



# Long List Options Report

Langstone Flood & Coastal Erosion Risk Management  
Scheme

East Solent Coastal Partnership

60578525

August 2018

Eastern Solent Coastal Partnership  
C/O Havant Borough Council  
Southmoor Office & Depot  
2 Penner Road  
Havant  
PO9 1QH

## Quality information

Prepared by	Checked by	Approved by
<b>Ben Taylor / Byron Ottey</b> Consultant / Intern	<b>Jonathan Short</b> Associate	<b>Peter Mansell</b> Technical Director

## Revision History

Revision	Revision date	Details	Authorized	Name	Position
Version 1	13/08/2018	Interim unapproved draft release to inform workshop discussion	JCAS	Jonathan Short	Associate
Version 2	17/08/2018	Updated version following workshop	JCAS	Jonathan Short	Associate

## Distribution List

# Hard Copies	PDF Required	Association / Company Name

**Prepared for:**

Eastern Solent Coastal Partnership  
C/O Havant Borough Council  
Southmoor Office & Depot  
2 Penner Road  
Havant  
PO9 1QH

**Prepared by:**

AECOM Infrastructure & Environment UK Limited  
Midpoint  
Alencon Link  
Basingstoke  
Hampshire RG21 7PP  
UK

T: +44(0)1256 310200

© 2018 AECOM Infrastructure & Environment UK Limited. All Rights Reserved.

**Limitations**

AECOM Infrastructure & Environment UK Limited ("AECOM") has prepared this Report for the sole use of Isle of Wight Council ("Client") in accordance with the Agreement under which our services were performed. No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by AECOM. This Report is confidential and may not be disclosed by the Client nor relied upon by any other party without the prior and express written agreement of AECOM.

The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by AECOM has not been independently verified by AECOM, unless otherwise stated in the Report.

The methodology adopted and the sources of information used by AECOM in providing its services are outlined in this Report. The scope of this Report and the services are accordingly factually limited by these circumstances.

AECOM disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to AECOM's attention after the date of the Report.

Certain statements made in the Report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. AECOM specifically does not guarantee or warrant any estimate or projections contained in this Report.

© This Report is the copyright of AECOM Infrastructure & Environment UK Limited. Any unauthorised reproduction or usage by any person other than the addressee is strictly prohibited.

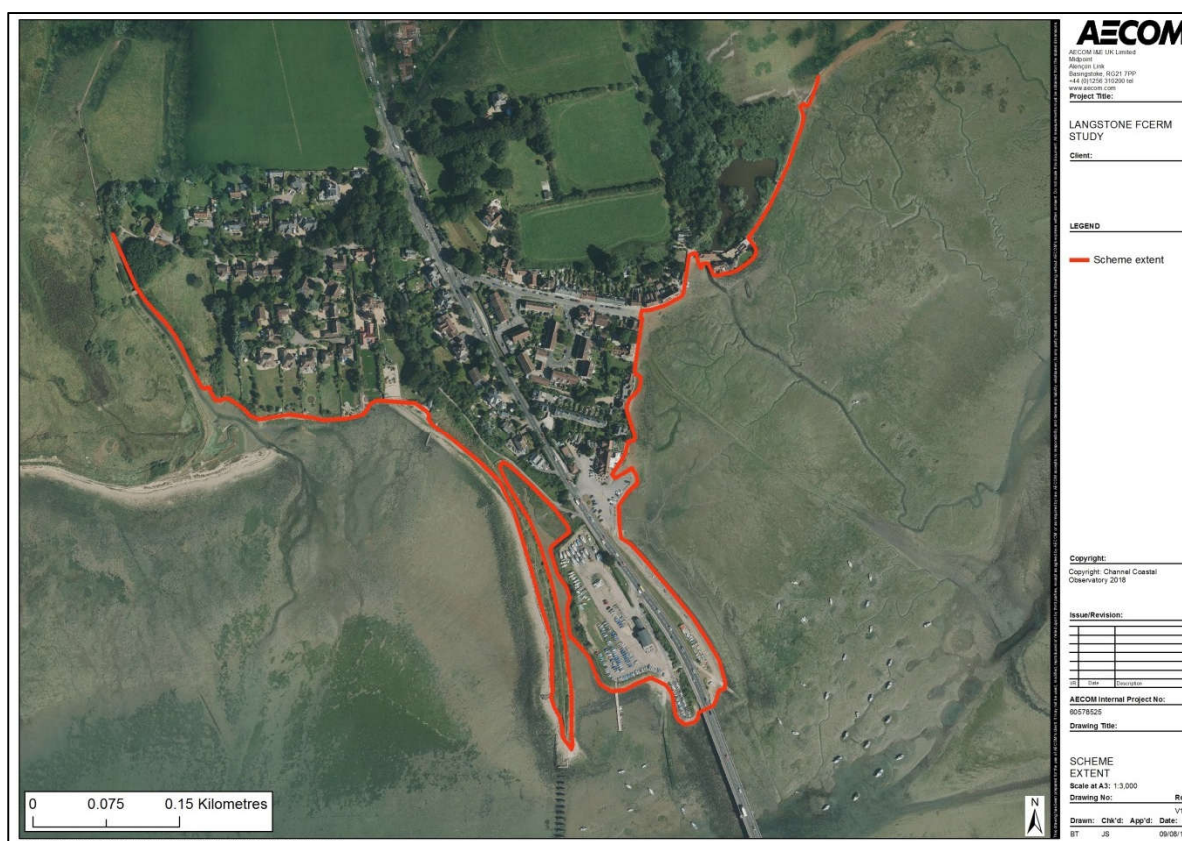
## Table of Contents

1.	Introduction .....	5
1.1	Background .....	5
1.2	Strategic context .....	5
1.3	Flood risk .....	5
1.4	Placemaking opportunities .....	6
1.5	Purpose of this report .....	6
1.6	Management options and potential measures .....	6
1.7	Study units .....	6
2.	Potential Measures .....	8
2.1	Measures for Do Minimum .....	8
2.2	Measures to Maintain .....	8
2.3	Measures for Sustain / Improve .....	9
2.4	Frontage wide measures .....	11
2.5	Advantages / Disadvantages .....	13
3.	Unit 1 (Langstone West) .....	21
3.1	Do Nothing .....	21
3.2	Do Minimum .....	21
3.3	Maintain .....	21
3.4	Sustain / Improve .....	21
3.5	Initial ideas for scheme alignments .....	22
4.	Unit 2 (Sailing Club and Langstone Spit) .....	23
4.1	Do Nothing .....	23
4.2	Do Minimum .....	23
4.3	Maintain .....	23
4.4	Sustain / Improve .....	23
4.5	Initial ideas for scheme alignments .....	24
5.	Unit 3 (Langstone East) .....	25
5.1	Do Nothing .....	25
5.2	Do Minimum .....	25
5.3	Maintain .....	25
5.4	Sustain / Improve .....	25
5.5	Initial ideas for scheme alignments .....	26
6.	Unit 4 (Mill and Millpond) .....	28
6.1	Do Nothing .....	28
6.2	Do Minimum .....	28
6.3	Maintain .....	28
6.4	Sustain / Improve .....	28
6.5	Initial ideas for scheme alignments .....	29
7.	Indicative defence heights .....	30

# 1. Introduction

## 1.1 Background

AECOM were commissioned by the East Solent Coastal Partnership (ESCP) to undertake an option appraisal study and develop an outline design and business case for a tidal flood risk management scheme at Langstone. The 1km Langstone frontage is within the jurisdiction of Havant Borough Council (HBC) and located on the mainland, immediately to the north of Hayling Island. At the site a number of residential properties as well as two public houses are located within a few metres of the water's edge. The study location forms part of a wider flood cell which also covers the adjacent Southmoor frontage to the west.



## 1.2 Strategic context

The 2010 North Solent Shoreline Management Plan policy for the frontage is to 'Hold the Line' for the next 100 years with potential for 'Managed Realignment' at Southmoor. The subsequent Portchester to Emsworth Flood and Coastal Erosion Risk Management Strategy (2011, herein referred to as PEMS) which was adopted by HBC recommends improving the defences at Langstone to a minimum 1:75yr (1.3% AEP) standard of protection through a phased approach.

In addition to the FCERM context of the Langstone frontage, the key A3023 road to Hayling Island passes through the site. The Local Plan review for HBC identified the potential for significant housing development on Hayling Island (>1000 properties by 2036) but this is likely dependant on a flood defence scheme at Langstone to protect access on, to and off the island during extreme flood events. Protection of the A3023 road to a 1:200yr (0.5% AEP) standard of protection is required by the National Planning Policy Framework (NPPF) to ensure safe access and egress is maintained. The Langstone scheme is therefore an essential element in supporting the planned housing development sites on the Island.

## 1.3 Flood risk

PEMS identified that 56 residential properties and 3 non-residential properties are currently at risk of tidal flooding from a 1:200yr return period event. Due to sea level rise, in 100 years' time 81 residential properties and 5 non-

residential properties are expected to be at risk from the same return period event. There is a discrepancy between the number of properties identified to be at risk within PEMS and those deemed to be at risk based on the latest EA flood mapping (2017) which suggests that 103 residential properties are at risk from present day from a 1:200 year event. This discrepancy is to be investigated as part of this study.

## 1.4 Placemaking opportunities

Placemaking is a multi-faceted approach to the planning, design and management of public spaces. The intention of placemaking is to create public spaces that promote people's health, happiness and wellbeing. The public space at the Langstone frontage, particularly along the Solent Way pathway between the Royal Oak and The Ship Inn, is highly valued by local residents for its character and footpath access. Whilst it is not a measure to reduce flood risk, placemaking is an important consideration in the development of options at the study site and will be considered throughout the option development and appraisal process.

A range of placemaking opportunities may exist depending on which option is identified as the preferred option. Placemaking may involve large scale landscaping across the frontage, or it may involve alternative small scale methods such as improved signage in the area and education boards. A wide variety of placemaking approaches will be considered during the option appraisal process.

## 1.5 Purpose of this report

This report details the development of the long list of options which is the first part of the option appraisal process. In developing the long list all potential defence measures to implement various management options have been considered to ensure that no possible approaches have been overlooked. The long list is wide ranging and through the option appraisal process the different measures identified in the long list will be scoped and reduced down to a short list of options and then finally to a preferred option.

In developing the long list all of the options have been considered consistently across the frontage. Aspects such as underground services, likely costs and benefits, placemaking, environmental designations and community support will feed into the next stage of the appraisal in developing the short list of options. In addition, more detail will be added to the options as the project moves through the option appraisal process.

## 1.6 Management options and potential measures

The preferred management option for the frontage that was identified in PEMS is to improve the defences to a 1:75yr standard of protection through a phased approach. As part of the appraisal process this option will be reassessed and confirmed. A number of alternatives exist, such as doing nothing, doing minimum, maintaining the defences and sustaining the existing standard of protection of the defences over time to keep pace with sea level rise.

In order to implement the preferred management option a number of different defence measures could be used, either separately or in conjunction with one another. Some examples of generic defence measures are construction of a seawall, beach nourishment, a setback floodwall etc. Defence measures may be phased through time to deliver the option and may not necessarily be implemented from present day. As part of the option appraisal process the various measures and combinations of measures to deliver options will be considered. At the long list stage of the process it has been the intention to identify the full range of measures to potentially implement a preferred management option at the study site.

## 1.7 Study units

The frontage has been broken down into 4 study units to facilitate the development and appraisal of options. These are presented in Figure 1-1 and are as follows:

- Unit 1: Langstone West, between the east bank of the Langbrook Stream to the edge of the formal defences and slipway at the northern end of Langstone Spit
- Unit 2: Sailing club and Langstone Spit, including the spit, sailing club and defences to the Ship Inn car park
- Unit 3: Langstone east, between the Ship Inn car park and the Mill
- Unit 4: Mill and Mill pond, between the Mill and the slipway to the north east of the Mill pond.



---

## 2. Potential Measures

---

This section provides a brief description of potential measures which could be implemented at the study site.

In the development of options a variety of alignments, standards of protection (SoP) and combinations of the different measures will be considered. The measures may need to be phased or sequenced through time to deliver different management options.

### 2.1 Measures for Do Nothing

#### No Active Intervention

With this approach the existing defences would be abandoned in terms of maintenance and repair, and no remedial or additional works would be carried out. In addition, adaptation to sea level rise or other climate change responses would not be addressed. Under this scenario the existing defences along the frontage would fail at the end of their residual life and the properties immediately behind the defences would be at increased risk of structural damage, undermining or collapse. Flood risk would be unmanaged and would increase significantly over time, resulting in much of the area becoming uninhabitable in the future.

### 2.2 Measures for Do Minimum

#### Patch and repair / small scale maintenance

This measure involves reactive repairs or maintenance of the existing defence structure to ensure health and safety compliance. This measure is small scale, for example replacing a small number of lost bricks in a masonry structure, and does not allow for capital interventions such as large scale refurbishment or full replacement of the existing defences. This measure is unlikely to significantly improve the residual life of a structure and is appropriate for use in a Do Minimum management option. However it is unlikely to be suitable for a more formal longer term maintenance option.

### 2.3 Measures to Maintain

#### Capital refurbishment / maintenance

This measure involves the proactive repair and larger scale improvement of the current defences. Refurbishments will significantly increase the residual life of the defence and could involve, for example, a seawall encasement, concrete spraying or like for like replacement of an existing masonry wall. The capital refurbishment is suitable for the Maintain option but by itself it will not increase the SoP of a defence as no raising would be undertaken. Refurbishment could be undertaken alongside a raising measure (such as crest raising) to improve the SoP of a defence.

#### Localised erosion protection

This measure involves the placement of erosion protection measures at applicable locations to help bolster existing defences. This could be concrete bags, an armourlock surface, rock armour or gabions. This measure is an approach to potentially extend the residual life of a structure but can't be used to reduce flood risk as it does not involve raising the height of any of the defences. This measure is therefore appropriate for the maintain option but not sustain or improve. Suitable locations for this measure along the frontage could be on Langstone spit which is at risk of breaching.

#### Beach recycling/ management

This measure involves moving some of the existing beach sediment to areas of the beach that are prone to erosion, without the sediment being outsourced. This measure could potentially be used along Langstone spit but is unlikely to be suitable elsewhere in the study area.



## 2.4 Measures for Sustain / Improve

### Crest raising of existing defences

This measure involves raising the crest level of the existing defences by raising the crest level of the structures. This could be done by constructing a new vertical capping beam / parapet wall on top of the existing defence. Along sections of the frontage this measure may not be favourable from a conservation and visual perspective but it would provide a robust defence against flooding.

### Setback floodwall

Construction of a new setback floodwall has the potential to improve the level of protection against flooding along the frontage. This is likely to be a reinforced concrete structure but alternative structure types could be considered. A setback floodwall could be located a few metres back from the existing defences, for example, at the back of a footpath, or could also be located much further back if a feasible route can be identified.

### Glass floodwalls

This measure involves raising the height of the existing structures, or constructing a setback structure, using reinforced glass panels. This approach is potentially less visually obtrusive than traditional flood wall structures and will help to preserve views of the harbour area and foreshore from the coastal footpath. Glass floodwalls are likely to be more expensive than traditional flood wall alternatives, adding an additional £1.5-3k of cost per m length of defence.

### Self-raising flood walls

Self-raising floodwalls or barriers are an innovative solution that require no human intervention or power to be deployed. Under normal conditions the floodwall would not be visible, stored either on the ground or beneath ground level. During flood conditions the floodwall design uses the approaching floodwaters to automatically raise the structure. The automatic operation, along with its minimal footprint with no need for steps or ramps makes this type of defence ideas for sites where the aesthetic considerations mean that a permanent raised defences are not acceptable. The walls or barriers are typically available in 5-10m long sections, up to 2.5m high. Multiple units can be linked together to form a continuous defence, with permanent or removable connecting posts. The space requirements and ground conditions suitable for this measure are likely to be a limiting factor at the site, as is cost with approximate costs for this type of defence approximately £20k per m length. However, this measure has been considered in the long list as it provides a viable alternative to permanent raised defences.

### Temporary barriers

A temporary flood barrier is one that is installed as the need arises (when high tidal water levels are forecast). Deployment of the temporary barriers would provide an improved standard of protection compared to the existing defences but the standard is typically defined by the height of the barriers that are available to the consumer and underlying ground levels. Barriers are provided in sections typically 5-10m in length and these can be joined together to form a continuous defence. The alignment of temporary defences can be altered depending on the flood conditions.

### Demountable flood walls

Demountable flood defences are a particular form of temporary defences that require built-in parts (i.e. connection posts) and therefore can only be deployed in one specific location. Demountable defences are typically used where a permanent defence is unacceptable, usually because of the visual intrusion and loss of amenity that a permanent defence would entail.

Both temporary and demountable defences require a considerable amount of pre-planning to ensure that they can provide an effective defence. It is essential that the operational resources, storage facilities and the logistics of deployment are fully appreciated by those responsible to deploying the defences.

### Reinforce de-facto defences, boundary walls and flood proof buildings

In sections along the frontage there are boundary and building walls behind the frontline defences which act as a second line and de-facto defence against high water levels. Whilst these walls provide a flood defence function, typically they would not have been designed to act as a formal flood defence and are far more likely to be at risk

of failure. In addition, there are numerous gaps between the walls which provide flow pathways for water to pass through into the land behind. A potential measure along the frontage would be to reinforce and modify the de-facto defences and to flood proof building walls. This measure has been included as a long list measure but the technical feasibility of this approach would need to be explored further if it is taken forward.

#### Flood gates

This measure involves installing a flood gate, often as part of a new defence alignment. The gate would be left open during normal conditions to allow continued access and visibility in key areas. However, during flood conditions the gate would be closed to form a flood defence. Flood gates are typically used in areas where access is essential and a suitable defence alignment cannot be identified around the access area, for example, slipways, roads or footpaths.

#### Wave return wall

This measure involves construction of a wave return wall on the crest of the existing defences. A wave return wall is a curved structure at the top of a defence which will help to reduce the wave overtopping risk and reduce the quantity of flood water passing over the defences during overtopping events.

#### Setback embankment

Construction of a new setback embankment could be used to improve the level of protection along the frontage. This measure would not be suitable across the full length of the frontage due to space constraints but may be a favourable approach in parts of Units 1, 2 & 3, particularly for tie-ins to higher ground.

#### Land raising

This measure involves the physical raising of the land along the frontline defences or even set back behind the existing defences. This could be a suitable measure in areas such as the car park adjacent to the Ship Inn.

#### Road raising

This measure involves the physical raising of roads / parts of roads that could form a physical barrier to flood waters and improve the standard of protection provided to an area. At the study site this could potentially involve raising parts of the A3023 or Langstone High Street. Inland from the Langstone frontage the A3023 could be raised to essentially split the flood cell from west to east and support a scheme either side of the road.

#### Concrete revetment / seawall

Construction of a new concrete revetment or seawall along the frontage to replace existing defences. A seawall is a vertical hard defence measure whilst a revetment is a sloped structure. Both measures are likely to be very costly and lead to encroachment into the foreshore area.

#### Sheet piling with capping beam

This measure involves piling sheet piles either in-front of the existing defences, in their place or behind along the footpath. The piles could be fitted with a capping beam improve the appearance. This approach is likely to be technically challenging due to unknown ground conditions and space constraints and could also lead to foreshore encroachment.

#### Beach nourishment

This measure involves increasing the level of sediment along the frontage. Beach nourishment could be carried out in a number of ways but is most likely to involve sediment being deposited onto the beach by heavy machinery or an offshore dredging vessel. This measure could potentially be used along Langstone spit but is unlikely to be suitable elsewhere.

#### Beach groynes

This measure involves the construction of groynes along a beach to help capture material and retain beach levels. This can improve the beach's ability to protect from wave attack due to the increased material. This measure could potentially be undertaken along Langstone spit but is unlikely to be appropriate elsewhere within the study site.

#### Property Level of Protection (PLP)

This option involves utilising property level protection (PLP) measures to reduce the flood risk to properties behind the existing defences or improving the current property protection that may be in place. The purpose of PLP is to help keep flood water out of properties and methods include flood proofing vents and installing small scale demountable barriers in front of doorways.

PLP is a cost-effective and easy to implement tool for homeowners to take more effective action to manage their flood risk. However, there are a number of limitations and the measures do not always perform as intended. Typically PLP can provide protection from flooding to individual properties up to around 600mm depth of water (although greater depths could potentially be accommodated through use of customised flood barriers). Above this depth, PLP is generally not considered to be an effective solution. In addition, there are often problems associated with installation, operation, maintenance and storage which can lead to poor performance.

#### Property Level Resilience (PLR)

This option involves improving the resilience of properties to flooding. This may involve moving electricity sockets to higher locations, installing wooden floors rather than carpets and moving valuable items upstairs or to higher locations. This measure can often be undertaken alongside PLP.

#### Vegetated buffer zones

A buffer zone is a land area adjacent to the frontline defences or shoreline that would be vegetated with native shoreline species and which acts as a natural transition zone between the coast and inland developments. A vegetated buffer zone would help to reduce wave energy and potentially reduce overtopping rates. Steps to create a buffer zone would involve seeding, planting and potentially depositing material to encourage saltmarsh growth in intertidal areas.

## 2.5 Frontage wide measures

This section outlines the potential measures which could be used on a frontage wide scale, providing protection or flood risk mitigation across all the study units. These measures are not included in the unit by unit long list outlined in Chapters 3 to 6 but still form part of the long list of measures for the frontage as a whole. These measures will be taken forward and considered further in the long list appraisal.

#### Tidal flood barrier

A potential measure which could be implemented to reduce the tidal flood risk at the study site would be the construction of a tidal flood barrier(s). This measure has been suggested during early consultation with the community and has therefore been considered in the long list of potential measures. There are a number of locations where a tidal barrier could be located and if this measure were to be taken forward from the long list a detailed feasibility assessment would be required to consider the alternatives. Any potential tidal barrier solution is likely to be extremely expensive and it is unlikely that it would be fundable based on the benefits of the Langstone site alone. In addition, to protect the Langstone site it could also be necessary to construct two separate tidal barriers, one in Langstone Harbour and one in Chichester Harbour as both would be required to prevent outflanking of the other and to reduce flood risk at the site. A tidal barrier is also likely to have significant environmental and access constraints.

#### Lagoon

A potential measure which could be used to reduce flood risk would be to construct a ring of impermeable offshore breakwaters around the frontage. This would create a sheltered lagoon which would protect from tidal surge and waves. A water level control system could be included in the structure via a series of gates to allow the water levels in the lagoon to rise and fall under normal tidal conditions; however, the gates would be closed during periods of increased risk to protect the frontage from flooding. There are a number of constraints associated with this measure, most notably a very high cost, construction in environmentally designated areas and access limitations to the shoreline.



#### Community preparedness and resilience




Improving the preparedness and resilience of the community is a measure which can be undertaken alongside other measures (for example, alongside new defences). Methods to improve the community preparedness and resilience could include improving flood warning systems and developing community evacuation plans. This measure could be delivered across the whole study area.




### Relocation




Should a flood risk management solution not be implemented at the frontage it is likely that there could be a significant risk to life from flood events. This is in addition to the risk to properties and other assets along the frontage which could lead to the area becoming uninhabitable. The risk is expected to increase in the future due to sea level rise. A potential solution to this would be to relocate the community to an alternative location. This measure is considered to be a last-resort given the importance of the area to the community and from a cultural and environmental perspective. However, should no solution be implemented in the appraisal period it could be considered in the decision making process.

## 2.6 Advantages / Disadvantages




Measure	Advantages	Disadvantages	Picture examples	Units included in
Patch and repair / small scale maintenance	<ul style="list-style-type: none"> <li>– Relatively inexpensive</li> <li>– Focus resources on at risk areas</li> </ul>	<ul style="list-style-type: none"> <li>– Reactive – no proactive attempts of improvements</li> <li>– Does not minimise probability of failures from occurring</li> <li>– Does not reduce flood risk</li> <li>– Health and safety risks associated with defences failing</li> </ul>		1, 2, 3 & 4
Capital refurbishment / maintenance	<ul style="list-style-type: none"> <li>– Proactive – extend the design life of structure</li> <li>– Potentially lower cost compared to construction of new structures</li> <li>– Focus resources on at risk areas</li> <li>– Typically no significant environmental impacts whilst working with existing structures (although encroachment may become an issue)</li> </ul>	<ul style="list-style-type: none"> <li>– Lower cost approaches (such as concrete spraying) may not have as long a service life as new structures</li> <li>– Does not include crest raising – not improving the SoP</li> </ul>	 <p>Langstone quay wall refurbishment</p>	1, 2, 3 & 4
Localised erosion protection	<ul style="list-style-type: none"> <li>– Focus resources on at risk areas or erosion</li> <li>– Proactive works</li> <li>– Increases the residual life of the current structure</li> </ul>	<ul style="list-style-type: none"> <li>– The choice of lower cost approaches may not be sufficiently effective.</li> <li>– The protection does not increase the SoP.</li> <li>– Could impact access</li> <li>– Would impact visual aesthetics of the area</li> </ul>	 <p>Gabions for erosion protection</p>	2



Measure	Advantages	Disadvantages	Picture examples	Units included in
Beach recycling/ management	<ul style="list-style-type: none"> <li>- Soft' management approach</li> <li>- Potential benefit for recreation / tourism in the area</li> <li>- Relatively inexpensive per cycle, although regular repetition needs to be allowed for.</li> <li>- Improves the beach's ability to protect from wave energy</li> </ul>	<ul style="list-style-type: none"> <li>- By moving sediment from one area to another, potential for the source area to have reduced beach levels</li> <li>- Continuous monitoring and maintenance</li> <li>- Likely to require repetitive interventions</li> <li>- It is likely that it will need to be combined with other beach management measures to prolong effectiveness</li> <li>- Potential environmental impacts – at both the removal and deposit sites.</li> </ul>	 <p>Hayling Island beach recycling (ESCP)</p>	2
Crest raising of existing defences	<ul style="list-style-type: none"> <li>- Will increase the SoP against flooding</li> <li>- Lower cost relative to construction of an entirely new structure</li> <li>- Requires little maintenance after completion</li> <li>- Potential for construction of glass walls to limit visual impacts</li> </ul>	<ul style="list-style-type: none"> <li>- Does not increase condition of existing defences and likely that a refurbishment will also be needed in some locations to prevent erosion</li> <li>- Could impact landscape and views in the area</li> </ul>	 <p>Sandown (Isle of Wight) crest raising</p>	1, 3 & 4
Setback floodwall	<ul style="list-style-type: none"> <li>- Will increase the SoP against tidal inundation</li> <li>- Long service life</li> <li>- Setback location less likely to impact views and landscape in the area</li> </ul>	<ul style="list-style-type: none"> <li>- Being set back from the frontline it will not improve the condition of the existing defences - likely that a refurbishment will also be needed in some locations to prevent undermining. No erosion prevention benefits.</li> <li>- Could impact access and services</li> <li>- Potentially high cost</li> <li>- Environmental impact if the floodwall is setback on designated land.</li> </ul>	 <p>Setback floodwall (Bristol)</p>	2, 3 & 4




Measure	Advantages	Disadvantages	Picture examples	Units included in
Glass floodwalls	<ul style="list-style-type: none"> <li>- Much reduced visible impairment from having increased level</li> <li>- Increased SoP</li> </ul>	<ul style="list-style-type: none"> <li>- Higher cost alternative to traditional flood walls</li> <li>- Public's opinion and concerns of using glass as a flood protection material may not be positive</li> </ul>	 <p>Glass floodwall (Flood Control International)</p>	1, 3 & 4
Self-raising flood walls	<ul style="list-style-type: none"> <li>- No visible flood defence when it is not required</li> <li>- No pre-planning required to set up the defence</li> </ul>	<ul style="list-style-type: none"> <li>- Failure of mechanic to raise flood wall failing</li> <li>- Takes up large under-ground area, including replacing current structure in the designated area.</li> </ul>	 <p>Self closing flood wall (The Flood Company)</p>	1, 3 & 4
Flip up flood walls / barriers	<ul style="list-style-type: none"> <li>- No visible flood defence when it is not required</li> <li>- Reduced foundation depth compared to self-raising flood walls</li> </ul>	<ul style="list-style-type: none"> <li>- Requires careful pre-planning as to when the defences may be required</li> <li>- Not as resource heavy as demountables when deploying</li> </ul>	 <p>Flip up flood wall (Flood Control International)</p>	3 & 4



Measure	Advantages	Disadvantages	Picture examples	Units included in
Temporary barriers	<ul style="list-style-type: none"> <li>- Potentially improved SoP against flooding</li> <li>- Low cost</li> </ul>	<ul style="list-style-type: none"> <li>- Does not reduce erosion risk</li> <li>- Cannot protect to a high SoP</li> </ul>	 <p data-bbox="1167 552 1592 576">Temporary flood barriers (fluvial innovations)</p>	2 & 3
Demountable flood walls	<ul style="list-style-type: none"> <li>- Temporary structure so not constantly impeding access to locations or visibility</li> <li>- Flood protection</li> <li>- Low cost compared to permanent structure</li> </ul>	<ul style="list-style-type: none"> <li>- Relies heavily on pre-planning for potential flooding event.</li> <li>- Considerable deployment time and operation effort</li> <li>- Storage requirements</li> <li>- Elements of the demountable defence permanently in place required</li> </ul>	 <p data-bbox="1167 903 1435 927">Demountable defences (EA)</p>	1, 2, 3 & 4
Flood gate	<ul style="list-style-type: none"> <li>- Would not impede access and visibility during normal conditions when open</li> <li>- Provides flood protection when closed</li> </ul>	<ul style="list-style-type: none"> <li>- Relies heavily on pre-planning for potential flooding events</li> <li>- Residual risk of gates being left open during flood events</li> </ul>	 <p data-bbox="1167 1222 1541 1246">Flood gate (Flood Control International)</p>	2, 3 and 4



Measure	Advantages	Disadvantages	Picture examples	Units included in
Reinforce de-facto defences and boundary walls	<ul style="list-style-type: none"> <li>- Secondary level of flood defence</li> <li>- Cost effective by improving structure not designed as flood defences to act as a defence (for example, garden walls)</li> </ul>	<ul style="list-style-type: none"> <li>- Would require being used with an additional defence</li> <li>- The extent and locations may or may not at majority of locations</li> <li>- Potential to impede on access</li> </ul>	 <p data-bbox="1167 528 1697 552">Langstone de-facto defences at the back of the footpath</p>	3
Wave return wall	<ul style="list-style-type: none"> <li>- Will increase the SoP against flooding from wave overtopping</li> <li>- Lower cost relative to construction of an entirely new structure</li> <li>- Requires little maintenance</li> </ul>	<ul style="list-style-type: none"> <li>- Does not increase condition of existing defences and likely that a refurbishment will also be needed in some locations to prevent erosion</li> <li>- Could impact landscape and views in the area</li> </ul>	 <p data-bbox="1167 879 1379 903">Pevensey wave return</p>	Not included in any units due to sheltered nature of the frontage and still water level inundation being the key driver of flood risk
Setback embankment	<ul style="list-style-type: none"> <li>- Will increase the SoP against flooding</li> <li>- Lower cost measure than setback floodwall, although this is not the case if a high new structure is required.</li> </ul>	<ul style="list-style-type: none"> <li>- Being set back from the frontline it will not improve the condition of the existing defences - likely that a refurbishment will also be needed in some locations to prevent undermining. No erosion prevention benefits.</li> <li>- Could impact landscape and views in the area</li> <li>- Could impact access and services</li> <li>- Can only be implemented where there is sufficient space behind the frontline defences which may not be available</li> <li>- Environmental impact if the embankment is setback on to designated land (potentially involving a large footprint if a high embankment is required).</li> </ul>	 <p data-bbox="1167 1225 1514 1249">Earth embankment defence (Bristol)</p>	1, 2, 3 & 4

Measure	Advantages	Disadvantages	Picture examples	Units included in
Land raising	<ul style="list-style-type: none"> <li>No large notable structures or features</li> <li>Can be implemented on the frontline and also more inland</li> <li>Increase in flood protection to areas behind raised land</li> </ul>	<ul style="list-style-type: none"> <li>Cost dependant of area size and height increase, can be significant</li> <li>Could impact landscape and views in the area</li> <li>Can result in access issues</li> <li>Large increase to have significant impact, resulting in more material meaning higher cost</li> <li>Potential to change character of an area</li> </ul>		1, 2, 3 & 4
Road raising	<ul style="list-style-type: none"> <li>Will increase the SoP against flooding</li> <li>Requires little maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Does not increase condition of existing defences</li> <li>Could lead to significant disruption during construction</li> </ul>		2 & 3
Concrete revetment / seawall	<ul style="list-style-type: none"> <li>New structure, could be landscaped to match character of area</li> <li>Will provide flood risk benefits by increasing the SoP</li> <li>Requires little maintenance and long residual life</li> </ul>	<ul style="list-style-type: none"> <li>Likely to be have a high capital cost</li> <li>Would impact visual aesthetics of the area</li> </ul>	 <p>Cromer seawall</p>	1, 2, 3 & 4
Sheet piling with capping beam	<ul style="list-style-type: none"> <li>Effective Flood defence without taking up too large a foot print</li> <li>Will provide flood risk benefits by increasing the SoP</li> <li>Requires little maintenance and long residual life</li> </ul>	<ul style="list-style-type: none"> <li>Corrosion risk with using sheet piling</li> <li>Would impact visual aesthetics of the area</li> <li>Could impact access and services</li> </ul>	 <p>Exeter sheet piling defence (Max Piling)</p>	1, 2, 3 & 4
Beach nourishment	<ul style="list-style-type: none"> <li>'Soft' management approach</li> </ul>	<ul style="list-style-type: none"> <li>Expensive</li> <li>Continuous monitoring and maintenance required</li> </ul>		2

Measure	Advantages	Disadvantages	Picture examples	Units included in
	<ul style="list-style-type: none"> <li>– Potential benefit for recreation / tourism in the area</li> <li>– Improves the beach's ability to protect from wave energy</li> </ul>	<ul style="list-style-type: none"> <li>– Likely to require repetitive interventions</li> <li>– It is likely that it will need to be combined with other beach management measures to prolong effectiveness</li> <li>– Potential significant environmental impacts – at both the dredge and deposit sites.</li> </ul>	 <p>Beach nourishment (Hayling Island)</p>	
Beach groynes	<ul style="list-style-type: none"> <li>– Optimal sediment retention on the beach</li> <li>– Potential to improve amenity of the beach area</li> </ul>	<ul style="list-style-type: none"> <li>– Likely to be very costly</li> <li>– Further disturb the natural movement of the beach sediment and lead to downdrift erosion</li> <li>– Potential health and safety issues with large changes in beach levels over the groynes</li> <li>– Further modelling studies required</li> <li>– Potential environmental impacts associated with groynes extending into the intertidal zone</li> </ul>	 <p>Hunstanton beach groynes</p>	2
Property Level of Protection (PLP)	<ul style="list-style-type: none"> <li>– Flood protection to local properties</li> </ul>	<ul style="list-style-type: none"> <li>– Primary flood defence would need to be implemented to optimise on this option</li> </ul>	 <p>Langstone PLP</p>	1, 2, 3 & 4
Property Level Resilience (PLR)	<ul style="list-style-type: none"> <li>– Decrease the extent of damage that would occur when flooded</li> </ul>	<ul style="list-style-type: none"> <li>– Does no benefit to the prevention of flooding</li> </ul>		

Measure	Advantages	Disadvantages	Picture examples	Units included in
Vegetated buffer zones	<ul style="list-style-type: none"> <li>– Positive reaction to aesthetics</li> <li>– ‘Soft’ environmental option to the reduction in trying to prevent overtopping</li> </ul>	<ul style="list-style-type: none"> <li>– Vegetation can be potentially destroyed in events making it obsolete for the next event</li> <li>– Not a highly effective form of defence</li> <li>– Does not increase the SoP against extreme still water levels</li> </ul>	 <p>Langstone saltmarsh</p>	1 & 3
Tidal flood barrier	<ul style="list-style-type: none"> <li>– Improved SoP against flooding</li> <li>– Can be placed in an effective way, not working on current structures (or with)</li> </ul>	<ul style="list-style-type: none"> <li>– Suitable location for flood barrier typically difficult to resolve.</li> <li>– Potential for environmental issues associated with the movement of water to other areas</li> <li>– Very high cost compared to other alternatives</li> <li>– Residual risk of gate operation failures</li> </ul>	 <p>Thames barrier</p>	All units
Tidal lagoon	<ul style="list-style-type: none"> <li>– Improve SoP against flooding</li> </ul>	<ul style="list-style-type: none"> <li>– Suitable location for flood barrier typically difficult to resolve.</li> <li>– Potential for environmental issues associated with the movement of water to other areas</li> <li>– Very high cost compared to other alternatives</li> <li>– Residual risk of gate operation failures</li> </ul>		All units
Community preparedness and resilience	<ul style="list-style-type: none"> <li>– The community to know what to do to prevent loss of life and excessive damages</li> </ul>	<ul style="list-style-type: none"> <li>– Dependent on the communities willingness to act on the knowledge</li> </ul>		All units
Relocation	<ul style="list-style-type: none"> <li>– Reduced risk to life from flooding</li> </ul>	<ul style="list-style-type: none"> <li>– Movement and loss of a whole community</li> </ul>		All units

## 3. Unit 1 (Langstone West)

The following sections identify which of the potential measures described in chapter 2 have been selected for the long list in Unit 1. The long list of measures for Unit 1 has been divided into those most appropriate for each option.

### 3.1 Do Nothing

- No active intervention.

### 3.2 Do Minimum

- **Patch and repair** to existing defences to the end of their residual life. For this unit the measure will be limited to the formal defences that are currently in place which consist of the concrete seawall and floodwall in front of the residential properties.

### 3.3 Maintain

- **Capital refurbishment** of the existing defences to extend their residual life, especially to the toe of structures which are showing signs of failure now. There is also a potential to undertake vegetation clearance along the east bank of the stream to improve access to the bank / accessibility for bank inspections and stabilisation works.

### 3.4 Sustain / Improve

- **Crest raising** of the existing defences alongside a capital refurbishment to extend the residual life of existing defences. The existing standard of protection for the existing concrete seawall and floodwalls in this unit is in excess of 1:200yr so these defences may not need to be raised until in the future to deliver a 1:75yr standard of protection. However, lower land to the east of the defences near the A3023 provides a flood pathway to outflank the defences and flood the residential properties behind. Therefore, in order to be effective the flow pathway from the east would also need to be prevented.

- Crest raising of the existing defences using a **glass** structure. This would help to limit the visual impact of the increased height of the defences. However, the foreshore in this location is comprised of a shingle beach and the suitability of a glass structure in this environment is not clear. This will need to be investigated further should this measure be taken forward.

- **Self-raising floodwalls** alongside a capital refurbishment of the existing defences.

- Construction of a new **seawall** to replace the existing defences which are in a locally poor condition.

- Replace existing defence with **sheet piling** and capping beam. This measure is likely to require less space than a new seawall and if an agreement is reached with the landowners there could be potential to place the piles behind the existing defence to the rear of the property gardens. This would avoid encroachment issues but would require close liaison and early consultation with the local landowners to seek permissions and consent.

- There could be the potential to **raise land levels** immediately behind the defences at the rear of the property gardens. The raised land could be landscaped so that it does not look like a coastal defence structure from the properties side, would avoid encroachment issues but would require close liaison and early consultation with the local landowners to seek permissions and consent.

- **Demountable defences** along crest of existing structure. This measure would require connection beam insertions on the crest of the existing defences and given that the site is relatively inaccessible except from on foot at low tides there would be a deployment risk. This particular section of defence may be an integral aspect of the wider scheme so the risk of a missed deployment is unlikely to be acceptable to the flood risk management authority.

- Install or improve levels of **Property Level Protection** and/or **Property Level Resilience** measures to the properties at risk of flooding in this unit.

- Construct an **earth embankment**. Due to space constraints this measure would not be suitable for the frontline alignment at the rear of the residential property gardens but could be used as a defence to tie-in the scheme to higher ground, for example, across the field to the west of the properties or adjacent to the east river bank.

- **Vegetated buffer zones** to potentially decrease wave energy across this unit

### 3.5 Initial ideas for scheme alignments

Figure 3-1 below presents some alignment ideas for a scheme in this unit. Potential alignments will be considered in more detail during the remainder of the option appraisal process, considering aspects such as ground levels, services and utilities, environmental designations, and stakeholder feedback. Some initial alignment ideas developed at this stage are:

- A defence along the frontline and east bank of the stream. To tie in with high ground to the north of the footbridge.
- A defence along the frontline and across the field to the east of stream. To tie in with high ground to the north.
- A defence along the alignment of the Solent Way footpath to tie in with high ground to the north. This gives an opportunity to compartmentalise the flood cell and could reduce the cost of defence. However, it could also reduce the scheme benefits. This will be investigated during the remainder of the option appraisal process and the economics.

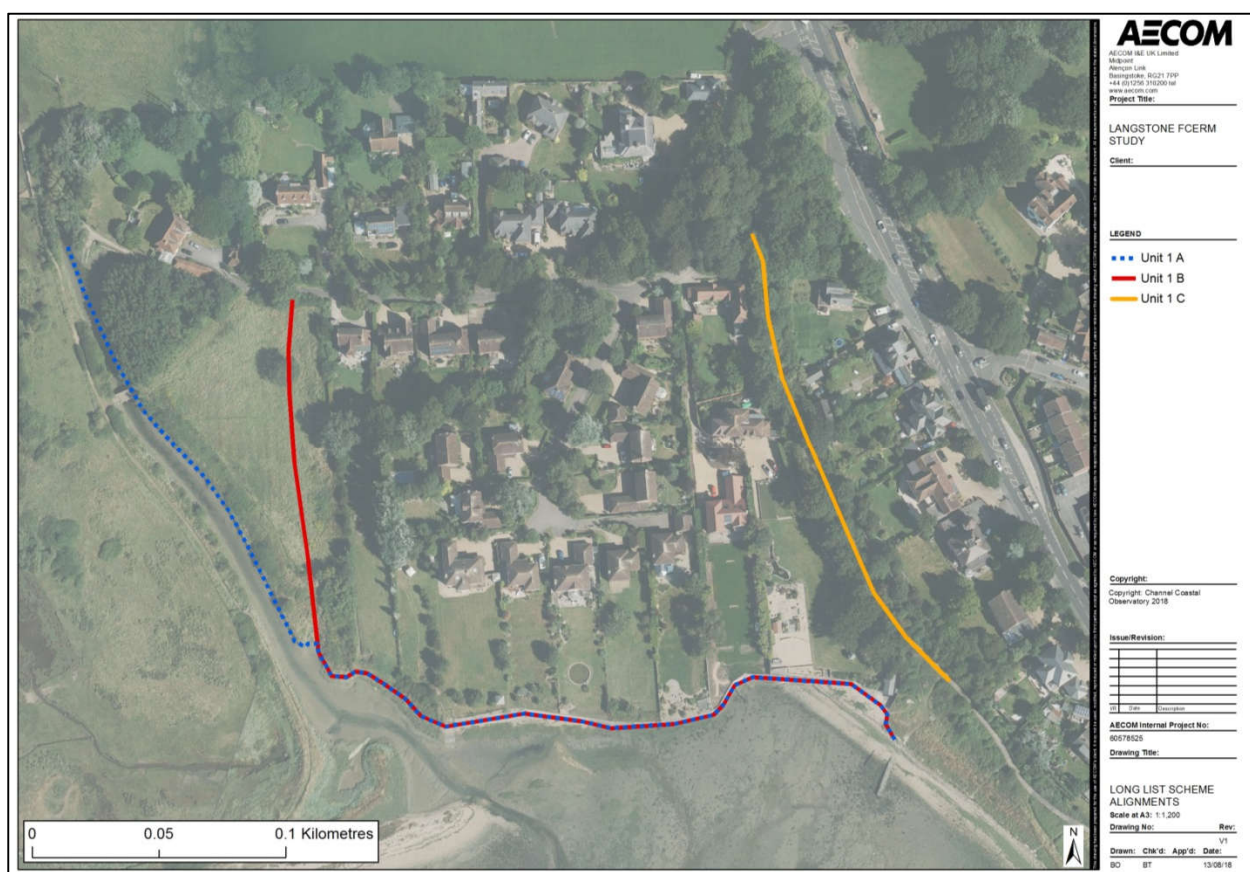


Figure 3-1: Potential defence alignments for Unit 1

## 4. Unit 2 (Sailing Club and Langstone Spit)

The following sections identify which of the potential measures described in chapter 2 have been selected for the long list in Unit 2. The long list of measures for Unit 2 has been divided into those most appropriate for each option.

### 4.1 Do Nothing

- No active intervention.

### 4.2 Do Minimum

- **Patch and repair** to the existing defences to the end of their residual life. For this unit the measure will be limited to the formal defences that are currently in place which include the revetment to the east and south of the sailing club. This defence is currently managed by Hampshire County Council (HCC) Highways Authority and further appraisal of what approach to follow with this defence is not within the scope of this study. However this defence may or may not form part of the scheme alignment and therefore for information purposes it has been included in the appraisal. It is recognised that there would need to be a commitment from HCC Highways Authority if measures are proposed to alter the existing structure. The approach to how to appraise this section is to be agreed at the project long list meeting on 14<sup>th</sup> August 2018.

### 4.3 Maintain

- **Capital refurbishment** of the existing defences to extend their residual life, such as to the revetment to the east and south of the sailing club. In addition this measure could include clearance of vegetation along the bank to the west of the sailing club to improve bank accessibility for inspections and potential stabilisation works.
- Undertake **stabilisation works or local erosion protection** along Langstone Spit and **beach recycling** to help minimise the risk of breaching. Localised erosion protection could include the placing of rock armour at the end of the spit where there is evidence of erosion. Protection of the spit is a key driver for the sailing club.

### 4.4 Sustain / Improve

- Construct a **setback RC floodwall**. There are many potential alignments and tie-in locations for this measure. If it were to be incorporated into an existing defence or bank it would likely require alongside it either a refurbishment scheme of the existing defence or bank stabilisation to support the structure.
- Extend the Hampshire Highways Authority defence around the remainder of the sailing club. This could be done through an extension of the **revetment** structure or alternatively the construction of a **seawall** or **sheet piling**. This would help to remove the reliance on Langstone Spit for the erosion protection that it provides to the sailing club.
- **Land raising** of any potential low spots or areas in this unit.
- **Demountable defences**. This would require the insertion of connection beams along the demountable defence alignment and deployment of the defences prior to a flood event. Potential alignments could be across the A3023 road however this would block access and egress to Hayling Island so this factor would need to be considered.
- **Road raising** along the length or small sections of the A3023 road which could act as a defence to prevent flooding from either the west or east directions.
- Install a **flood gate** across key access points.
- Construct a formal **earth embankment**. There are potential locations for this, for example, on top of the natural bank immediately to the west of the Solent Way footpath or on the west bank of the sailing club.
- **Beach nourishment** to increase sediment volumes on Langstone spit and to decrease the risk of breaching. This measure could potentially minimise the need to stabilisation or toe protection along the west bank of the sailing club, although it would not help to reduce flood risk in this unit.
- Construct beach **groynes** on Langstone spit to help improve the retention of material and potentially decrease the risk of the spit breaching.

- Install or improve levels of **Property Level Protection** and/or **Property Level Resilience** measures to the properties at risk of flooding in this unit, notably the sailing club.

## 4.5 Initial ideas for scheme alignments

Figure 4-1 below presents some alignment ideas for a scheme in this unit. Potential alignments will be considered in more detail during the remainder of the option appraisal process, considering aspects such as ground levels, services and utilities, environmental designations, and stakeholder feedback. Some initial alignment ideas developed at this stage are:

- A defence around the frontline, incorporating the Hampshire Highways Authority revetment, following the west bank of the sailing club and improved defence of Langstone Spit
- A defence along the west side of sailing club and adjacent to Solent Way footpath. This alignment could incorporate the Hampshire Highways Authority revetment but would not involve protection of Langstone Spit.
- A defence from the car park across the A3023 and along the Solent Way footpath. This alignment would essentially remove the sailing club and Langstone spit from the benefit area of the scheme but would significantly reduce the length of defences required.

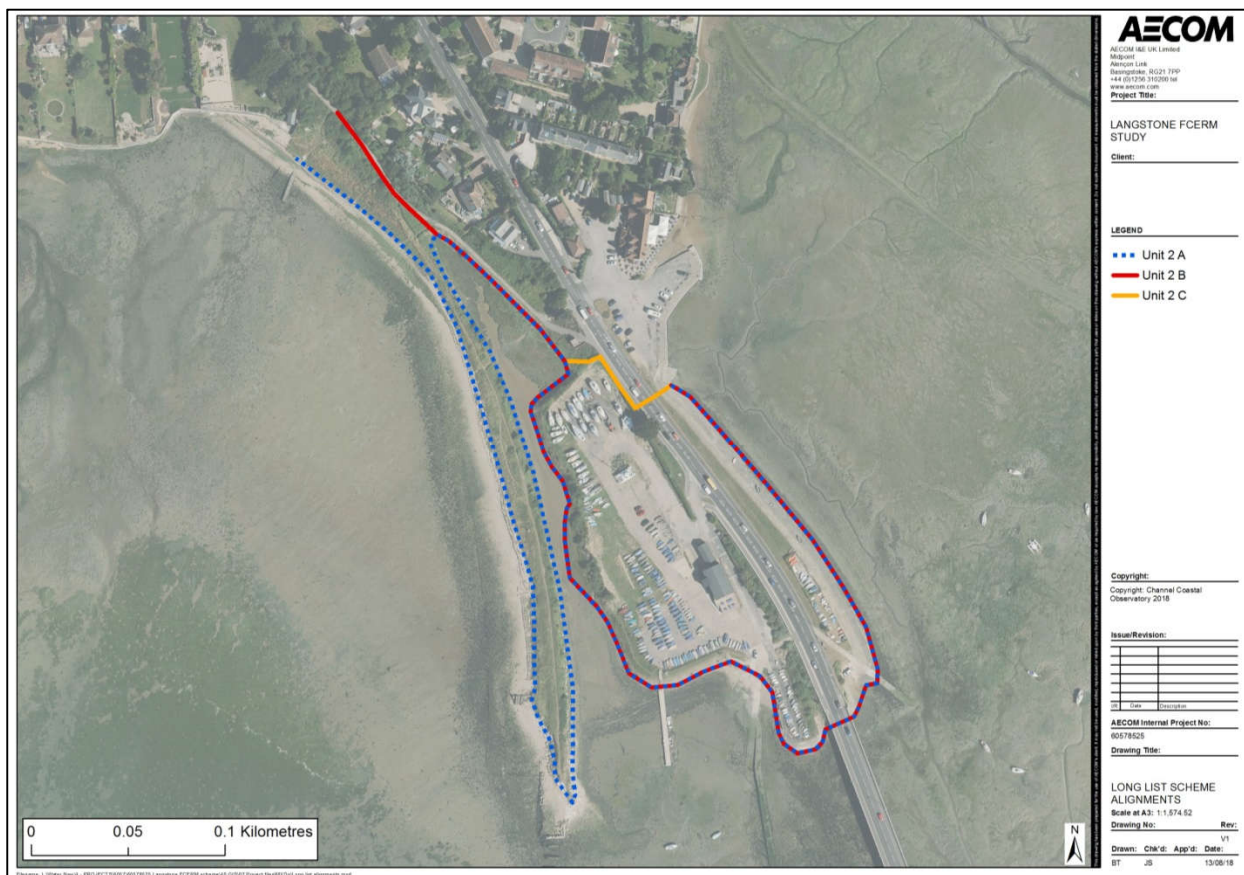


Figure 4-1: Potential defence alignments for Unit 2



## 5. Unit 3 (Langstone East)

The following sections identify which of the potential measures described in chapter 2 have been selected for the long list in Unit 3. The long list of measures for Unit 3 has been divided into those most appropriate for each option.

### 5.1 Do Nothing

- No active intervention

### 5.2 Do Minimum

- **Patch and repair** to existing defences to the end of their residual life. For this unit the measure will be limited to the formal defences that are currently in place including the masonry walls and slipways immediately in front of the waterside properties and Ship Inn car park.

### 5.3 Maintain

- **Capital refurbishment** of the existing defences to extend their residual life. Sections of the existing defence around the Ship Inn car park have recently undergone a like-for-like masonry refurbishment and it is possible that this approach could be undertaken along the remainder of the masonry structures in this unit. Other potential approaches include a concrete encasement or spraying.

### 5.4 Sustain / Improve

- Construct a **setback RC floodwall**. Due to space constraints in this unit this measure is likely to be limited to the area around and potentially through the Ship Inn car park. For the vast majority of the unit there is unlikely to be sufficient space for a setback structure. To support a setback structure and to prevent erosion in the future it is likely that a capital refurbishment of the existing frontline structure would be required.

- **Crest raising** or construction of a **parapet wall** along the front of the existing defences. This would likely need to be supported by a capital refurbishment of the existing defences to extend the residual life and to ensure the defences could support additional height. To protect to a present day 75 SoP the crest raising/parapet wall could need to be up to 1.5m in height, above the existing wall (see section 7).

- Crest raising of the existing defences using a **glass** structure. This would help to limit the visual impact of the increased height of the defences although the local / community perception of glass walls is unclear at this stage. This will need to be investigated further should this measure be taken forward.

- **Self-raising floodwalls** alongside a capital refurbishment of the existing defences. Due to potential space constraints it is unclear at this stage as to which areas of this unit may be acceptable for this measure but it could be a useful approach for the areas immediately in front of the public houses where the visual aspect and linkage with the shoreline may be an essential factor.

- **Flip-up floodwalls / barriers** alongside a capital refurbishment of the existing defences.

- **Demountable defences**. This would require the insertion of connection beams along the demountable defence alignment and deployment of the defences prior to a flood event. Potential alignments could be across the Ship Inn car park and along the frontline defences in front of the coastal footpath. In some areas in the unit access to deploy the demountables is likely to be limited and therefore access permissions from local residents / property owners may be required to ensure the defences are deployed appropriately. This may or may not be considered acceptable to the local flood risk authority as this particular section of defence may be an integral aspect of the wider scheme so the risk of a missed deployment is unlikely to be acceptable to the flood risk management authority. In addition, the demountables would need to be stored on site and a location to do so would need to be found.

- Advance the line by building a **walkway** and constructing a flood defence adjacent to the existing defences. This would lead to foreshore encroachment so is unlikely to be acceptable on environmental grounds but it would allow for more space, landscaping opportunities and also potentially a more sympathetic defence design in keeping with the character of the area. For example, the defence could be turned into a stepped revetment providing access to

the foreshore, or alternatively it could be sloped in the opposite direction to provide public seating along the frontage.

- An alternative to the above would be to raise the existing defences with a **parapet wall** and construct a **wooden boardwalk** in seaward of the defence to improve access along the frontage and landscaping of the area. To support this approach the parapet wall may include demountable sections in key viewpoint areas (i.e. adjacent to the public houses) to provide improved access. A wooden boardwalk is likely to have environmental impacts but potentially less significant impacts than advancing the line with the solid structure.

- Reinforce the **de-facto defences** in this unit, such as the setback garden / boundary walls, to improve the level of flood protection that these structures provide. This would also likely need to be supported by flood proofing any adjacent building walls which align with the garden / boundary walls. Logistically this measure could be very challenging due the historic nature of the old properties and potential designations, in addition to having to get agreement with a range of property owners.

- Construction of a new **seawall** to replace the existing defences which are in a locally poor condition.

- Replace existing defence with **sheet piling** and capping beam. This measure is likely to require less space than a new seawall but due to the proximity to the historic properties along the sea front in this unit there could be technical challenges during construction (e.g. vibration).

- **Land raising** of any potential low spots or areas in this unit, potentially the Ship Inn car park. This measure is not really feasible along the footpath as it could cut-off access to the properties behind.

- **Road raising** along the length or small sections of the A3023 road which could act as a defence to prevent flooding from either the west or east directions. This could also be done at Langstone High Street.

- Install a **flood gate** across key access points.

- Install or improve levels of **Property Level Protection** and/or **Property Level Resilience** measures to the properties at risk of flooding in this unit.

- Deploy **Temporary Defences** in this unit during periods of increased flood risk.

- Construction of an **earth embankment** to tie-in the defences to higher ground. This measure could potentially be used at the north of the alignment.

- Due to access requirements any formal defence in this area is likely to require **flood gates** at key access points. During normal conditions the flood gates would be kept open to allow access but during periods of flood risk the gates would be closed to prevent inundation.

- **Vegetated buffer zones** to potentially decrease wave energy across this unit

## 5.5 Initial ideas for scheme alignments

Figure 5-1 below presents some alignment ideas for a scheme in this unit. In this unit, due to space constraints, environmental designations and other factors there are only a limited number of alignments which could be used.

Potential alignments will be considered in more detail during the remainder of the option appraisal process, considering aspects such as ground levels, services and utilities, environmental designations, and stakeholder feedback. Some initial alignment ideas developed at this stage are:

- A defence along the frontline of the car park and coastal footpath
- A defence along the frontline around the footpath, but setback across or at the back of the car park to tie in with solent way or defence along the A3023 road.
- As above but a defence tie-in at the north end to higher ground across the field, essentially removing the Mill pond and area to the east from the benefit area of the scheme



Figure 5-1: Potential defence alignments for Unit 3

## 6. Unit 4 (Mill and Millpond)

The following sections identify which of the potential measures described in chapter 2 have been selected for the long list in Unit 4. The long list of measures for Unit 4 has been divided into those most appropriate for each option.

### 6.1 Do Nothing

- No active intervention

### 6.2 Do Minimum

- **Patch and repair** to existing defences to the end of their residual life. For this unit the measure will be limited to the formal defences that are currently in place including the masonry walls along the frontage and defences around the Mill.

### 6.3 Maintain

- **Capital refurbishment** of the existing defences to extend their residual life.

### 6.4 Sustain / Improve

- Construct a **setback RC floodwall**. There are a range of possible alignments for this measure, for example along the back edge of the footpath or setback in the land behind the existing defences. To support a setback structure and to prevent erosion in the future it is likely that a capital refurbishment of the existing frontline structure would be required.

- **Crest raising** or construction of a **parapet wall** along the front of the existing defences. This would likely need to be supported by a capital refurbishment of the existing defences to extend the residual life and to ensure the defences could support additional height. To protect to a present day 75 SoP the crest raising/parapet wall could need to be up to 1.5m in height, above the existing wall (see section 7).

- Crest raising of the existing defences using a **glass** structure. This would help to limit the visual impact of the increased height of the defences although the local / community perception of glass walls is unclear at this stage. This will need to be investigated further should this measure be taken forward.

- **Self-raising floodwalls** alongside a capital refurbishment of the existing defences.

- **Demountable defences** along crest of existing structure.

- **Flip-up floodwalls / barriers** alongside a capital refurbishment of the existing defences.

- Advance the line by building a **walkway** and constructing a flood defence adjacent to the existing defences. This would lead to foreshore encroachment so is unlikely to be acceptable on environmental grounds but it would allow for more space, landscaping opportunities and also potentially a more sympathetic defence design in keeping with the character of the area. For example, the defence could be turned into a stepped revetment providing access to the foreshore, or alternatively it could be sloped in the opposite direction to provide public seating along the frontage.

- As in Unit 3, a wooden **boardwalk** is also a potential measure in this location.

- Construction of a new **seawall** to replace the existing defences which are in a locally poor condition.

- Replace existing defence with **sheet piling** and capping beam. This measure is likely to require less space than a new seawall but due to the proximity to the historic properties along the sea front in this unit there could be technical challenges during construction (e.g. vibration).

- **Footpath raising** of the entire or sections of the footpath. This would ensure that the views from the footpath are not obstructed. Unlike the other units there are no properties immediately behind the footpath so this measure is a possibility.

- Install a **flood gate** across key access points.
- Install or improve levels of **Property Level Protection** and/or **Property Level Resilience** measures to the properties at risk of flooding in this unit.
- Construction of an **earth embankment**. This could be used to tie-in to high ground to the north of the Mill Pond.

## 6.5 Initial ideas for scheme alignments

Figure 6-1 below presents some alignment ideas for a scheme in this unit. Potential alignments will be considered in more detail during the remainder of the option appraisal process, considering aspects such as ground levels, services and utilities, environmental designations, and stakeholder feedback. Some initial alignment ideas developed at this stage are:

- A defence along the frontline, wrapping around the Mill and following the existing defences to the slipway
- A defence along the footpath behind the Mill but then following the frontline for the remainder of the frontage.
- A defence setback behind the Mill and setback along the back edge of the footpath

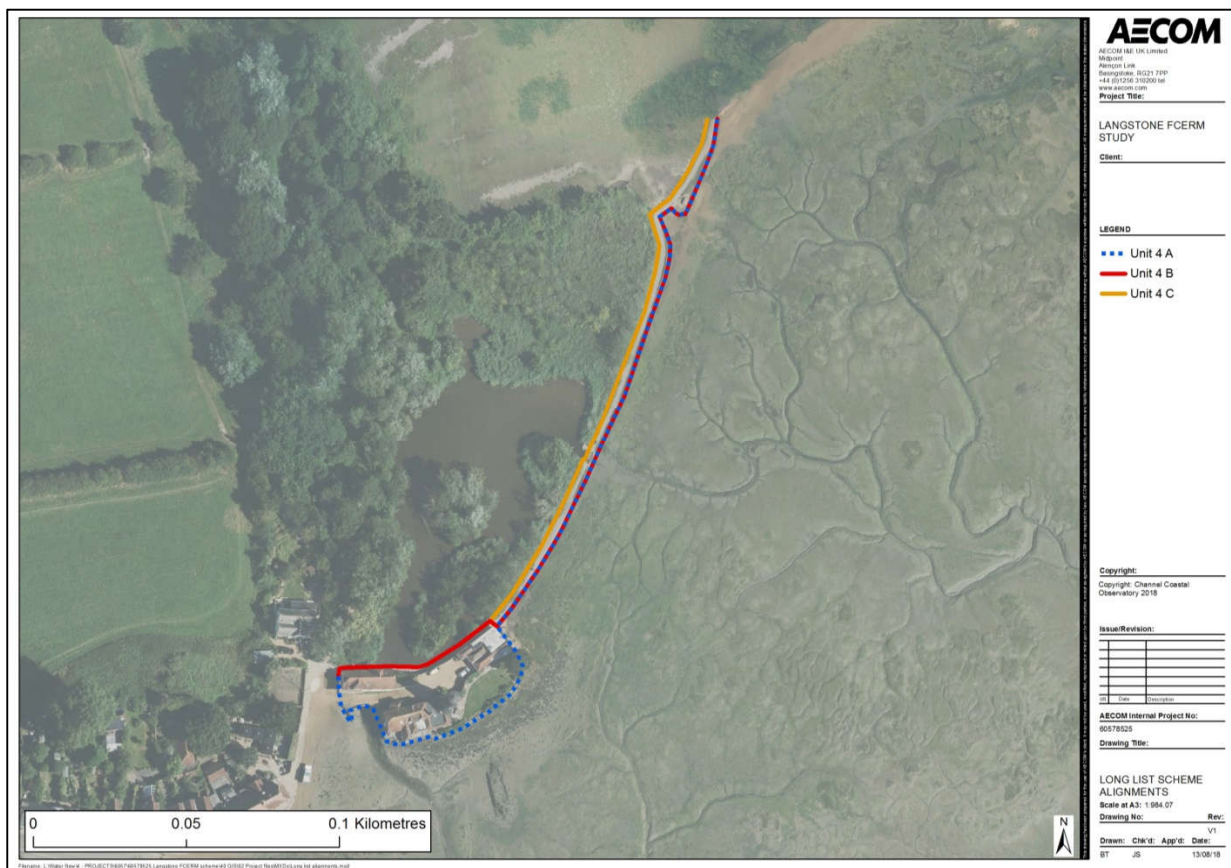


Figure 6-1: Potential defence alignments for Unit 4

## 7. Indicative defence heights

Figure 7-2 overleaf provides indicative defence heights for an alignment along the frontline between the Ship Inn car park and the eastern end of a potential alignment, to the east of the Mill building. The heights are provided for a range of standards of protection. Note that the heights are indicative only and are based on the flood depths for the different return period events obtained from the JBA model. Ground levels, topo surveys or freeboard allowances have not been considered in the estimation. The purpose of this section is to provide an indication of what defence heights could potentially be expected to inform the long listing discussion.

The alignment used to estimate the defence heights that may be required to mitigate different return period events along the frontage (Figure 7-2 ) is provided below in Figure 7-1.



Figure 7-1: Alignment used to indicate potential defence heights in Figure 7-2 overleaf

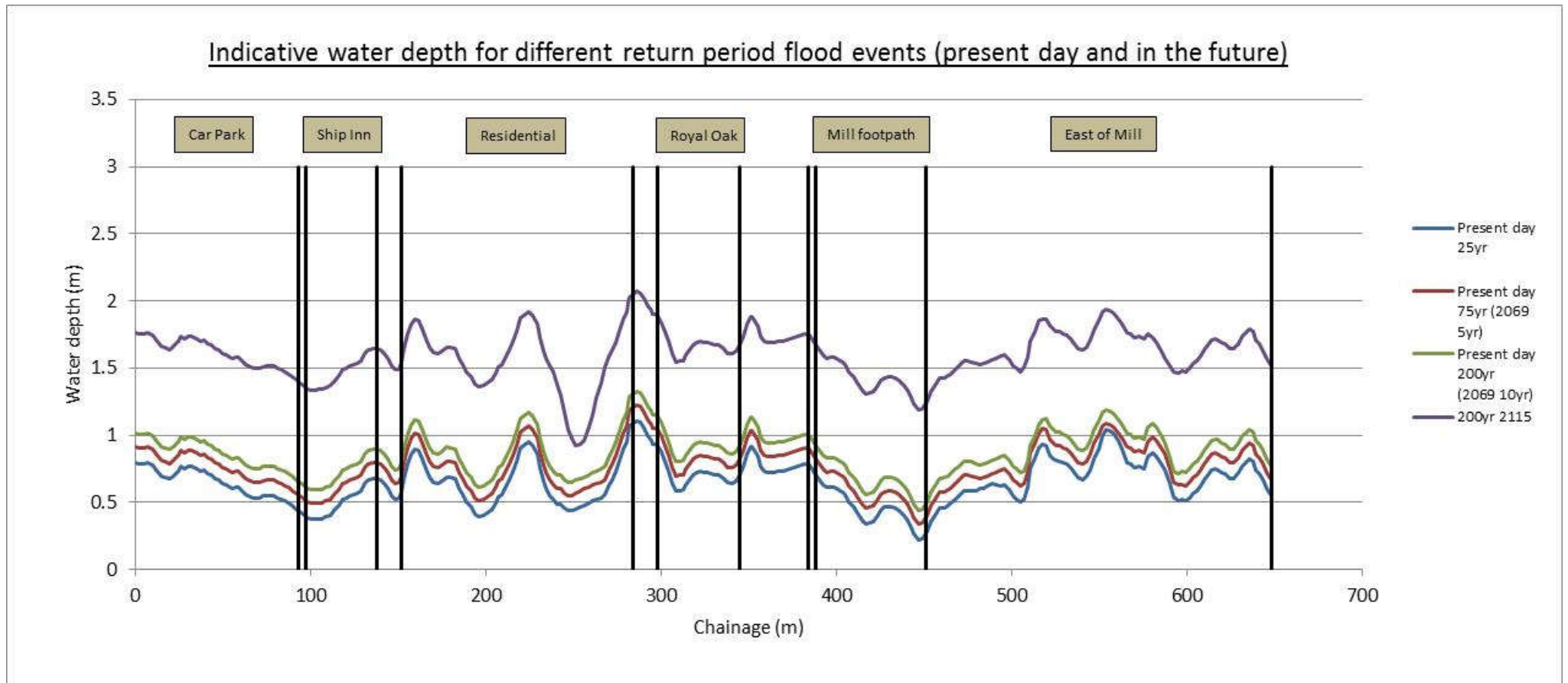


Figure 7-2: Indicative flood depths above the frontline defences between the Ship Inn car park and to the east of the Mill under a range of return period flood events.





