintenance of flood and coastal risk management assets, (England only) Version 2 December 2013

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- 7.2.20 Delays to schemes on Arun West Bank will cause increasing flood risk as the defences south of the A259 deteriorate further. With an already low SoP further delays to investment would increase the risk of a breach occurring, flooding the marina and residential property in Rope Walk.
- 7.2.21 As noted in section 2 above, development has been suggested for Arun West Bank. We anticipate that if this does happen, it would incorporate measures to manage flood risk recommended by this Strategy. If and when the flood bank at Rope Walk is built, this will affect the economic case for continuing maintenance at the Climping non-legal frontage.
- 7.2.22 For Climping legal frontage, the Environment Agency will carry out works necessary to comply with the legal agreements. Without the legal agreements in place, there would be little economic justification for defences to be maintained and renewed here. If at any point the legal agreements cease to be in force, the Environment Agency will implement the relevant maintenance protocol in force at the time as described in this section above.

Elmer

- 7.2.23 The Strategy recommends that the current high SoP afforded by the rock islands and existing defences is maintained at Elmer. Works to the exposed embayment where the existing rock revetment requires additional toe protection and replacement of dislodged rock are proposed. Beach recharge and recycling as recommended by the original Elmer scheme should be undertaken periodically to maintain the embayment beaches.
- 7.2.24 The Maintain option includes construction of two inland bunds at Poole Place and in the vicinity of Ryebank House, as shown in Strategy Key Plan 2 to protect the residential areas of Elmer from potential outflanking. The recommendation is for the Poole Place bund to be constructed as part of the beach and rocks scheme in 2014/15 to provide a consistent SoP to Elmer. The timing of the Ryebank bund (2085) has been set to coincide with establishment of floodplain connectivity between Elmer and Climping for the 0.5% AEP (1 in 200) flood event and is subject to future sea level rise (refer to section 5.1).
- 7.2.25 Damage or disturbance to sensitive habitats from maintenance activities will be minimised through sensitive beach management practices, in consultation with the County Ecologist where the activities take place within Elmer Rocks SNCI.
- 7.2.26 If external contributions are not forthcoming, the resultant application of the Do Minimum option would mean the beach and rock revetment will continue to degrade. Providing the revetment can be reformed as necessary and with localised beach profiling, it is estimated that the Do Minimum could extend the life of the defences by ten years when compared to the Do Nothing scenario.

Middleton

- 7.2.27 The Strategy recommends maintaining the current level of protection at Middleton. To achieve this, the Strategy recommends investment to replace the existing failing groyne field in the next five years with progressive replacement throughout the Strategy period. Annual beach management through recycling and maintenance and a beach recharge every ten years is recommended. The existing sea walls are generally in good to fair condition with some short lengths of timber breastwork requiring immediate maintenance attention. Providing the beach management measures can be put in place, re-building the existing sea wall should not be required.
- 7.2.28 Damage or disturbance to sensitive habitats from maintenance activities will be minimised through sensitive beach management practices, in consultation with the County Ecologist where the activities take place within Middleton Shingle SNCI. The beach profiles will be monitored and the Risk Management Authorities will work with residents and other stakeholders to adapt to the effects of climate change.

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7.2.29 Under Do Minimum, ongoing maintenance works would aim to minimise, as best possible, further loss of the beach which already requires recharge in the absence of the timber groynes being replaced. Continued loss of beach material would increase the risk of undermining and failure and breach of the sea wall defences. It is estimated that the Do Minimum could extend the life of the defences by ten years when compared to the Do Nothing scenario.

Bognor Regis and Felpham

7.2.30 The Strategy recommends maintaining the existing SoP at Bognor Regis and Felpham. Replacement of the existing groyne fields is recommended along with annual beach recycling and periodic beach recharge. Delivery of this is reliant on Natural England assent to recycle beach material through the Felpham and Bognor Reef SSSI.

7.2.31 The existing sea walls are generally in good to fair condition with some short lengths requiring maintenance attention. The sea walls are durable and providing there is ongoing maintenance and the beach management measures are put in place, extensive re-building should not be required.

7.2.32 The Aldingbourne Rife outfall is primarily a gravity flow with over pumping triggered when tide locking of fluvial water risks the occurrence of flooding. The pumping station has been included as a coastal asset in the Strategy and allowances for annual maintenance and future replacement of the pumps have been included in the relevant option costs.

7.2.33 Damage or disturbance to sensitive habitats from maintenance activities will be minimised through sensitive beach management practices, in consultation with the Natural England where beach recycling activities take place within Felpham and Bognor Reef SSSIs. The beach profiles will be monitored and the Risk Management Authorities will work with residents and other stakeholders to adapt to the effects of climate change.

7.2.34 For Bognor Regis and Felpham a majority of the coastal defences have a residual life in excess of ten years. The main concern for this frontage is loss of beach material adjacent to the Aldingbourne Rife Outfall. At this vulnerable point loss of beach material could eventually lead to failure and breach of the outfall and tidal flood inundation propagating up the Aldingbourne Rife as well as fluvial flooding through the rife system because of pump failure. It is estimated that the Do Minimum option could extend the life of the defences by 20 years when compared to the Do Nothing scenario.

Aldwick

7.2.35 The Strategy recommends maintaining the existing defences at their current levels at Aldwick. This will require investment to replace the existing groyne fields, annual beach monitoring and recycling and periodic beach recharge as shown in Table 6-10. Delivery of this is reliant on Natural England assent to recycle beach material through the Bognor Reef SSSI.

7.2.36 If funding isn't available for Aldwick, the principal risk is from erosion as a result of failure of the sea wall at Dark Lane with flooding from wave overtopping a secondary concern. Providing the rock revetment can be reformed and the beach re-profiled, it is estimated that the minimum maintenance option could extend the life of the defences by ten years when compared to the Do Nothing scenario.

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7.3 Delivery Risks

High Level Risk Register

7.3.1 Once approval is gained for the Strategy, funding our recommendations is the overriding issue for its implementation. Table 7-4 below identifies the high level risks for the implementation of the Strategy, and mitigation measures.

Table 7-2 High Level Risk Schedule and Mitigation

| Key Project Risk | Mitigation Measure |
|--|--|
| Insufficient external funding to enable recommended new schemes to proceed as scheduled. | Work with stakeholders and communities to seek funding contributions. Carry out Do Minimum maintenance as long possible and practical and funding is available. Keep affected people informed as well as Regional Flood and Coastal Committee and Arun District Council's cabinet. |
| Maintenance works limited by funding availability increasing risk of asset failure. | Monitor. Inform Regional Flood and Coastal Committee and Arun District Council Cabinet. Provide practical support and advice to communities regarding resistance measures. Ensure emergency plans take account of developing situation. |
| Landowners object to works being undertaken. | Early and regular engagement with the affected landowners. Gain Planning Authority support. Seek funding and in-kind support from communities and landowners. |

Appendices

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| APPENDIX B | LIST OF REPORTS PRODUCED |
| APPENDIX C | STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) ENVIRONMENTAL REPORT INCLUDING APPENDICES AND ADDENDUM |
| APPENDIX D | ARUN DISTRICT COUNCIL CORRESPONDENCE |
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