



Appendix H1 Outline Design Report

Outline Design and Decision Criteria Report

Langstone Flood and Coastal Erosion Risk Management
Scheme

Eastern Solent Coastal Partnership

Project number: 60578525

November 2019

Quality information

Revision	Prepared by	Checked by	Verified by	Approved by
V1	George Batt Engineer Byron Ottey Graduate Engineer	Eric Iribarren Principal Engineer	Peter Neville-Jones Technical Director	Jon Short Associate
V2	George Batt Engineer	Eric Iribarren Principal Engineer	Peter Neville-Jones Technical Director	Jon Short Associate

Revision History

Revision	Revision date	Details	Authorized	Name	Position
V1	16/09/2019	Draft issue for client comment	JCAS	Jon Short	Associate
V2	18/11/19	Update following workshop and client comments	JCAS	Jon 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
United Kingdom

T: +44(0)1256 310200
aecom.com

© 2019 AECOM Infrastructure & Environment UK Limited. All Rights Reserved.

This document has been prepared by AECOM Infrastructure & Environment UK Limited ("AECOM") for sole use of our client (the "Client") in accordance with generally accepted consultancy principles, the budget for fees and the terms of reference agreed between AECOM and the Client. Any information provided by third parties and referred to herein has not been checked or verified by AECOM, unless otherwise expressly stated in the document. No third party may rely upon this document without the prior and express written agreement of AECOM.

Table of Contents

1.	Introduction.....	6
1.1	Background.....	6
1.2	Site location	6
1.3	Preferred options.....	6
1.4	Scope of report.....	9
2.	Basis of design	10
2.1	Design objectives	10
2.2	Site Data.....	11
2.3	Design methodology.....	14
3.	Core scheme	16
3.1	ODU2 – Sub-unit 2b.....	16
3.2	ODU3 – Sub-unit 3b.....	18
3.3	ODU3 – Sub-unit 3d, 3e	20
3.4	ODU3 – Sub-unit 3f, 3g, 3h.....	21
3.5	ODU3 – Sub-unit 3i	25
3.6	ODU3 – Sub-unit 3j	26
3.7	ODU3 – Sub-unit 3k	28
3.8	ODU3 – Sub-unit 3l	30
3.9	Summary of flood gate / stoplog locations	32
4.	Additional scheme.....	34
4.1	ODU1 – Sub-unit 1a.....	34
4.2	ODU1 – Sub-unit 1b.....	35
4.3	ODU2 – Sub-unit 2a.....	39
5.	General considerations for the scheme	42
5.1	Visual impact of scheme.....	42
5.2	Temporary permissions.....	43
6.	Designer's Risk Assessment	44
7.	References	45
	Appendix A – Drawings	46
	Appendix B – Designer's Risk Assessment.....	47
	Appendix C – Flood gate / stop log proposed location photographs	48

Figures

Figure 1-1: Study frontage plan (frontage indicated by red line)	6
Figure 1-2: Preferred alignment and option plan (core scheme and additional scheme), from Preferred Option Report.....	8
Figure 2-1: 1:200 year present day (2019) flood map of Langstone (no overtopping included)	10
Figure 3-1: Northern section of sub-unit 2b	16
Figure 3-2: Sub-unit 2b southern section existing raised ground - orange areas are above 3.8m AOD	17
Figure 3-3: Existing wall proposed to be left in place at northern end of sub-unit 3b (photo ©2019 Google Maps).....	19
Figure 3-4: Sub-unit 3d to 3e existing wall in front of Ship Inn.....	21
Figure 3-5: Sub-unit 3d to 3e existing fence along private property boundary	21
Figure 3-6: Sub unit 3f to 3h showing existing seawall apron	22
Figure 3-7: Sketch plan of wall and boardwalk alignment at Green Cottage	23
Figure 3-8: Sub unit 3f to 3h property to south of Green Cottage	24
Figure 3-9: Sub unit 3f to 3h flood gate location	25
Figure 3-10: Sub-unit 3i property	26
Figure 3-11: Sub-unit 3j.....	26
Figure 3-12: Sub-unit 3J potential alignment	27

Figure 3-13: Sub-unit 3k Royal Oak.....	29
Figure 3-14: Sub-unit 3l existing wall	31
Figure 3-15: Sub-unit 3l/3k transition proposed flood gate location.....	31
Figure 3-16: Sub-unit 3l flood gate location across property vehicle access	32
Figure 4-1: Sub-unit 1a southern section existing raised ground - orange areas are above 3.6m AOD	35
Figure 4-2: Structure 1 sub-unit ODU1b West	36
Figure 4-3: Structure 2 sub-unit ODU1b East – failed apron	36
Figure 4-4: Structure 2 sub-unit ODU1b – exposed steel piles	36
Figure 4-5: Structure 2 sub-unit ODU1b – vertical crack in seawall	37
Figure 4-6: Eastern end of sub-unit 1b seawall.....	38
Figure 4-7: Sub-unit 1b access steps.....	39
Figure 4-8: Navigation chart highlighting raised areas and a feasible fetch length (Admiral Chart, 1961).....	39
Figure 4-9: Concrete rubble located on the spit.....	41

Tables

Table 1-1: Preferred option in each sub-unit (from Preferred Option Report).....	7
Table 2-1: Tidal levels	11
Table 2-2: Utilities information by sub-unit.....	12
Table 2-3: Design guidance applied	14
Table 2-4: Freeboard allowance for each sub-unit	15
Table 3-1: Summary of flood gate / stop log locations in Core Scheme	32
Table 5-1: Height of new defences above existing ground levels.....	42

1. Introduction

1.1 Background

AECOM was commissioned by the Eastern Solent Coastal Partnership (ESCP) to undertake an option appraisal study and develop the outline design and outline business case for a tidal flood risk management scheme at Langstone, Hampshire.

1.2 Site location

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 and the Sailing Club are located close to the water's edge. The study frontage is part of a wider flood cell which also covers the adjacent Southmoor frontage to the west. The study frontage is shown in Figure 1-1.



Figure 1-1: Study frontage plan (frontage indicated by red line)

1.3 Preferred options

The previous stage of work, undertaking an options appraisal to identify preferred options, has identified potential alignment choices comprising a range of options. Two alignments have been selected to progress to the outline design stage due to differences in affordability. This is further explained in the Preferred Options Report¹ (AECOM, 2019).

The most likely alignment to be delivered is known as the 'Core Scheme', the extension to this scheme is known as the 'Additional Scheme'. The schemes have been broken down into Option Development Units (ODU) that each represent an area of similar coastal characteristics, where a single type of structure can be provided to guard against flooding. Figure 1-2 shows the locations of the schemes and the ODU sub-units.

In the option selection stage the alignments were broken down into sub-units and in these sub-units preferred options have been determined. The process of determining the preferred alignments and sub-unit options is described in the Preferred Option Report¹. Table 1-1 summarises the preferred options for the sub-units.

Note that there is some overlap between the two schemes meaning that if the Additional Scheme was delivered in combination with the core scheme the defence structure in sub-unit 2b would be shortened where the flood defences tie in.

Table 1-1: Preferred option in each sub-unit (from Preferred Option Report)

ODU sub-unit	Preferred defence measure
<u>Core scheme</u>	
2b	Setback floodwall (north section) and earth embankment (south section)
3b	Flip-up floodwall across car park and setback floodwall (south section)
3d to 3e	Floodwall with glass top
3f to 3h	Floodwall with boardwalk
3i	Flood proof residential building
3j	Flood gate
3k	Frontline floodwall
3l	Setback floodwall (footpath section) and earth embankment (field area)
<u>Additional scheme</u>	
1a	Earth embankment
1b	Capital refurbishment
2a	Rock armour

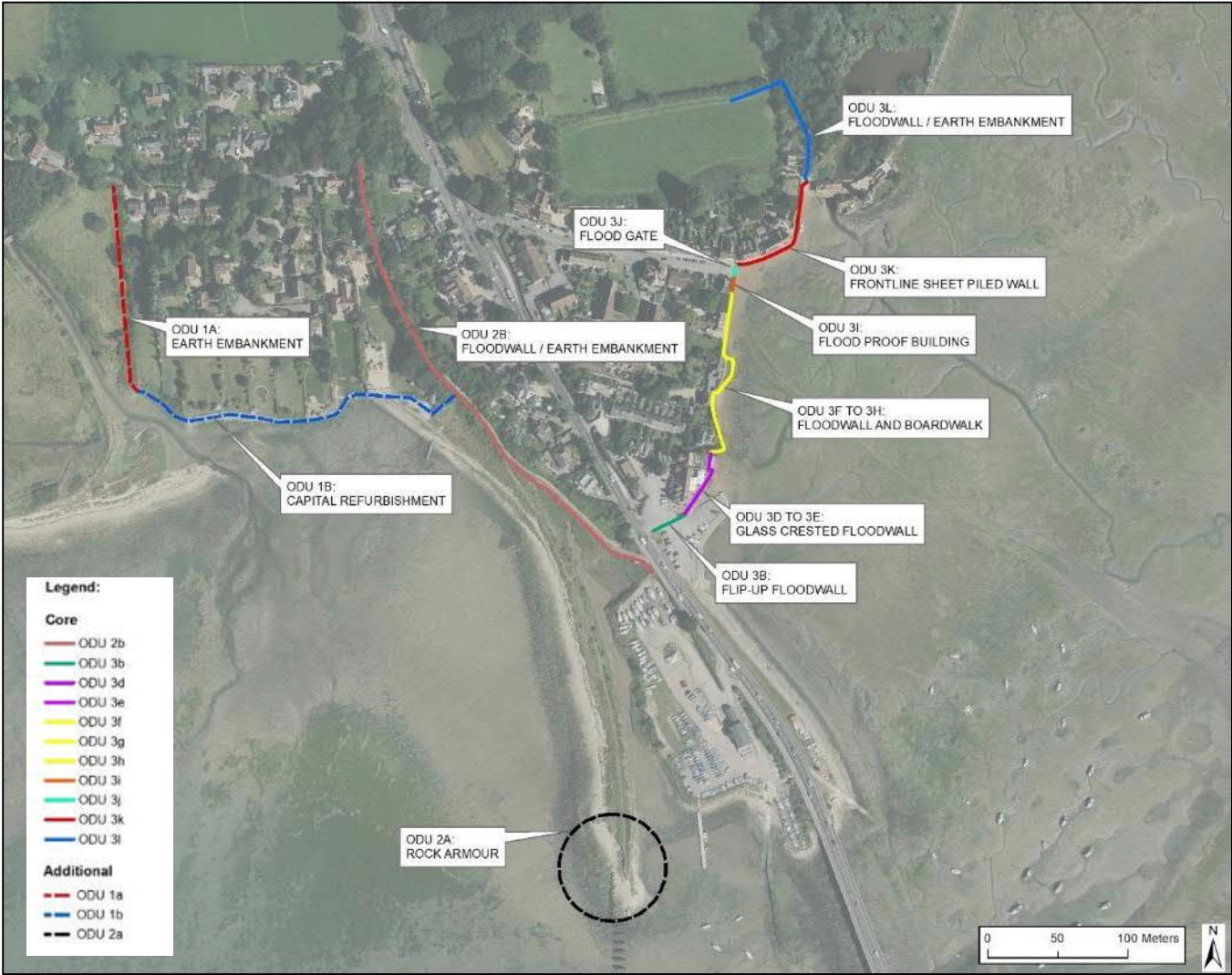


Figure 1-2: Preferred alignment and option plan (core scheme and additional scheme), from Preferred Option Report

1.4 Scope of report

This report presents the outline design report for the scheme. The primary objective of the outline design is to:

- Develop the preferred options to validate technical feasibility and assess preliminary geometry of the options.
- Determine the required heights and to optimise the alignments of the preferred options to provide information for consultation.
- Identify and mitigate risks throughout construction and operation of the scheme in the form of a Designer's Risk Assessment (DRA).
- Support buildability assessment and cost estimates for the scheme (core scheme and core scheme with additional scheme).

The report outlines the key design decisions taken to achieve the above. The basis of design is presented followed by key design decisions taken for each sub-unit defence. A designer's risk assessment and cost estimate are also provided.

2. Basis of design

2.1 Design objectives

2.1.1 Standard of protection

The objective of the scheme is to protect against a still water level corresponding to a 1:200 year return period event at the present day, giving a flood level of +3.5m AOD (above ordnance datum). The extent of this flooding is shown in Figure 2-1. Description of how wave action has been addressed is included in Section 2.3.2 (Crest height).

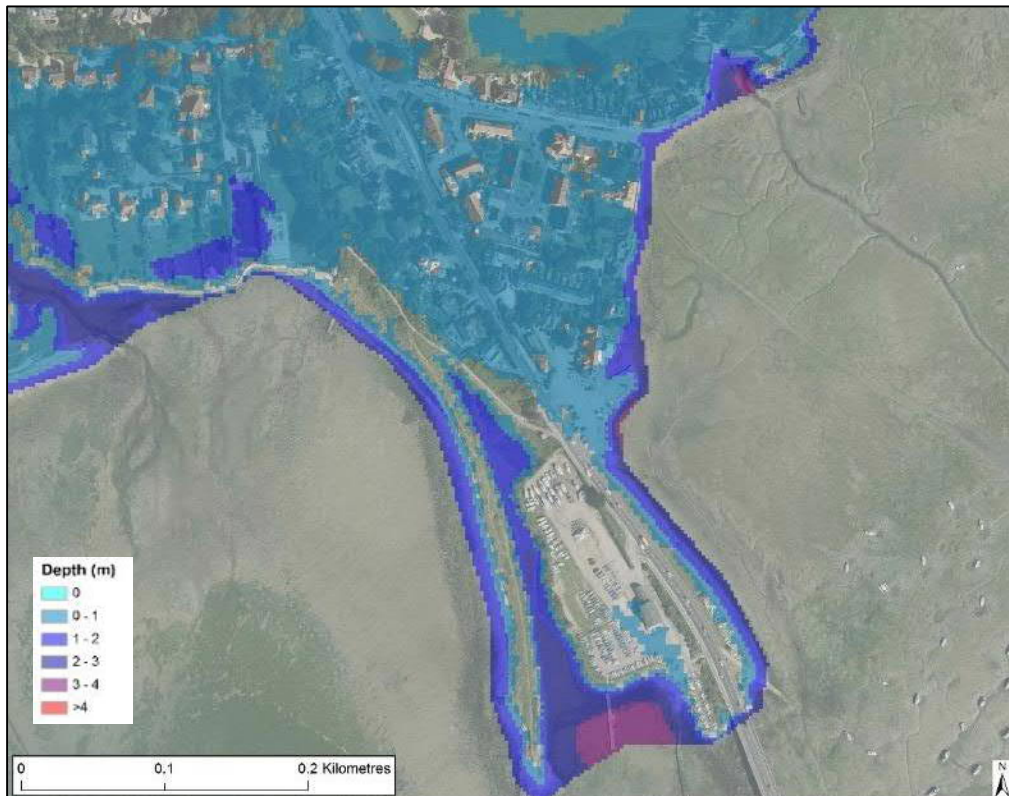


Figure 2-1: 1:200 year present day (2019) flood map of Langstone with existing defences (no overtopping included)

2.1.2 Design life

The appraisal of the different potential options in the Preferred Option Report¹ has been for a 50 year appraisal period. The recommendation for the design working life of maritime structures in BS 6349-1-1² (Table 1) is 50 years. Therefore, this has been adopted as the design working life of the scheme to fit with the appraisal period of the Outline Business Case. Structures will be designed to minimise maintenance during the design life.

2.2 Site Data

2.2.1 Water levels and waves

Tidal Water Levels

The tidal water levels for Langstone Harbour entrance are shown in Table 2-1 below (Admiralty Tide Tables, 2017³).

Table 2-1: Tidal levels

Tidal level	Chart Datum (m ACD)	Ordnance Datum (m AOD)
HAT	5.40	2.66
MHWS	4.80	2.06
MHWN	3.90	1.16
ML	2.93	0.19
MLWN	1.90	-0.84
MLWS	0.80	-1.94

Extreme water levels

The present day 1:200 year return period maximum flood still water level is 3.5m AOD, at high tide.

Waves

No wave data is available at the site. For the design of the rock armour protection, fetch limited wave calculations have been used to estimate the wave conditions (as described in Section 4.3). For establishing crest flood defence levels a freeboard allowance is included as described in Section 2.3.

2.2.2 Topography

The following sources of topographical data is used to support the outline design:

1. Topographical survey data obtained by ESCP, supplied July 2019.
2. Lidar data (DTM) produced by the Environment Agency, composite file download April 2019.
3. Cross sections produced by ESCP, dated March 2013.

Where required due to data gaps interpolation or engineering judgement has been applied.

2.2.3 Geology

A ground investigation was undertaken by WYG in November 2018⁴. AECOM has developed a conceptual ground model based on this data⁵. The typical stratigraphic sequence encountered in the ground investigation is:

- Beach Deposits,
- Occasional Made Ground (typically silty clay)
- River Terrace Deposits
- Alluvium
- Portsdown Chalk Formation

The ground investigation covered most of the frontage, however no investigation has taken place in ODU 1a and 3l (east and west extents of scheme).

2.2.4 Heritage and environment

The Langstone frontage contains several environmentally designated areas. These are:

- Special Area of Conservation – Solent Maritime
- Ramsar – Chichester and Langstone Harbours
- Site of Special Scientific Interest – Chichester and Langstone Harbours
- Special Protection Area – Chichester and Langstone Harbours

There are several Grade II listed buildings along the frontage: as indicated in Drawing LNST-ACM-XX-XX-DR-CE-01002 along with the environmental designations.

The frontage also contains the Langstone, Wade Court and Mill Lane Conservation Areas.

2.2.5 Utilities

Utilities information was obtained in January 2018 by Landmark Information Group⁶. The utilities information is shown on Drawing LNST-ACM-XX-XX-DR-CE-01003.

Table 2-2 below identifies utilities that are in or near the sub-unit frontages and describes their type and location.

Table 2-2: Utilities information by sub-unit

ODU Sub-unit	Utility company	Description	Location
1a	n/a – no utilities located in sub-unit frontage		
1b	Southern Water	900mm concrete surface water pipe and 150mm surface water pipe	Through the private gardens behind the seawall a pipe runs north to south and exits through the seawall. In the east end of the sub-unit a pipe runs from north to south terminating at in an outfall.
2a	Scottish and Southern Electricity Networks	2no. sets of high voltage 33kV cables	These are located near the southern end of the spit, travelling west to east, to the north of the indicative location of sub-unit 2a.
2b	Portsmouth Water	450mm fibre reinforced concrete main	In the northern half of the sub-unit a pipe runs alongside the eastern edge of the footpath, offset varies approximately 2-4m. Towards the southern end of the sub-unit the pipe passes below the footpath to the southwestern side and continues towards the sailing club property. Labelled 'Main in Easement'.
	Southern Water	900mm concrete surface water pipe	In the northern half of the sub-unit a pipe runs alongside the western edge of the footpath, offset varies approximately 1.5-7m. The pipe then travels towards the sea through an outfall (in sub-unit 1b).
	Openreach	One cable.	Located at the eastern end of the sub-unit, where the footpath meets the road pavement.
3b	SGN	Medium pressure polyethylene gas main	Southwest side of car park, continues south down the east side of road embankment before bridge.
	Southern Water	450mm concrete surface water pipe	Runs along southwest side of car park, outfalls through wall.

3d to 3e	n/a – no utilities located in sub-unit frontage		
3f to 3i	Scottish and Southern Electricity Networks	Low voltage underground mains cable	Runs from Langstone High Street along the footpath to south of Green Cottage where it terminates in a pot end joint.
	Openreach	Two cables.	One cable runs from Langstone High Street in front of the footpath terminating at Green Cottage. The other cable is shown aligned behind the footpath in private property.
3j	Southern Water	225mm vitrified clay/ cast iron surface water pipe	Runs west-east along High Street terminating at an outfall on the foreshore. Perpendicular to frontage.
	Openreach	One cable.	Cable runs perpendicular with the frontage alignment across road. Approximately 3m west of timber gate.
	Scottish and Southern Electricity Networks	Low voltage underground mains cable	Cable runs perpendicular with the frontage alignment across road. Approximately 5m west of timber gate.
3k	Scottish and Southern Electricity Networks	Low voltage underground mains cable	Runs along all sub-unit, located in footpath.
	Openreach	One cable.	Runs along all sub-unit, located in footpath for southern half and shown in foreshore on northern half.
	Portsmouth Water	4" PVC main	Runs along most of sub-unit, located in footpath. Terminates just before northern end of sub-unit.
	SGN	Low pressure polyethylene gas main	Runs along most of sub-unit, located in footpath. Just before northern end of sub-unit turns perpendicular to frontage towards Old Mill building.
3l	n/a – no utilities located in sub-unit frontage		

2.2.6 Unexploded Ordnance (UXO)

An Explosive Ordnance Threat Assessment has been undertaken by PLANIT UXB Limited in February 2018⁷. This assessed the threat level as medium recommending mitigation measures to: review and emplace strict control measures if necessary and that a UXO threat mitigation strategy is required to be in place prior to intrusive engineering works at this site of concern. This has been captured in the Designer's Risk Assessment (Appendix B).

2.3 Design methodology

2.3.1 Approach

The preliminary design approaches taken for different structure types are described in the following sub-unit sections. The design has been carried out in accordance with the standards and guidance outlined in Table 2-3. The list presented is not exhaustive and will be supplemented as required.

Table 2-3: Design guidance applied

Design Document
British Standards BS 6379 Maritime Works
Management of Flood Embankments, Defra/Environment Agency, 2007
Performance of River Flood Embankments, HR Wallingford, 1995
CIRIA C731, The International Levee Handbook, 2013
CIRIA C683, The Rock Manual, 2007
Building Regulations Part M, 2010
Inclusive Mobility, Department for Transport, 2005

2.3.2 Design Flood Protection Crest Level

A design flood protection crest level for the outline design of the scheme of +3.8m AOD has been identified collaboratively by the project team based on the still water level design event, providing a 0.3m freeboard to allow for uncertainties. This crest level has been selected to provide a compromise between the competing interests of the scheme; aiming to maximise the benefits delivered but accepting that the local community and stakeholders have reservations about a high defence due to the landscape / visual impacts and impacts on the local heritage and conservation features. It is unlikely that a defence with a crest level any higher than 3.8m AOD would be supported by the community and stakeholders and an increase in defence height would also increase construction costs. A lack of support from the community for the scheme would impact the deliverability of the scheme.

Without additional joint probability and wave overtopping analysis the exact design standard of protection of the scheme considering overtopping is uncertain. Based on a still water level alone, the proposed crest level will protect against a present day 1:200 year return period which has an estimated still water level of 3.5m AOD. The flood risk at the site is tidally dominated due to its sheltered estuarine location, but in localised areas along the frontage which are more exposed, such as in ODU 1b and ODU 3k, there is potential for wave action which could lead to overtopping of the defence crest and a reduced standard of protection. In order to accurately determine the standard of protection, a study to determine the wave overtopping rates based upon the joint probability of extreme still water levels and sustained winds is required.

The design crest level of the defence is approximately 0.3m higher than the present day 0.5% AEP still water level. This difference acts as the defence freeboard (or residual uncertainty allowance) and helps to mitigate the uncertainty in still water levels and to a limited extent the potential wave action that may occur in extreme events.

In some locations where there is a setback defence as part of the scheme, the design crest level has been reduced to 3.6m AOD. For example, at either end of the scheme alignment where the embankment structures tie in to high ground (ODU 1a, ODU 2b and ODU 3l). The decision to reduce the crest height of the scheme in these locations was made because there is less uncertainty in these locations with regards to wave action, as the defence alignment is sheltered and wave action would be significantly depth limited. In these areas a 100mm allowance is applied to reflect potential modelling uncertainty, giving a level of 3.6m AOD.

At the tie-in points to high ground at the western ends of the schemes (core scheme and additional scheme) it is proposed to taper down the ends of the defences from 3.6m AOD to 3.5m AOD. This is to shorten the defence lengths as the ground in these areas tends to be quite flat and retaining to the extra 100mm level increases the defence lengths significantly. A level of 3.5m AOD is viewed as acceptable in these areas as they are not directly adjacent to properties and therefore would not be expected to impact the functioning of the scheme should some

minor outflanking around the end of the defences occur over the short high tide period during the worst case design event.

Table 2-4: Design crest level / freeboard allowance for each sub-unit

ODU Sub-unit	Setback from coastline or frontline	Freeboard (residual uncertainty) allowance	Design crest level
1a	Setback	0.1m	3.6m AOD
1b	Frontline	0.3m	3.8m AOD
2a	n/a – not a flood defence	-	Approximately 4.6m AOD (rock armour erosion protection designed to match crest level of existing spit which varies)
2b	Setback in northern section Frontline in southern section	0.1m in northern section 0.3m in southern section	3.6m AOD in northern section 3.8m AOD in southern section
3b	Frontline	0.3m	3.8m AOD
3d to 3e	Frontline	0.3m	3.8m AOD
3f to 3h	Frontline	0.3m	3.8m AOD
3i	Frontline	0.3m	3.8m AOD
3j	Frontline	0.3m	3.8m AOD
3k	Frontline	0.3m	3.8m AOD
3l	Setback	0.1m	3.6m AOD

2.3.3 Limitations

The outline design of the Langstone scheme has been developed in the presence of a number of limitations, as described below:

- Topographical data:** Topographical data is mostly complete across the frontage. However, interpolation between points has taken place in some locations. Lidar was used to fill gaps, taken on a 1m grid.
- Fluvial flooding:** No consideration has been made on fluvial flooding impact on the scheme. This is particularly relevant at the west end of the frontage, sub-unit 1a where a stream exists.
- Geotechnical data:** The scheme has been developed based on the available geotechnical data. The area covered by ground investigation does not cover all the frontage of the scheme. It is recommended that additional ground investigation take place to provide full coverage for detailed design stage.
- Overtopping:** As discussed in Section 2.3.2 to more accurately define the standard of protection in certain key locations, a study to determine the wave overtopping rates based upon the joint probability of extreme still water levels, tides and sustained winds would be required to support an assessment of residual risk.

3. Core scheme

The following section presents the outline design approach taken for each sub-unit of the core scheme.

3.1 ODU2 – Sub-unit 2b

The preferred option in sub-unit 2b is to raise the level of the footpath in the northern section and an earth embankment in the southern section. The transition between the two different sections is in the area where the footpath turns inland from the coast.

Note that the preferred option for the northern section has been revised since the Preferred Option Report, from a flood wall in the northern section to the raising of the footpath. This change was made due to the required increase in levels being less than originally expected which means that raising of the footpath can take place without requiring significant vegetation clearance (a reason why it was not considered in the earlier options appraisal).

3.1.1 Structure Definition

Crest level

The crest of the footpath in the northern section will be constructed to 3.60m AOD, as it is inland and sheltered by a screen of vegetation (see Figure 3-1 below). In the southern section where some wave action is likely the earth embankment will be constructed to 3.80m AOD. Allowance for settlement of the embankments should be assessed at detailed design with a settlement allowance included if required. Given the relatively low heights of the raising any settlement allowance will be small and will not change the feasibility of the options.

Slope angle

Both the sides of the raised footpath and earth embankment alongside the footpath will have an angle of 1V:3H. The slope angle has been designed balancing the need to reduce the footprint of the structure and to have a structure which is easy to maintain and stable without needing more complex soil strengthening works.

The side slope angle definition is subject to further ground investigation results (in northern section) and a stability assessment. A steeper slope angle than this will make it more difficult to safely maintain and poses a risk of pedestrian falls.



Figure 3-1: Northern section of sub-unit 2b

Width

The width of the raised footpath will match the existing footpath width, typically 1.9m. The surface finish of the footpath will match with the existing finish.

There is no footpath requirement on top of the structure in the southern section. The crest width has been designed as 1m. Vegetation should be planted on top of the embankment to prevent pedestrians using it as a walkway instead of the existing footpath.

Fill

The existing footpath will be retained and the ground level raised using a low permeability material such as compacted clay to prevent seepage through the embankment. It has been assumed based on the conceptual

ground model for the preliminary design that the existing material under the embankment is of low permeability, this will need to be verified in the next design stage to ensure there is no significant seepage beneath the embankment, that could lead to piping failure.

Earth embankment scour protection

As the earth embankment is not setback from the coastline the need for scour protection in the southern frontage has been preliminarily assessed. The frontage where the earth embankment is proposed in this ODU is sheltered by the spit and the sailing club. Both these areas are raised above the design extreme water level (3.5m AOD) and therefore provide shelter from waves to the frontage. The toe of the embankment will be above MHWS and therefore will only be exposed to high tidal water levels infrequently in extreme events. Therefore, scour protection is not considered as a requirement, this should be confirmed at the detailed design stage.

3.1.2 Alignment

The earth embankment in the southern section will be built alongside the southern edge of the footpath, this alignment makes use of the existing raised ground in this location. At the western end of the earth embankment the existing ground level is above the design water level and therefore raising in this area is not required, as shown in Figure 3-2 (based on Lidar data). The exception of this is two low spots where there are access tracks to the foreshore which will be raised. In these locations timber plank steps are recommended to prevent foot traffic erosion. Further topographical investigation is required in this area to confirm its level is suitable. At the eastern end of the embankment it will tie-in to the edge of the pavement which is at the design crest level (3.8m AOD).



Figure 3-2: Sub-unit 2b southern section existing raised ground - orange areas are above 3.8m AOD

The raised footpath will follow the alignment of the existing footpath, this will minimise the vegetation clearance required. At the northern end the new footpath crest will taper downwards to tie-in to the existing footpath at a level of 3.5m AOD just before the footpath 'crossroads'. At the southern end, the footpath, once it runs behind the southern section embankment should gradually taper down to the level of the existing footpath.

3.1.3 Other Considerations

Utilities

There is a Portsmouth Water main and a Southern Water surface water drainage pipe alongside the footpath in the northern section, the depth of these pipes is currently unknown. These should be investigated further to confirm their depth and consideration given on how this influences the design of the proposed defences. It is expected that they will be at greater depth than any proposed excavation and will not impact the works.

Accessibility

There is the potential opportunity to increase the width of the footpath and make it more user friendly by introducing a dedicated cycle lane. However, given that the new footpath is a relatively short length of a longer footpath, and some of the existing footpath is at an adequate level, this has not been included in the design and so the width of the footpath is proposed to match the existing.

Raising southern section footpath

Extending the length of footpath that is raised, to run across all of the sub-unit, has been considered. However, it is not included in the design to make best use of the existing raised bank along the south side of the footpath and to reduce the cost. The level of the existing footpath in this location is lower than in the northern section meaning that it would have a larger width.

Historic railway line

The footpath is located on the alignment of the old Hayling Island 'Billy' railway line. This has not impacted the design of the scheme given that the options involve limited excavation, but the historic use should be a consideration during construction.

There are potential plans led by Havant Borough Council to regenerate this line. No information is currently available on the likelihood of this or what the plans will be, therefore this has not influenced the design.

3.2 ODU3 – Sub-unit 3b

The preferred option in sub-unit 3b is for a concrete flood wall with a flip-up flood barrier allowing access to the car park. The wall and flip-up barrier will have crest heights of 3.60m AOD as they are setback in the car park and therefore wave energy will be reduced in this location compared to if they were nearer the foreshore.

Since the development of the Preferred Option Report further topographical survey data has confirmed the need to extend the western end of the flood defence to the south, parallel with the road. This is to prevent flood water flowing over the southwest edge of the car park and reaching Langstone Road. This is considered a cheaper solution than extending the flip-up barrier to the required tie-in point.

3.2.1 Structure definition

Flip-up flood barrier

The flip-up flood barrier has been designed based on a product from Flood Control International Limited, other similar products are available. Flood Control International Limited have visited the site and confirmed the viability of their product in this location.

As the location of the barrier is in a public car park the ground must be levelled for vehicle access not to be affected. The level across the car park where the barrier is aligned varies by approximately 20cm (2.8 – 3.0m AOD). The design proposes that along the barrier alignment the ground will be raised and levelled locally so the crest of the undeployed barrier is at 3.0m AOD. This is seen as a lower cost option compared to lowering the ground level.

The transition from the existing ground level to the raised level will be made by sloping the ground on either side of the barrier to a 1:12 gradient. This gradient has been chosen as it is suitable for unassisted wheelchair users⁸ as well as for cars to drive over.

Flood wall

The flood wall will be reinforced concrete to provide a non-permeable structure to interrupt the passage of flood water. Given the low height of the wall and the lack of constraints relating to the size of the base of the wall no geotechnical stability or structural calculations have been undertaken which is appropriate for this stage of design.

Where the flood wall does not run adjacent to the existing handrail, it will require a handrail on top to avoid becoming a trip hazard.

3.2.2 Alignment

The flip-up barrier shall span the shortest possible distance, given its high unit cost, on the alignment from the end of the Ship Inn existing wall to the edge of the grass area to the south of the entrance. To reduce the length

of the flip-up barrier it is proposed to increase slightly the length of the adjacent concrete wall flood wall. This will reduce the width of access into the southern area of the car park, a preliminary width of 8m has been designed for the length of the flip-up barrier. 7.3m is the minimum recommended dimension for a two lane urban all-purpose road and therefore this allows two vehicles to pass each other⁹. This length and location of flip-up barrier should be optimised in detailed design including review of optimal parking arrangements / useable space. If the access is sufficiently narrow flood gates could be considered.

As it is proposed for the flood wall to be extended into the car park, either side of the flip-up barrier, consideration must be given to preventing it becoming a hazard to drivers. Potentially the ground surrounding the new flood wall extending into the existing car parking area could be landscaped or railings fixed to the top to make it more visible.

The flood wall should be adjacent to the existing pavement handrail in the southern section to avoid becoming a trip hazard and then continue on this alignment until it turns perpendicular to meet the flood barrier. The southern end of the flood wall will tie-in to the existing ground level at 3.6m AOD. Where it extends beyond the existing handrail it will have a new handrail in top.

The northern end will meet the southern end of the existing wall in front of the Ship Inn. The crest level of this wall is estimated to be just above 3.6m AOD, this requires verifying in the next design stage. Therefore, as it has an appropriate crest level (setback defence) it is proposed to incorporate the existing wall into the flood defence. Through visual inspection the wall appears in good condition, the structural suitability and crest level of the wall should be confirmed in detailed design, if it is not suitable it will be modified or replaced.



Figure 3-3: Existing wall proposed to be left in place at northern end of sub-unit 3b (photo ©2019 Google Maps)

3.2.3 Other Considerations

Operation

There are different methods of deploying flip-up barriers including sensors, automatic push-button operation and manual deployment. Generally, the automatic operation has a manual backup. A sensor-based system is not recommended given the associated risks of a barrier deploying without supervision. On preliminary assessment, the forecastable nature of flood events means that the emergency response team should have adequate time to manually deploy the barriers. At a later design stage the cost difference between automatic and manual systems should be investigated along with consideration of the emergency response plan to decide on the preferred system.

No parking zone

There are currently no parking bays marked in the public car park. The upper face of the undeployed barrier and an offset area should be painted to mark it as a no parking zone. A vehicle being parked over the barrier and stopping it from being deployed is a potential risk for the scheme. However, coastal flooding is a forecastable event and the Environment Agency provides a minimum of twelve hours advanced warning in locations at risk of tidal flooding. Therefore, if this occurred there would be time for the response team to have the car removed.

Surface water drainage

The ground in the car park slopes from northwest to southeast, towards the coastline. Therefore, the ground raising for the barrier, when undeployed, will interrupt the surface water drainage across the car park. This should be explored further at detailed design.

Utilities

Towards the western end of the car park the flood wall crosses a gas main and a surface drainage pipe, the depth of these pipes are unknown.

Emergency vehicle egress

The design must consider what action to take if unattended vehicles are on the seaward side of the flip-up barrier when it is to be deployed. There is the potential risk of the vehicle owner returning to their car to find the vehicle partially submerged. Two potential solutions are available:

1. Have the vehicles moved to the dry side of the wall by a vehicle recovery service prior to deploying the barrier. A disadvantage of this option is that it relies on the availability of a service to move the cars within the time available.
2. Include in the design an emergency egress ramp in the south corner of the car park. This would take vehicles up onto the road with the ramp crest height matching the flood defence. A gate would be positioned along the alignment of the handrail next to the road pavement at the top of the ramp and would normally be padlocked. During a flood event emergency response staff would have to supervise vehicles exiting the ramp onto the road. A disadvantage of this option is that emergency response staff are required to stay at the barrier to manage traffic along the road to ensure a safe vehicle exit. It also could encourage drivers to take risks such by driving their vehicles into the car park in unsafe flood conditions.

Both these options have risks associated with them. These options should be assessed further during detailed design.

3.3 ODU3 – Sub-unit 3d, 3e

The preferred options in sub-unit 3d and 3e are a flood wall incorporating a glass flood barrier at the top along the Ship Inn as well as a flood wall along the edge of the private property garden adjacent to the Ship Inn.

3.3.1 Structure definition

The crest level of the defence should have a level of 3.8m AOD. At the Ship Inn a new reinforced concrete flood wall will be constructed behind the existing wall to provide a flood defence and support the glass barrier. The new flood wall is to be no higher than the existing flood wall shown in Figure 3-4 to maintain the view from the pub seating area. The level of the existing wall means the glass barrier will be 0.4m high.

The wall along the edge of the property garden will also be a reinforced concrete flood wall but with no glass barrier top. Given the low height of the walls and the lack of constraints relating to the size of the base of the wall no geotechnical stability or structural calculations have been undertaken which is appropriate for this stage of design.



Figure 3-4: Sub-unit 3d to 3e existing wall in front of Ship Inn

3.3.2 Alignment

The alignment of the wall at the Ship Inn is to be behind the existing wall to restrict loss of space as much as possible and avoid impacts on the intertidal foreshore and slipway. The wall along the private garden will be located on the alignment of the existing white picket fence at the top of the concrete revetment structure seen in Figure 3-5.

The west and east ends of the defence will tie-in to the floodwalls in sub-units 3b and 3f respectively.

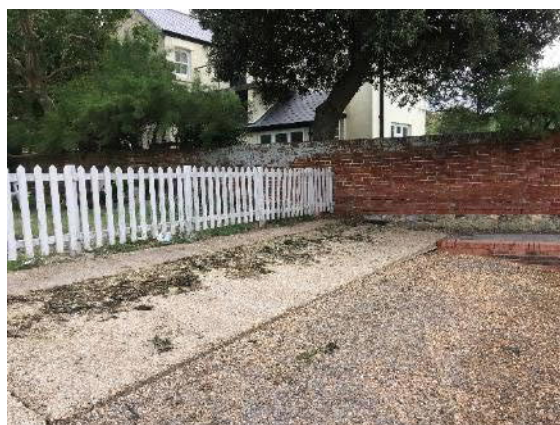


Figure 3-5: Sub-unit 3d to 3e existing fence along private property boundary

3.3.3 Other Considerations

Surface water drainage

The existing drainage pipes in the wall at the Ship Inn will either be extended through the new wall or consolidated into larger pipes in new locations. Both solutions will require tidal flap-valves. This should be explored further at detailed design.

Flood gates

Two flood gates will be required along this sub-unit frontage. One positioned at the top of the steps shown in Figure 3-4 and the other to give access to the residential property garden. As an alternative to flood gates stoplogs should also be considered.

3.4 ODU3 – Sub-unit 3f, 3g, 3h

The preferred option in sub-unit 3f to 3h is to build a new flood wall in front of the existing garden walls and then provide improved access via a boardwalk. In the location of the Green Cottage where there are no existing garden walls the flood wall will be aligned with the existing seawall.

3.4.1 Structure Definition

Flood wall

It is proposed to install trench sheets in front of the existing brick seawall in Figure 3-6 to ensure the future stability of the wall, against reductions in foreshore level and undermining of the seawall and footpath by wave action. The option of a 'like-for-like' replacement of the seawall has been assessed and it is viewed as an expensive option with significant risks.

The existing seawall retains the footpath, the flint wall and the private gardens behind. There are missing bricks in the wall, so it is likely that material has been washed out from below the footpath and voids formed. Replacing the brick seawall would have to take place in short sections and would involve excavating down in front of the seawall risking instability of the ground behind. It would involve a significant amount of temporary works at high cost, which is avoided by the use of trench sheets, that do not require excavation of the beach.

Installing permanent trench sheets and filling in between the sheets and the existing seawall would act to stabilise the existing seawall. It is proposed that these would be installed just in front of the existing seawall apron which is exposed along much of the frontage, as shown in Figure 3-6.



Figure 3-6: Sub unit 3f to 3h showing existing seawall apron

Behind the trench sheets a new reinforced concrete flood defence will be constructed in front of the existing garden walls. This should be slightly offset from the existing garden walls to cope with any undulations in the profile of the existing walls. Behind the new flood wall the gap between it and the existing will be sealed to prevent any water entering. To achieve this the gap will be filled with lightweight no fines concrete and the top sealed. Weep holes should be provided through the existing wall to prevent any build-up of water in the gap should it enter through the seal (no fines concrete is permeable). Potentially there will be a requirement to support the existing garden walls during pouring of the no fines concrete to prevent instability. This could be achieved through installing tie-rods between the new and existing wall.

Boardwalk

The boardwalk structure is proposed because the new flood walls will narrow the footpath which is only currently approximately 1100mm wide in some sections.

Width of boardwalk

The timber boardwalk has been designed to have a width of 1500mm to give sufficient space for a wheelchair user and pedestrian to pass each other¹⁰. To allow two wheelchair users to pass each other, 2000mm is recommended by guidance, however 1500mm is acceptable where there are constraints. Given the site constraints including environmental concerns regarding shading of the foreshore the minimum width of 1500mm has been selected. Potentially, passing places of 2000mm width could be incorporated at intervals.

Material

Consultation feedback from Historic England¹¹ recommends the boardwalk is constructed from "high quality natural materials, possible timber" to protect the character of the conservation area, this has been applied in the

design. Hardwood timber has a lower design working life than the 50 year design life and therefore refurbishment of this structure will have to be included in the whole-life scheme costs.

3.4.2 Alignment

Typically, the flood wall is to be located along the existing garden walls. In front of Green Cottage the wall follows the alignment of the existing seawall to reduce visual impact on the listed building. The boardwalk is to be continuous along the frontage including around the land in front of the Green Cottage frontage, as shown in Figure 3-7.

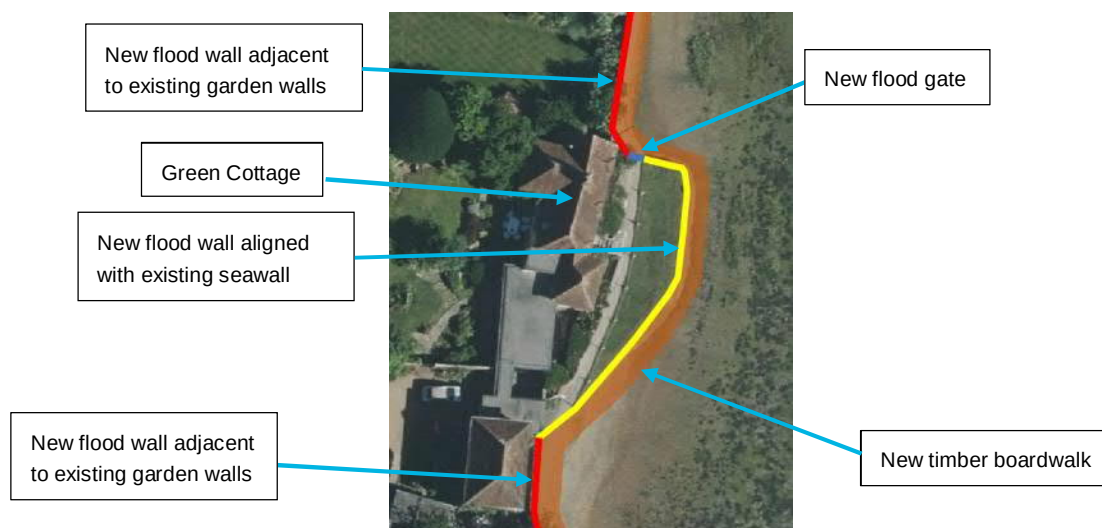


Figure 3-7: Sketch plan of wall and boardwalk alignment at Green Cottage

To the north the upstand of the flood wall will end at the start of sub-unit 3i, however the trench sheets and boardwalk will continue to end of the sub-unit to ensure the stability of the existing wall and provide the same amount of access as the rest of the modified frontage. To the south the flood wall will connect with the floodwall of sub-unit 3e.

3.4.3 Other Considerations

Level of new defence structure

There are two potential options for the level of the new floodwall and boardwalk which have different advantages and disadvantages.

Option 1: Install new flood wall on level of existing footpath with boardwalk on top.

The advantage of this option is that it avoids the requirement to excavate in front of the existing garden walls. The wall height will also be less. The installation of the wall units will therefore be quicker and lower cost. The disadvantage is that the boardwalk will end up at a raised level compared to the existing footpath, preliminarily estimated at a 0.40m increase in level.

Option 2: Install new flood wall and boardwalk so that the level of the boardwalk matches the level of the existing footpath.

This option will require excavating in front of the existing walls, construction will be slower and more expensive because of having to work in small sections potentially with additional temporary works to stabilise the walls. The advantage of this option is that there will be no change in level of the footpath.

Option 1 is the recommended option based on cost and risk during construction, however it is understood there are concerns from residents about being 'overlooked' when they are not currently. Based on the typical cross-sections this concern will not be realised, however the crest levels of the garden walls have been estimated. One area where raising the footpath level will have an impact is in front of the property to the south of Green Cottage shown in Figure 3-8. The significance of raising the footpath level could be better assessed by undertaking a topographical survey along the crest level of the existing garden walls and further consultation with residents.

Property to south of Green Cottage

The wall in front of the property to the south of Green Cottage, shown in Figure 3-8, has been estimated to be lower than the design crest level (3.8m AOD). This is based on an on site measurement of the wall being 82cm height and the level of ground being 2.8m AOD from the topographical survey. Therefore, the new flood wall will be approximately 20cm higher. The existing wall crest level appears to have been set to not obstruct views from the windows of the property. The potential options are to continue the flood wall across this area, accepting the 20cm increase in level, or potentially the use of a glass barrier top could be investigated to maintain the existing view whilst implementing the design flood level.



Figure 3-8: Sub unit 3f to 3h property to south of Green Cottage

Utilities

Located in the footpath is a Scottish and Southern Electricity low voltage cable that runs from the high street to near Green Cottage. This cable was uncovered during the ground investigation 0.45m below ground level. It is recommended that during the detailed design stage the utility company is contacted about the approach to be taken to this cable and what form of future access is required. Potentially the cable could be left in place beneath the new flood wall or a duct could be located along the base of the new flood wall, below the timber decking, to accommodate the relocated cable.

Pile differential settlement

The continuous timber beam supporting the timber deck should be designed to allow for different rates of settlement of the piles. This should be considered in the detailed design stage.

Flood gates

A flood gate will be required to give residents of Green Cottage access onto the boardwalk. This should be designed as private access. Another flood gate will be required at the rear of the boardwalk to maintain the existing access to the footpath, through the gate shown in Figure 3-9.



Figure 3-9: Sub unit 3f to 3h flood gate location

Alignment around Green Cottage

As shown in Figure 3-7 the proposed alignment at Green Cottage is for the new wall to follow the alignment of the existing wall and for the boardwalk to extend seawards from this. Potentially in this location there is an opportunity for the new seawall to be placed further landward and for the new footpath to be placed over the existing land. This would remove the encroachment of the timber boardwalk on the environmentally designated foreshore in this area. As the land in front of Green Cottage is privately owned consultation will be required with the property owners in order to assess the viability of this alternative alignment.

3.5 ODU3 – Sub-unit 3i

The preferred option in sub-unit 3i is to use the current property as a flood defence, from ESCP discussions with the residential property owner it is understood that the building wall has already been flood-proofed internally, although the exact detail has not been determined.

There is considerable uncertainty regarding the building, therefore it is recommended to undertake further investigation of the existing building to confirm that the property is appropriate to be used as a flood defence as part of the scheme. Discussions with the building owner will also be necessary to ensure that they are in support of any scheme involving their building acting as a flood defence and that they are aware of the potential implications that this brings.

Along the front of the property, where the current footpath is located, the trench sheet, new brick wall and the boardwalk will be continued along this sub-unit.

Depending on the outcomes of the further investigation work additional flood proofing could be added to the wall to increase the robustness of the defence, for example, a water proof membrane could be added to the outer wall (similar to the Royal Oak).

Alternatively, if it is assessed that the building cannot be used as a flood defence then the option of sub-unit 3f to 3h could be extended to 3i. In this case the level of the lower window sill, shown in Figure 3-10, is approximately 20cm below the design crest level of 3.8m AOD so consideration of how this is integrated must be given. Potentially a small section of glass flood barrier could be positioned in front of the window supported by the new flood wall to retain the existing view.



Figure 3-10: Sub-unit 3i property

3.6 ODU3 – Sub-unit 3j

The preferred options in sub-unit 3j is to use flood gates across the end of the road.

This will include two flood gates: a pedestrian gate adjacent the flood-proofed property (sub-unit 3i) and a double leaf gate along the width of the road with a demountable central post.

3.6.1 Alignment

The preliminary position of the flood gates has been determined considering a range of factors. Firstly, the gates are designed to open seawards as opening them landwards would require regrading of the road. Secondly it has been considered that positioning the main gate across the end of the road, on the alignment of the existing timber posts shown in Figure 3-11, is near the MHWS level. There is the risk that the built-up deposits of debris could interfere with the operation of the gates (seen in photo). And that as the ends of the undeployed gates will extend seawards, the lower level of ground here means the water level potentially could prevent the gates being closed safely in a flooding event.



Figure 3-11: Sub-unit 3j

Therefore, it is proposed to position the gates approximately 3m in from the end of the road as shown in Figure 3-12. In order to achieve this the flood wall from sub-unit 3k should be extended on the north side. On the south side either the side of the property in sub-unit 3i is relied on as a flood defence or a short section of flood wall is constructed as shown in Figure 3-12. This is dependent on the investigation of the flood-proofing of the building described in Section 3.5.

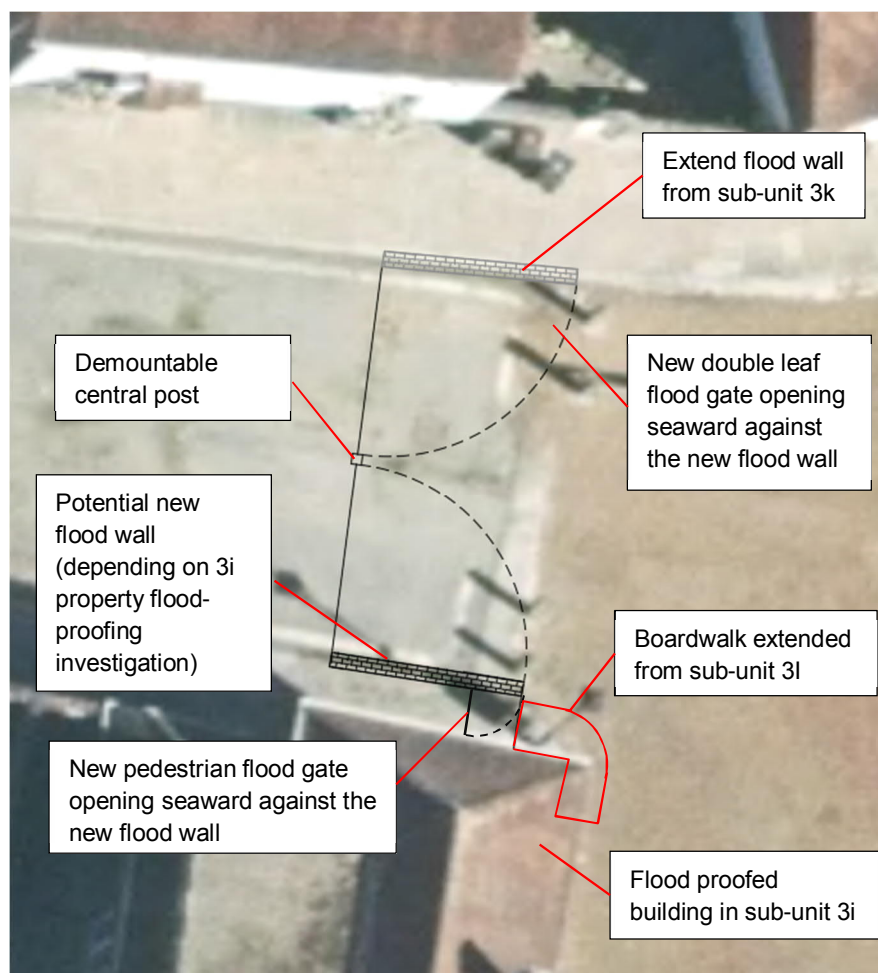


Figure 3-12: Sub-unit 3J potential alignment

3.6.2 Structure definition

Pedestrian flood gate

The pavement alongside the property in sub-unit 3i will have a flood gate. The flood gate will connect to a post adjacent to the wall of the sub-unit 3i property and on the other side to the potential new flood wall. The approximate width of the flood gate will match the pavement width of 1.5 metres (assuming the new wall is located along the edge of the road). The gate height will be approximately 1.1m and will be padlocked against the new flood wall when not in use.

Flood gate across road

The width across the road is approximately 8m. A double gate is proposed rather than a single gate because the width of a single gate would potentially require additional support and at the proposed alignment its end would be located below MHWS when not in use. The height of the double gate would be approximately 1.4m spanning between the two new flood walls. The demountable intermediate post can be stored in a metal padlocked box located along one of the walls.

3.6.3 Other Considerations

Utilities

There are a number of utilities passing along the road and going through sub-unit 3j. These utilities should be investigated further to confirm their depth and consideration given on how this influences the design of the proposed defences.

Emergency response plan – Old Mill

The emergency response plan should also consider how to give warning to the Old Mill property and its neighbouring property when the flood gate across the road in sub-unit 3j is to be deployed in order that they can

evacuate their vehicles if they wish. The property owners currently use the slipway and the foreshore as vehicle access and the Old Mill property is not within the area the scheme will protect from flooding.

Obstruction of resident's views

Extending the wall from sub-unit 3k 3 metres in from the end of the road in order to remove the operational concerns of being aligned near MHWS level will impact the views from the lower windows of the property at the end of the High Street on the north side. Potential mitigation could be to include short sections of glass barrier in front of the windows or sections of 'cutout' parapet designed to be filled with stoplogs.

3.7 ODU3 – Sub-unit 3k

The preferred option in sub-unit 3k is to construct a new parapet wall on the alignment of the existing seawall.

Note that the preferred option has been revised since the preferred option report, from a sheet piled wall to a parapet wall. This change was made because in the options appraisal the existing wall was assumed to not be suitable to support another structure and it was assumed any new structure would require foundations that would not be possible given the amount of buried services in the footpath. This has since been re-assessed and the parapet option developed.

Initial stability calculations and geometric checks confirm that a parapet is feasible without significant foundations. It is recommended a further structural assessment of the existing wall to confirm it can take the additional load of the parapet. Because there is some uncertainty about the structural condition of the existing wall, the original option of a wall in front of the existing seawall is provided as alternative option.

3.7.1 Structure Definition

Option 1 – Parapet wall

The parapet wall option will involve constructing a parapet wall on top of the existing wall. The parapet wall will be constructed of stone using a similar technique and materials as the existing wall. A structural survey of the wall by Scott Wilson undertaken in 2008¹² identified there were no immediate structural concerns for the stability of the wall and recommended local re-pointing and replacement of missing stones take place. This work has since been completed. For the parapet option to be progressed a similar structural survey is recommended to check the wall has no defects which may indicate it cannot cope with the extra load imposed by a parapet structure.

The thickness of the wall has been preliminarily sized as 400mm. A hand calculation has been performed to assess the stability of this parapet wall. The results indicate, using the global safety coefficient method, that dowel bars are potentially required fixed into the existing structure to prevent sliding and overturning. Drainage holes with flap valves should be provided at the bottom of the wall to prevent any water overtopping the wall or rainwater from building up.

A constraint of the parapet wall option is the width of the existing footpath. The narrowest section of the footpath, at the eastern end of the Royal Oak, is estimated to be 1.7m wide, this should be verified through on site measurement. 1000mm is the narrowest recommended clear width for a wheelchair user and is acceptable if there is an obstacle and the footpath widens either side¹⁰. Therefore, there is enough space for a 400mm parapet wall. If the width of the footpath in this area is less than 1.4m then potentially local widening works could take place. During detailed design it should also be considered that locating the parapet offset from the front of the existing seawall will reduce loading of the front of the seawall. Should dowels be required offsetting the wall could be more likely to interfere with the buried services.

Option 2 – Wall in-front of the existing structure

This option should be progressed if Option 1 is prohibited because of the stability of the existing walls or because of the location of existing buried services.

This will involve installing king posts (H sections) at intervals in front of the existing wall. A steel beam will then be welded between the posts and used to support precast reinforced concrete panels. Between the precast concrete panels barrier and the existing wall there will need to a waterproof barrier. A potential method is horizontal precast concrete panels fixed between to the beam and to the existing wall with any gaps sealed.

Some leakage between the panels and H beams would be acceptable, due to the level of the existing walkway it will be for a short duration associated with tidal flooding.

3.7.2 Alignment

The parapet option would ideally be aligned along the front of the existing seawall to maximise the width of the footpath. As discussed above this will depend on the structural integrity of the existing seawall and potentially could have to be offset. The king post wall in-front of the existing seawall would have to be slightly offset from the existing seawall to avoid the foundation of the wall.

Both options would tie-in to the flood gate to the west and the proposed flood wall in sub-unit 3l to the east.

3.7.3 Other Considerations

Utilities

As discussed above there are numerous key services buried beneath the footpath in this location. Should Option 1 be progressed these should further be investigated.

Emergency egress

There is a requirement for an emergency egress plan for the Old Mill Property (which is outside the flood defence), its neighbouring property and along the coastal footpath to the northeast during extreme coastal flooding events. There is a risk that when the flood gate is closed between sub-unit 3k and 3l that people are trapped 'outside' the flood defence. One option would be to provide signage to direct people along the public footpath running to the north where high ground can be reached (sub-unit 3l), however this option carries the risk of people not noticing or following the instructions. It is also seen as impracticable because the person would have to travel approximately 200m before exiting the 1:200 year return period event flood extent. Another potential option with less risk would be to provide some access steps for emergency use only near the slipway to provide a safe route for people to take over the flood defence in an emergency. The steps potentially could be located alongside the southern end of the sub-unit 3l flood wall, next to the flood gate. They will have a handrail on either side of the steps and will be closed off during normal operation and only opened during a flood event once the flood gate is closed. The detail design will confirm this requirement.

Obstruction of Royal Oak and neighbouring property windows

The Royal Oak and the neighbouring properties have windows which are at a lower level than the crest level of the new flood wall in this location, shown in Figure 3-13. Therefore, the sea views from these properties will be obstructed. Potential solutions could be short sections of glass barrier in front of the windows or sections of 'cutout' parapet designed to be filled with stoplogs. Including glass flood barrier will increase the cost of the scheme and there are increased risks using stoplogs rather than a permanent structure, whether to include either of these refinements should be assessed at the detailed design stage.



Figure 3-13: Sub-unit 3k Royal Oak

Continuation of existing property level protection

As seen in Figure 3-13 there is existing property level protection in the doorways of the Royal Oak and the neighbouring properties. Potentially these property level protection measures should be retained even after the scheme is implemented to protect against the risk of residual wave overtopping risk (as discussed in Section 2.3.2) or flood events which exceed the design standard of protection.

3.8 ODU3 – Sub-unit 3I

The preferred option in sub-unit 3I is a flood wall along the west side of the footpath in the southern section, transitioning into an earth embankment in the field in the northern section.

3.8.1 Structure Definition

Southern section – flood wall

The flood wall will be a reinforced concrete to provide a non-permeable structure to interrupt the passage of flood water. Given the low height of the wall and the lack of constraints relating to the size of the base of the wall no geotechnical stability or structural calculations have been undertaken which is appropriate for this level of design.

The structure will replace the existing wall towards the southern end of the sub-unit, either side of the property access, and the fence further north along the property boundary next to the footpath. Therefore, on top of the wall a fence should be installed to the same crest level as the existing so the appearance remains unchanged.

The crest of the wall will be 3.60m AOD. No waves are expected at this location. The foundations of the private property are unknown. The flood wall has been designed to offset the base from the side of the property for this reason.

Northern section – earth embankment

Crest height

The crest of the embankment impermeable fill will be 3.60m AOD. Allowance for settlement of the embankments should be assessed at detail design with a settlement allowance included if required. Given the relatively low height of the raising any settlement allowance will be small and will not change the feasibility of the option.

Slope angle

The slope angle has been designed balancing the need to reduce the footprint of the structure and to have a structure which is easy to maintain and stable without needing more complex soil strengthening works. The side slope angle will be 1V:3H subject to further ground investigation and stability assessment. A steeper slope angle than this will make it more difficult to safely maintain.

Width of crest

The only known maintenance requirement is grass and vegetation cutting in the field. There is no footpath requirement on top of the structure. The crest width has been designed as 1m.

Fill

The embankment will be formed of a low permeability material such as clay to prevent seepage through the embankment. It has been assumed based on the conceptual ground model for the preliminary design that the existing material under the embankment is low, this will need to be verified in the next design stage to ensure there is no significant seepage beneath the embankment. There has been no ground investigation along the alignment of this structure.

3.8.2 Alignment

The flood wall has been designed to run along the private property boundary on the west of the footpath (on the inside), replacing the existing walls and fence. This will result in a loss of width from the property garden of approximately 300mm. This should be discussed with the property owner during consultation. The alternative is to reduce the footpath width, however it is already narrow and this could affect accessibility along the footpath. Potentially, an alternative alignment would be along the inside of the private property on the east side of the footpath. Again, consultation with the property owner should take place to assess the viability of this alignment.

The preliminary design has assumed the walls either side of the property vehicle access are to be replaced (shown in Figure 3-14 and Figure 3-15). In the further design stage it is recommended to investigate whether these walls can be formalised into flood defences avoiding the need to replace them. This will involve confirming the crest heights of these walls and assessing their structural stability in the design flood event.



Figure 3-14: Sub-unit 3l existing wall

At the southern end of the sub-unit the wall will connect to a flood gate positioned perpendicular, this will cross the footpath connecting to the sub-unit 3k flood wall on the other side as shown in Figure 3-15.

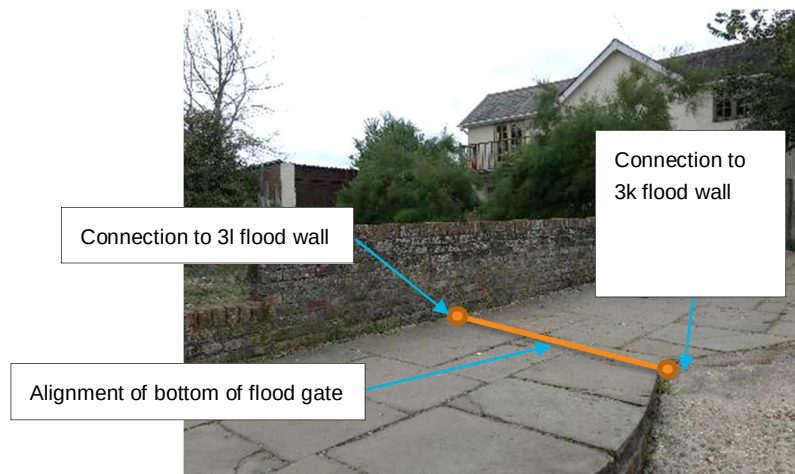


Figure 3-15: Sub-unit 3l/3k transition proposed flood gate location

At the north end of the sub-unit the earth embankment will continue until an existing ground level of 3.5m AOD is reached.

3.8.3 Other Considerations

Narrowing of footpath

The narrowing of footpath has been discussed above. To establish the most appropriate alignment consultation with the property owners is recommended and consideration given to the impact of narrowing the footpath in this location.

Flood gates

As well as the flood gate shown in Figure 3-15, towards the southern end of the sub-unit a flood gate will be required across a private property vehicle entrance, shown in Figure 3-16. As an alternative to flood gates stoplogs should also be considered in both these locations.



Figure 3-16: Sub-unit 3f flood gate location across property vehicle access

Embankment wave action protection

Due to the lack of exposure, shallow profile and relatively low height of the embankment there is no requirement for surface protection against wave action.

Land drainage in field

It has been assumed that no land-drains exist in the field the embankment is aligned in. This should be confirmed at detailed design stage as their existence would provide a potential pathway for flood water.

Implications on groundwater movement should be considered at detailed design to ensure that pluvial flood risk is not increased on the by the flood defence embankment.

3.9 Summary of flood gate / stoplog locations

At this design stage the locations and approximate dimensions of flood gates have been identified. None are required for the Additional Scheme section.

Currently it is the preferred option to utilise floodgates rather than stop logs to reduce residual risk. Typically stop logs are a less expensive option, however they require space for storage and take longer to deploy. It is understood that the ESCP will be responsible for the maintenance and operation of whatever system is chosen.

The required heights and lengths of the flood gates have been assessed at this stage based on available topographic data and are shown in Table 3-1. No on-site measurements have been taken to confirm the gate length requirements. Photographs of the locations of the proposed flood gates / stop logs are shown in Appendix C.

Table 3-1: Summary of flood gate / stop log locations in Core Scheme

Flood gate no.	Sub-unit location	Approximate height	Approximate length	Description
1	3d to 3e	1.1m	0.8m (to match existing access width)	Across existing steps by Ship Inn
2	3d to 3e	1.0m	1.5m	Along flood wall aligned on private property boundary
3	3f to 3h	0.9m	0.8m (to match existing access width)	Across access footpath to boardwalk frontage
4	3f to 3h	0.9m	1.5m	Private access for Green Cottage residents to boardwalk

5	3j	1.1m	1.5m	Across pavement at end of Langstone High Street
6	3j	1.4m	7.5m	Double leaf flood gate. Across end of Langstone High Street.
7	3k / 3l	1.2m	1.5m	Across footpath where floodwall changes from frontline to setback
8	3l	1.0m	3.5m (to match existing access width)	For vehicular access to property
9	3l	0.8m	0.8 (to match existing access width)	Pedestrian access to property where there is existing gate in fence

4. Additional scheme

The following section presents the outline design approach taken for each sub-unit of the additional scheme.

4.1 ODU1 – Sub-unit 1a

The preferred option in sub-unit 1a is an earth flood embankment.

4.1.1 Structure definition

Crest height

The crest of the embankment impermeable fill will be 3.60m AOD. Allowance for settlement of the embankments should be assessed at detailed design with a settlement allowance included if required. Given the relatively low height of the raising any settlement allowance will be small and will not change the feasibility of the option.

Slope angle

The slope angle has been designed balancing the need to reduce the footprint of the structure and to have a structure which is easy to maintain and stable without needing more complex soil strengthening works. The side slope angle will be 1V:3H subject to further ground investigation and stability assessment. A steeper slope angle than this will make it more difficult to safely maintain.

Width of crest

The only known maintenance requirement is grass and vegetation cutting in the field. There is no footpath requirement on top of the structure. The crest width has been designed as 1m.

Fill

The embankment will be formed of a low permeability material such as clay to prevent seepage through the embankment. It has been assumed based on the conceptual ground model developed that the existing material under the embankment is low, this will need to be verified in the next design stage to ensure there is no significant seepage beneath the embankment. There has been no ground investigation along the alignment of this structure.

4.1.2 Alignment

The alignment of the defence is set-back along the eastern edge of the field. It will be less prone to erosion here compared to placing along the riverward face due to exposure to larger waves and higher velocity river flows along the riverbank. This alignment will also avoid working in tidal conditions.

The level of the field increases to the north where the defence will tie-in to the existing ground level at 3.5m AOD. The alignment along the eastern edge of the field is the shortest available alignment to tie into the design flood level.

To the south of the field is a heavily vegetated area where the topography is uncertain. The Lidar data indicates that in this location until the tie-in to sub-unit 2b to the east that most of the ground is raised above the design crest level of the embankment with some low spots as shown in Figure 4-1. If this is confirmed through investigation on site then some local ground raising will be required to fill the low spots in the existing embankment.



Figure 4-1: Sub-unit 1a southern section existing raised ground - orange areas are above 3.6m AOD

4.1.3 Other considerations

Wave action protection

Due to the lack of exposure, shallow profile and relatively low height of the embankment along the eastern edge of the field there is no requirement for surface protection against wave action.

Land drainage

It has been assumed that no land-drains exist in the field. This should be confirmed at detailed design stage as their existence would provide a potential pathway for flood water.

Implications on groundwater movement should be considered at detailed design to ensure that pluvial flood risk is not increased by the flood defence embankment.

4.2 ODU1 – Sub-unit 1b

The preferred option in sub-unit 1b is to undertake capital refurbishment of the existing defences.

4.2.1 Structure definition

Existing defence structure condition

The sub-unit frontage has two typical defence structure types.

1. The first structure to the west (Structure 1) is approximately 30m long and is a revetment formed of stone pitching and concrete blocks bound with mass concrete, shown in Figure 4-2. At the landward extent of the apron is a concrete wall along the private property boundary. The condition of the apron is poor due to the loss of material and undermining at the toe, the condition of the wall is good with no significant cracks evident.



Figure 4-2: Structure 1 sub-unit ODU1b West

2. The second structure (Structure 2) is a concrete wall with a concrete apron extending approximately 150m along the frontage. The foreshore level in front of this structure is lower than the stone pitched revetment Structure 1 to the west. The apron is formed of mass concrete and has steel sheet piling protecting the toe. The apron in places is in poor condition with undermining causing failure of the structure, see Figure 4-3.



Figure 4-3: Structure 2 sub-unit ODU1b East – failed apron

In other places along the apron the mass concrete facing the sheet piles has broken off due to undermining where it encases the sheet pile as shown in Figure 4-4, there are signs that this process is occurring along other sections of the apron. The wall is generally in fair condition, there is evidence is many patch repairs along the wall. In one location there is a significant vertical crack, shown in Figure 4-5.



Figure 4-4: Structure 2 sub-unit ODU1b – exposed steel piles



Figure 4-5: Structure 2 sub-unit ODU1b – vertical crack in seawall

The existing defence structures in sub-unit 1b have a crest height of >3.8 m AOD. Therefore, there is no need to raise the height of the existing defences.

There is no information available describing the construction of the existing structures. Therefore, the depth and original thickness of the sheet piling is unknown and the alignment of the back of the walls are unknown.

Refurbishment works

Structure 1 (west)

The revetment will be removed and replaced as it is in poor condition. Although most of the revetment, apart from the toe, appears in fair condition it appears to be an ad-hoc informal defence and its structural resilience should a design flood event occur over the 50-year design life of the scheme is uncertain. Therefore, it is proposed to replace all the revetment rather than just protect the toe. It is proposed to protect the revetment from undermining with steel sheet piling and then construct a new 500mm thick concrete revetment, with dowels to connect it to the existing wall. This thickness is considered appropriate for preliminary costing and should be verified by structural calculation at detailed design stage should the additional scheme be progressed.

The wall behind the apron appears in good condition and therefore it is proposed to retain this structure without modification. A structural check should take place at detailed design stage to confirm it will not fail in a design flood event, however given the relatively high level of the ground behind this is considered unlikely unless confirmed otherwise by detailed assessment.

Structure 2 (east)

The apron will be removed and replaced as it is in poor state of repair, having failed in some sections and having voids and material washed out, it is not suitable to encase. The condition of the existing sheet piling is unknown because it is not visible in most areas, where it is visible it appears weakened by heavy corrosion. Based on this it is proposed to install new steel sheet piling, however this requirement should be investigated as part of the design process. This will provide scour protection to prevent undermining of the structure and will provide geotechnical stability against sliding and overturning. No calculation has been undertaken at this stage of the design to confirm the required pile toe depth.

The new sheet piling should include drainage holes to reduce build-up of water pressure behind. Similarly, the weep holes in the existing wall should be extended through the encasement.

Any major cracks found on the existing wall shall be treated prior to encasement and voids filled. The encasement has been preliminarily sized as 400mm thick and the apron as 500mm, with dowels to connect it to the existing wall. This thickness is considered appropriate for preliminary costing and should be verified by structural calculation at detailed design stage should the additional scheme be progressed.

4.2.2 Alignment

The profile of the new apron has been designed to match that of the existing structure. The new sheet piling is to be driven seaward of the existing sheet piles. An offset allowance will have to be provided from the existing sheet piles as these might have not been installed completely vertical. Therefore, the proposed structure will end up having a larger footprint along the lengths with existing sheet piling. Potentially in the location of Structure 1 (west) the width of the revetment could be narrowed as the existing apron is being removed and replaced, however at this stage the existing profile has been maintained.

To the west the new structure will tie-in to higher ground at the end of the existing wall. At the eastern extent of the seawall the foreshore height increases and provides additional protection to the seawall, see Figure 4-6. Here the typical apron ends and it is unknown what type of apron structure continues beneath the shingle. In this location the beach level is above MHWS and there is thick vegetation on top of the beach suggesting there is little variation of this upper foreshore level. The seawall here is in better condition with no patch repairs in contrast to the rest of the seawall. Because of this the design has not extended the refurbishment all the way to the end of the seawall. Investigation of whether this is suitable is recommended at the next design stage with further investigation to expose the apron in this location.



Figure 4-6: Eastern end of sub-unit 1b seawall

4.2.3 Buildability

The Mean High Water Springs (MHWS) level is above the apron level, however, the Mean Water Level (MWL) is below the apron toe.

- Apron toe level = 0.9m AOD
- MHWS = 2.1m AOD
- MWL = 0.2m AOD

Access to most areas of the seawall will be possible working either side of low water. However, tidal working hours are yet to be determined. Tidal working is a constraint that will likely have an impact on the programme and cost of construction due to the associated risks involved.

Appropriate precautions must be taken for when removing the existing apron. The existing wall should be monitored during the apron removal work for any movement which could lead to instability.

It is envisaged that the steel sheet piles will be installed from the foreshore. During the design development, the location of the new piles in relation to the existing should be carefully considered to ensure that there is sufficient space allowed for installation. Due to the close proximity to the local residents and property, the noise, dust and vibration will need to be carefully monitored to mitigate against causing damage or nuisance.

4.2.4 Other considerations

Existing outfalls through wall

Along the sub-unit two outfall pipes with flap valves are present on the existing wall/apron. One of these is indicated as being connected to a Southern Water surface water drainage pipe which runs beneath the private gardens behind the wall, the other pipe is not shown on the utility search. These outfalls are to be extended through the new encasement.

Existing steps

A set of concrete steps is present in one location along the existing seawall from a private garden leading down onto the apron. Should the additional scheme be progressed a decision is required as whether to incorporate or remove this access.



Figure 4-7: Sub-unit 1b access steps

4.3 ODU2 – Sub-unit 2a

The preferred option in sub-unit 2a is to install rock armour protection at the south end of the spit. This is the most heavily eroded area of the spit which has been identified as important for dissipating wave energy at the Sailing Club frontage. This option is not designed for flood protection.

4.3.1 Structure definition

Rock sizing

The preliminary rock armour size was quantified using Van der Meer formulae (1988) modified by Van Gent (2004) for shallow water¹³. At this site there is no available wave data, therefore a conservative wave condition was calculated using fetch limited calculations. The wave generation fetch length was set as the longest straight line distance from the far shore to the south end of the spit, as shown in Figure 4-8.

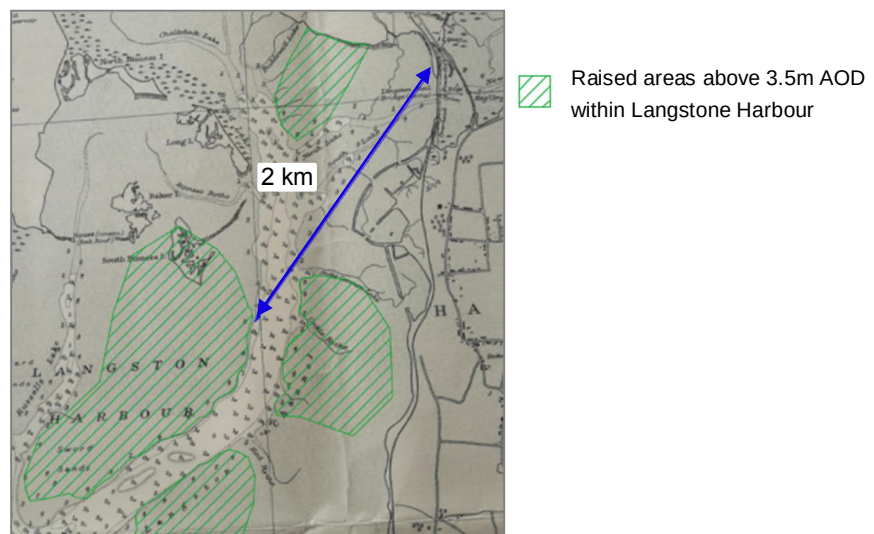


Figure 4-8: Navigation chart highlighting raised areas and a feasible fetch length (Admiral Chart, 1961)

The fetch limited maximum wave condition was calculated according to the Coastal Engineering Manual¹⁴ to have a wave height of 0.9m and a wave period of 2.37s. Using this wave condition the required rock armour size

was determined to be a standard grading of 60-300kg using EN 13383 and assuming a density of 2400kg/m³. The rock sizing is based on a maximum possible wave height for the 1:200 year return period still water level. As discussed previously no joint probability has been undertaken meaning that a conservative rock size has been calculated, potentially this can be refined with joint probability data.

Slope angle

Rock armour units will have a maximum slope angle of 1V:1.5H. This is considered the steepest acceptable slope angle of the rocks and has been chosen to minimise the footprint of the structure.

Rock layer thickness

The layer of primary armour will have a thickness of at least two rocks. This will provide increase wave dissipation and will provide better protection to the spit than one layer.

Quarry Run

The armour layer is best laid on quarry run to provide a suitable transition between the armour rocks and filter below.

Filter layer

A filter layer is required so that the material underlying the rock is not eroded/washed away through the gaps in the rock. Given the relatively small size of the primary rock a geotextile is proposed.

Toe structure

The toe of the structure has been designed as a berm of three armour rocks long two rocks high, supported on the geotextile.

Crest Level

A wave run-up calculation has confirmed the run-up level will be above the highest crest level of the spit. Therefore, the rock armour crest level will extend to match the crest level of the spit. The top of the spit is vegetated and for the preliminary design, considering the conservative wave conditions used, it is assumed will not erode from the run-up. If a joint probability analysis was undertaken this would likely lead to a reduction in run-up level and therefore quantity of rock.

4.3.2 Alignment

As determined during the preferred options stage the rock armour protection will only cover the south end of the spit which is currently being lost to erosion, over an approximate 40m in length. Erosion is also occurring further north, however this is not addressed in this scheme – only the highest priority area will be defended.

Consideration has been given to avoiding the high voltage cables that pass beneath the spit. The northern end of the rock armour works are approximately 30m south of the cables and therefore the risk is appropriately mitigated.

4.3.3 Other considerations

Existing concrete block work

At the southern end of the spit an ad-hoc failed coastal defence currently exists formed of concrete rubble as shown in Figure 4-9.



Figure 4-9: Concrete rubble located on the spit

An efficiency would be to incorporate this rubble into the structure to reduce the amount of imported rock; this should be explored at the next stage of design.

5. General considerations for the scheme

5.1 Visual impact of scheme

5.1.1 Summary of defences and heights

The table below presents a summary of the preferred flood defence measures and their approximate crest heights above existing ground levels (not including ancillary structures such as handrails or fencing). Heights are presented to the nearest 0.1m.

Table 5-1: Height of new defences above existing ground levels

ODU sub-unit	Minimum crest height (above existing ground level)	Maximum crest height (above existing ground level)	Flood protection crest level	Comment
<i>Core scheme</i>				
2b – raised footpath	0.0m	0.5m	3.6m AOD	Ties into existing ground at north end.
2b – earth embankment next to footpath	0.0m	0.6m	3.8m AOD	Based on existing ground level at top of earth bund adjacent to pavement. No topographic data adjacent to road tie-in, maximum crest height may increase depending on this information.
3b – flood wall and flip-up flood barrier	0.0m	0.8m	3.8m AOD	
3d to 3e – flood wall with glass top (Ship Inn)	0.9m	1.0m	3.8m AOD	Concrete wall matches height of existing wall, glass above wall measures 40cm.
3d to 3e – flood wall along private property	1.0m	1.1m	3.8m AOD	
3f to 3h – flood wall along existing garden walls (South of Green Cottage)	0.8m	1.6m	3.8m AOD	
3f to 3h – flood wall along existing seawall alignment (Green Cottage)	0.9m	1.0m	3.8m AOD	
3f to 3h – flood wall along existing garden walls (North of Green Cottage)	1.0m	1.4m	3.8m AOD	
3i – flood proofed existing property	n/a	n/a	-	No new defence structure.

3j – flood gates	1.1m	1.4m	3.8m AOD	Flood gate across road 1.4m, across pavement 1.1m.
3k – parapet flood wall	1.0m	1.3m	3.8m AOD	
3l – flood wall next to footpath	0.7m	1.0m	3.6m AOD	
3l – earth embankment	0.0m	0.7m	3.6m AOD	Ties into existing ground at west end.
<u>Additional scheme</u>				
1a – earth embankment	0.0m	1.3m	3.6m AOD	Ties into existing ground at north end.
1b – capital refurbishment	n/a	n/a	-	No increase in crest levels.
2a – rock armour erosion protection	n/a	n/a	-	No increase in crest levels.

5.1.2 Structure finishes

The finish of the structures should be determined at the detailed design stage, as should landscaping which is beyond the scope of this report. The concrete flood walls, sheet piling and flood gates can all be clad or have architectural finishes. Historic England have advised¹¹,

“The aesthetic of the sections of floodwall should draw on boundary walls found in close proximity within each respective conservation area. The walls should as far as practical use high quality natural materials and emulate design patterns found in neighbouring walls within the conservation area.”

The existing walls behind the proposed new defences are constructed of various materials: brick, concrete block, stone and flint. Drawing LNST-ACM-XX-XX-DR-CE-04001 shows some indicative examples of potential finishing options for the walls.

5.2 Temporary permissions

During the works the following will have to be considered:

- Footpath closures – most of the core scheme is aligned along footpaths and there will be disruption to these. Temporary diversions will have to be established and managed during the construction stage.
- Land use – access routes and work areas may involve private land. Potentially temporary land acquisition will be required.
- Traffic / highways disruption and diversions. Management plan and permissions to be sought as required.
- Carpark closures – e.g. Ship Inn will require landowner permissions.

6. Designer's Risk Assessment

The preliminary Designer's Risk Assessment is presented in Appendix B.

Risks have been assessed throughout construction, operation, maintenance and demolition. Risks identified include: working within residential areas, buried services, intertidal working, stability of existing structures, deployment of flood defences and falls from height.

7. References

- ¹ Preferred Option Report, Langstone Flood & Coastal Erosion Risk Management Scheme, AECOM, April 2019
- ² BS 6379 Marine Works, British Standards Institution, 2013
- ³ Admiralty Tide Tables – United Kingdom and Ireland, 2017
- ⁴ Langstone FCERMS, Ground Investigation Report, WYG, November 2018
- ⁵ Option Development Unit Ground Model Technical Note, AECOM, December 2018
- ⁶ Landmark Information Group Utilities Search, January 2018
- ⁷ Explosive Ordnance Threat Assessment, Langstone, Havant: Centred on Mill Lane & Langstone Road, PLANIT UXB Limited, February 2018
- ⁸ Building Regulations Part M, 2010
- ⁹ Design Manual for Roads and Bridges, Volume 6: Section 1: Part 2, 2005
- ¹⁰ Inclusive Mobility, Department for Transport, 2005
- ¹¹ Langstone Flood Scheme, Pre-application advice, Ref: PA00855569, Historic England, July 2019
- ¹² Structural Survey of Historic Sea Wall at Langstone, Scott Wilson, 2008
- ¹³ The Rock Manual, CIRIA C683, 2007
- ¹⁴ Coastal Engineering Manual, US Army Corps of Engineers, 2002

Appendix A – Drawings

Drawing list:

Drawing Title	Drawing Number
Site location plan	LNST-ACM-XX-XX-DR-CE-01001
Heritage and environment plan	LNST-ACM-XX-XX-DR-CE-01002
Utility plan	LNST-ACM-XX-XX-DR-CE-01003
Chainage plan	LNST-ACM-XX-XX-DR-CE-02001
General arrangement plan: core flood defence scheme	LNST-ACM-XX-XX-DR-CE-02002
General arrangement plan: additional flood defence scheme (constructed after core scheme)	LNST-ACM-XX-XX-DR-CE-02003
General arrangement plan: core and additional flood defence scheme	LNST-ACM-XX-XX-DR-CE-02004
Core flood defence scheme cross sections (sheet 1 of 4)	LNST-ACM-XX-XX-DR-CE-03001
Core flood defence scheme cross sections (sheet 2 of 4)	LNST-ACM-XX-XX-DR-CE-03002
Core flood defence scheme cross sections (sheet 3 of 4)	LNST-ACM-XX-XX-DR-CE-03003
Core flood defence scheme cross sections (sheet 4 of 4)	LNST-ACM-XX-XX-DR-CE-03004
Additional scheme cross sections	LNST-ACM-XX-XX-DR-CE-03005
Wall material options	LNST-ACM-XX-XX-DR-CE-04001

Appendix B – Designer's Risk Assessment

Appendix C – Flood gate / stop log proposed location photographs



Flood gate no. 1 location



Flood gate no. 2 location – along fence line



Flood gate no. 3 location



Flood gate no. 4 location



Flood gate no. 5 location



Flood gate no. 6 location



Flood gate no. 7 location



Flood gate no. 8 location



Flood gate no. 9 location