SHOREHAM HARBOUR REGENERATION

SHOREHAM HARBOUR

FLOOD RISK MANAGEMENT GUIDANCE

SUPPLEMENTARY PLANNING DOCUMENT

TECHNICAL ANNEX

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Contract

This report describes work commissioned by the Shoreham Harbour Regeneration Partnership. Tim Ash-Edwards and Oliver Francis of JBA Consulting carried out this work.

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Purpose

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Abbreviations

1D..... One-dimensional
2D..... Two-dimensional
ADC..... Adur District Council
AEP ..... Annual Exceedance Probability
ALWC..... Accelerated Low Water Corrosion
AOD..... Above Ordnance Datum
CC ..... Climate change
CDM ..... Construction Design and Management Regulations (2007)
Defra..... Department for Environment, Food and Rural Affairs
DIS ..... Design Input Statement
DHI ..... Designers Hazard Inventory
DTN..... Design Technical Note
EA..... Environment Agency
EIA..... Environmental Impact Assessment
FRM ..... Flood Risk Management
JAAP ..... Joint Area Action Plan
MCA ..... Multi Criteria Analysis
MIC..... Microbially Induced Corrosion
OS ..... Ordnance Survey
SS..... Strategic Site
SSSI ..... Site of Special Scientific Interest

UK ..... United Kingdom

UKCP09 ..... United Kingdom Climate Predictions 2009

WHA..... Western Harbour Arm

1 Introduction

1.1 Overview of technical annex

This technical annex has been produced as an accompanying document to the Shoreham Harbour Flood Risk Management Guide Supplementary Planning Document (SPD). The purpose of this document is to provide an evidence base for the preferred approaches set out within the SPD. The annex details: how the appraisal process was undertaken; the technical information that supported the appraisal; evidence of the assumptions made and; initial cost estimates of the flood risk management measures.

1.2 Purpose of appraisal

The purpose of the flood defence appraisal was to identify a short list of feasible flood mitigation measures for the Western Harbour Arm site. Firstly a long list of defences was compiled and then an initial screening undertaken to remove defence options that would not work. A Multi Criteria Analysis (MCA) was completed to determine which options were best suited at each of the three frontages. The MCA, described in more detail in Section 2.3, considered all aspects of the design including aesthetics, relationship with the river, and integration with the urban realm along with engineering considerations such as defence life, cost, ease of construction, etc.

This short list of defence options was then taken through concept design with Design Technical Notes (DTN) and Designers Hazard Inventories (DHI) completed for each option (refer to Appendices D and E). Finally a construction and maintenance cost estimate was calculated for each defence option (refer to Appendix G).

1.3 Design standards

Design standards have been compiled to enable the concept design development of defence options (see section 1.4.3 for further details).

1.3.1 Design life (see Section 3.2, Appendix A)

The scheme design life will be the lifetime of the proposed development assumed to be 100 years for this study, i.e. to 2115.

1.3.2 Design levels (see Sections 3.5, 3.8 and 3.9, Appendix A)

The defence design level is calculated using UK Climate Projections (UKCP09) for the 1 in 200-year still water level for 2115. This gives a sea level of 5.08mAOD. Freeboard allowances are given in the Design Input Statement (DIS) (see Appendix A) as a minimum of 150mm for hard defences and 300mm for soft defences. Hard defences are those considered not to suffer settlement of their crest level e.g. concrete or masonry walls, sheet piling, etc. Soft defences are those which are subject to settlement of their crest level over time e.g. earth embankments, land raising, etc. Consequently the design levels used are as follows:

- 5.25mAOD for hard defences and
- 5.40mAOD for soft defences

1.3.3 Standards (see Section 3.16, Appendix A and Appendix D)

All design assumptions have been developed using the following reference material:

- ArcelorMittal. (2008). Piling Handbook (8th edition)
- British Standards Institute. (2002). BS EN 13383-1:2002, Armourstone – Part 1: Specification
- British Standards Institute. (2002). BS EN 13383-2:2002, Armourstone – Part 2: Test methods
- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design
- CIRIA. (2007). The Rock Manual: The Use of Rock In Hydraulic Engineering (second edition)
- CIRIA (2010), The Beach Management Manual (second edition)
- CIRIA. (2013). The International Levee Handbook
- DEFRA. (2009). Adapting to climate change - UK Climate Projections
- Environment Agency. (2010). Fluvial Design Guide
- Environment Agency. (2011). Temporary and demountable flood protection guide (SC080019)
- HR Wallingford. (1998). Revetment systems against wave attack - A design manual
- Shoreham Port. (2014). Adur River - Left Bank Quay Wall Survey 2014

Design standards for the following are given in the DTN in Appendix D:

- revetment
- flood wall
- sheet piles
- raising the existing capping beam
- land raising
- rock armour and
- demountable defences

Please note the raising of the existing capping beam would not meet the proposed design standards without being combined with another defence choice. However it could be readily implemented and could offer an improved standard of protection to a possible riverside walkway (please see 2.5.2.1 for further information).

2 Development and appraisal of options

The appraisal of flood defence options and preparation of this Technical Annex has involved the identification of mitigation measures, the short listing of measures using multi-criteria analysis and the concept design and cost estimation of emerging favoured options.

2.1 Identification of options

A long list of options was determined by considering all possible flood defences for the Western Harbour Arm (WHA). These were then categorised and split into types and defence alignment (see Table 2-1).

Table 2-1: Long list of potential options

Category	Type	Alignment
Piling	Steel sheet piles	Maintain existing
		New - set forward
		New - set backwards
	Concrete piles	New - set forward
		New - set backwards
	Plastic piles	New - set forward
		New - set backwards
	Timber piles	New - set forward
		New - set backwards
Revetments	Rock armour	As a defence line
	Concrete proprietary (Xbloc, tetrapod etc.)	As a defence line
	Concrete blockwork (modular)	As a defence line
	Masonry blockwork (pitching)	As a defence line
	Timber	As a defence line
	Gabions	As a defence line
	Reinforced earth	As a defence line
Land raising	Self supported	As a defence line
	Supported by a retaining flood wall	As a defence line
Embankments	Raised concrete revetment	As a defence line
	Earth	As a defence line
Flood walls	Reinforced concrete	On top of existing defence line
		Set back from existing defence
	Steel sheet piled	Set back from defence line - low depth piling, utilising existing piling to provide main defence
	Concrete piled	Set back from defence line - low depth piling, utilising existing piling to provide main defence
	Masonry	On top of existing

		defence line
		Set back from existing defence line
Demountable defences	Flood gates	As a defence line
	Drop in defences	As a defence line
	Temporary flood walls (permanent columns)	As a defence line
	Other temporary defences	As a defence line
Flood resilience	Property level protection	To protect individual property
	Elevated buildings	To protect individual property
Tidal barrier		As a defence line
Other	Shingle beach / beach nourishment	
	Mud flats	
	Slipways	
	Hards	
	Inlets	

2.2 Initial screening

An options matrix was created to enable consideration of the feasibility of each of the flood defence type, based on the following categories:

- applicability at each defence zone
- cost
- maintenance
- adaptability
- design life
- environmental impact and
- visual impact

The number of options in the long list was reduced by discounting options that were considered unfeasible, based on the criteria set out above. This short list can be seen in Table 2-3.

The initial screening process was based on engineering judgement and not a consideration of the architectural opportunities. Materials and finishes are not integral to short listing design concepts. Finishes may change based on planning requirements to integrate flood defences into the overall redevelopment. The integration of flood defence and mitigation measures within the redevelopment is considered further within the Guide.

2.3 Multi Criteria Analysis

Multi Criteria Analysis (MCA) is a method whereby each option is assessed on its ability to meet key project criteria. It has the advantage of simplifying comparative assessment where there are many factors to take into account, when seeking to identify favoured options. MCA is subjective and is primarily a qualitative approach to identify preferences amongst the options proposed.

A MCA has been completed to facilitate the options selection process; to enable the relative merits of defence options that had passed the initial screening to be assessed.

The categories considered within the MCA were developed based on the technical requirements of the appraisal. The four primary categories under which the options have been assessed are: technical, environmental and social; economic; and climate change adaptation. Within these, a number of sub categories (see Table 2-2) have been used for scoring purposes, with each defence option marked out of 5 for suitability and all assessment criteria weighted equally. For further information on the MCA please refer to Appendix B.

Table 2-2: Criteria for assessment of options

Assessment criteria	Technical	Design	Capable of providing standard of protection to required level
			Maximised protected area
			Design longevity - material properties
			Low land take requirements
			Protection of infrastructure
			Protection from wave energy[1]
		Construction and maintenance	Design is simple to construct
			Future maintenance requirement is minimised
	Environmental and social	Public amenity	Low impact on public amenity (General)
			Low impact on recreational / commercial water users
		Natural environment	No adverse impact on tidal habitat
			Capable of incorporation of additional habitat features that benefit flora and fauna
			Low impact of contaminated land
		Landscape and visual amenity	Minimise impact on landscape character and visual amenity of the local environment
			Public acceptability and potential for adverse public opinion
		Heritage	Minimise impact on fabric and setting of historic structures
	Economic	Cost	Low capital investment required
			Low maintenance costs
	Climate change adaptation		Design can be easily adapted to accommodate climate change impacts
			Design minimises carbon footprint during construction (concrete & steel usage and delivery)

[1] Only applicable at the Kingston Beach frontage

Defence options for each frontage, informed by the MCA, taken forward to concept design are shown in Table 2-3.

Table 2-3: Short list of options

Frontage	Category	Type	Alignment
Adur Ferry Bridge to Riverside Business Centre	Piling	Steel sheet piles	New - set forward
	Revetments	Concrete blockwork (modular)	As a defence line
	Flood walls	Reinforced concrete	On top of existing defence line
			Set back from existing defence line
Riverside Business Centre to Kingston Beach	Piling	Steel sheet piles	Raise existing
			New - set forward
	Land raising	Self supported	As a defence line
	Flood walls	Reinforced concrete	On top of existing defence line
			Set back from existing defence line
Kingston Beach	Piling	Steel sheet piles	New - set backwards
	Revetments	Rock armour	As a defence line
	Flood walls	Reinforced concrete	On top of existing defence line

2.4 Decision tree

A decision tree is a flow chart used to aid choice selection and understanding of consequences. Decision trees can simplify interdependent processes and facilitate interpretation and communication.

The decision tree (see Appendix C) supports the prioritisation of defences based on certain site required attributes. These are as follows:

- Is the location being developed ahead of neighbouring sites?
- Does the location require additional protection from wave action?
- Is there the possibility that land use change occurs at the Yacht Club?
- Is the condition of the existing defence suitable for the lifetime of the proposed development?

Based on these questions it is possible to determine which type of defences should be preferred for any development frontage.

2.5 Setting the vision - flood defence considerations

2.5.1 Adur Ferry Bridge to Riverside Business Centre

The Sussex Yacht Club is situated between the Dolphin Hard (adjacent to the Adur Ferry Bridge) and the Parcelforce site. It comprises the yacht club, working boat yard, slipways and two hards. The yacht club is a private entity and there is no public access along the waterfront although the Stowes Gap Hard, located by the entrance to the site, is accessible to the public. The current flood defence is a concrete blockwork revetment. The line of defence is complex, as it steps in

and out from the river to accommodate the slipway and hards. The defences, which are currently at a level of between 3.1mAOD and 3.9mAOD, do not afford a significant standard of protection as evidenced by the inundation of the A259 in the winter of 2013/14. The levels on the A259 fall away from 5.4mAOD at the Adur Ferry Bridge to 3.7mAOD at Tarmount Hard.

There are no formal plans to redevelop the yacht club site. However the site is critical as the low crest levels of the existing defences offer a preferential route for flooding to affect a wide area of Shoreham and could potentially allow flood water in behind new defences constructed on adjacent sites.

To facilitate yachting and boat yard activities, slipways or other forms of water front access must remain. However, it is not practical to raise the crest of the slipways to design flood levels as steep gradients may be prohibitive to boat use. Demountable defences such as flood gates should be included at the crest of slipways to address this and to ensure a continuous defence line. Consolidation of existing slipways to a smaller number, possibly a single slipway, may be beneficial. Alternatively the incorporation of stepped quays or hards may be appropriate.

The Parcelforce site formerly housed a Parcelforce depot and is located between two hards (Tarmount Hard in the west and Surry Hard in the east) and bounded by the A259 and the Surry Boat Yard. An electricity substation is also present on the site. There is currently no access along the waterfront although both hards are accessible to the public. The site is currently defended by steel sheet piles on two sides (west and south) with crest levels of approximately 3.9mAOD. Surry Hard, a concrete structure, comprises the line of defence on the east. The A259 rises from a level of 3.7mAOD at Tarmount Hard to 4.4mAOD at Surry Hard. A formal technical assessment of this section should be carried out due to the fact that the tie bar anchorages are badly corroded and the original pile section is thin[1].

There is an extant plan to redevelop the Parcelforce site which is understood to have received full planning permission (AWDM/0501/12). This would see the warehouse replaced with a six-storey mixed-use development. Surry Hard would also be upgraded to provide a stepped quay wall. Flood defence would be afforded by the construction of a flood wall at a height of 5.57mAOD all around the site with demountable flood barriers at the road access to the site. Conditions 21, 33, 34, 35 all pertain to flood risk and identify that there is scope for changes to the proposed form of the flood defence. The S106 agreement also confirms the legal requirements in relation to the flood defence.

There is also a plan under consideration to infill Tarmount Hard to form a new stepped quay wall at southern end with pedestrian access (AWDM/0784/14).

The frontage is subject to multiple ownership and non-concurrent plans for redevelopment. As redevelopment opportunities come forward, a continuous line of flood defence must be ensured. Where an adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

Future defences at the Sussex Yacht Club will need to tie in with the footbridge to the west and the redevelopment at the Parcelforce site to the east. There are a number of technically feasible alignments that a new defence could follow. The simplest, from a construction perspective, would be to build a defence at the rear of the site along the A259. This option is technically the simplest to achieve and likely to be cheaper than other options considered. However the option has

[1] Refer to the Adur River – Left Bank Quay Wall Survey (SPA, 2014)

a number of public realm issues and is unlikely to be popular with stakeholders because a line of defence at the rear of the site would:

- Sever the connection between the A259 and the waterfront
- Provide limited opportunities for improving public access to the site
- Require flood gates onto the A259 to allow continued vehicular access to the site
- Afford no protection to the yacht club with its operation becoming increasingly affected by rising sea levels over time
- Make future re-development of the site more challenging and costly

Discussions with the yacht club identified that they would like to be afforded a better standard of protection against flood events and in their opinion any proposed defences should be on the river side of the site. To minimise the land take of raising the defences to the required height (5.25mAOD) the preference would be for a new line of defence formed from steel sheet piles with breaks in the line in order to maintain a number of slipways and hards. This may also require the provision of flood gates to allow access to the river at slipways whilst maintaining flood protection for site.

At the Parcelforce site, whilst planning consent has been granted, it is also necessary to consider the preferred form of any defence and how it should tie in with the wider frontage. There are a number of approaches that might be possible.

If the Parcelforce defence can be delivered as proposed, then defence improvements to the Yacht Club and Riverside Business Centre will need to connect to the Parcelforce flood wall. The connection would be subject to detailed design and would depend on the flood defence option taken forward at the other sites, but could include connecting two flood walls or a more complicated connection between a flood wall and a pile cap.

If the condition of the Parcelforce piles precludes the current consented defence arrangement then it may be more appropriate to construct a new sheet piled defence line which could at a later date be connected with defences at the Yacht Club or Riverside Business Centre. There is the possibility that defences options at both the Yacht Club and Riverside Business Centre may include new sheet piling which could then be connected to those at the Parcelforce site.

Across the frontage there is a need to tie-in the proposed defences to high ground to ensure closure of the flood cell. At the Sussex Yacht Club this would require any defence to be tied in with the bridge abutments and may necessitate some amendments to Dolphin Hard, as the existing levels are not high enough to prevent water coming behind the flood defences. This could constitute a flood gate or raising the hard to the flood level.

Improving public accessibility to the waterfront will be a key component of any new defences and the form of defences will influence what can be constructed. The overarching vision is to provide a riverside walkway and this will need to be included within any plans. It will also be necessary to integrate the slipways, hards, and stepped quays within the defence line which may require the provision of flood gates to prevent slipways having to be too steep.

Defence options at this location are significantly influenced by the assumed continued use of the frontage to support yachting and boat yard activities, together with the extant planning permissions granted at the Parcelforce site. In the case of the water compatible uses at the yacht club and boat yards, defence options must support safe interaction with the waterfront whilst mitigating flood

risk across the wider frontage to the design flood water level. In respect of the extant planning permission at the Parcelforce site, there is a need to ensure that preferred flood defence options for the rest of the frontage can integrate with those already permitted in support of the immediate redevelopment. Along this section possible defence options will be:

- Concrete blockwork revetment
- Flood wall on a set back alignment
- Flood wall on top of existing defences
- Steel sheet piling

2.5.1.1 Concrete blockwork revetment

Concrete blockwork revetments are commonly used in marine environments that are not exposed to excessive wave activity. Consequently, it is considered to be a suitable form of defence for the section fronting the Sussex Yacht Club. Under this option, the revetment would be constructed in front of the existing defence line. Land raising and backfill will be required to enable the integration of the defence into existing land and defences. The extent of land raising could be up to 2m in places based on existing levels unless it remained feasible for parts of the site to be below the defence level although this could complicate the integration of hards and slipways.

Construction of the revetment in front of the existing defence though will encroach, potentially significantly, into the river channel. Approval from the Environment Agency will be required before construction can occur and it is likely that compensatory inter-tidal habitat will be required to be provided elsewhere. Land take is not an issue with this option if the defence is extended outwards from the land. However, to mitigate river encroachment and loss of inter-tidal habitat, the existing defence may need to be removed and the new revetment set along the original defence line. If this were to occur then there would be a considerable loss of site land area.

As with all of the other riverside defences the revetment would need to be tied in to the abutments of the Adur Ferry Bridge and/or Dolphin Hard to ensure closure of the flood cell. This would entail building the defence as close to the tie-in point and infilling with a suitable material to form a joint. The revetment would also need to tie in a similar manner with the proposed stepped quay at Tarmount Hard.

2.5.1.2 Flood wall, set back

Flood walls would enable a raising of the existing defence level and minimal change to the nature and use of the existing site. It is assumed that existing flood defence structures will remain in place. Under this option a flood wall would be constructed to the rear of the existing defence line; protecting the A259 and communities behind but allowing some riverside inundation during flood events.

The existing land use for boating related activities at the Sussex Yacht Club site is considered to be compatible, although the defence line might need to be amended locally to ensure the clubhouse was protected. A change of land use and land use vulnerability is likely to be restricted in these circumstances.

The precise location of a set back flood wall was not determined but assumed to be largely to the rear of the site adjacent to the A259. Initial feedback from stakeholders on a set back flood wall suggests that the potential for this site to be periodically flooded in the future is not favoured. However this option is

technically simpler to implement and is expected to be cheaper than the others to construct. There is the risk that a wall which could be up to 1.5m high would significantly alter the relationship between the site and the A259. If the option were to be progressed these concerns should be further explored through consultation and detailed design.

Based on the EA Design Guidance a reinforced concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key (a downward extension of a portion of the foundation) to improve sliding resistance (lateral movement of the wall when loaded e.g. under flood conditions) and also increase the flow path for potential flood water which will help minimise seepage of floodwater through the ground underneath the defence. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements and architectural master plan.

The tie-in with existing defences is much simpler for this option as the flood wall can tie into the higher ground at the Adur Ferry Bridge end and join directly with the permitted flood wall at the Parcelforce site.

2.5.1.3 Flood wall, on existing defence

For this option flood walls constructed on top of the existing line of defence would enable a raising of the existing defence level without requiring additional land take and ensuring the entire site is protected. The existing flood defence structure is assumed to be structurally sound to allow the new flood wall to be constructed on top. Based on the level of the existing defences the new wall is likely to be in excess of 1.5m along much of its length. As the existing structure is to be retained, repair and maintenance activities, over the course of the new structures design life, will be considered in the development and costing of the flood wall option.

Under this option the flood wall will be constructed on the existing defence line. Based on the EA Design Guidance a reinforced concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key (a downward extension of a portion of the foundation) to improve sliding resistance (lateral movement of the wall when loaded e.g. under flood conditions) and also increase the flow path for potential flood water which will help minimise seepage of floodwater through the ground underneath the defence. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements.

The flood wall would need to be tied in to either the abutment of the Adur Ferry Bridge or Dolphin Hard to ensure closure of the flood cell. In order to achieve this the wall would be built as close as possible to the point of tie-in and a joint formed by infilling with a suitable material. A similar tie-in with the proposed stepped quay at Tarmount Hard would also need to be formed.

2.5.1.4 Sheet piles, in front of existing defence

A new sheet pile wall may facilitate the expansion and improvement of the existing yachting and boatyard facilities. The steel sheet pile wall will be constructed in front of the existing defence line under this option. Whilst it is possible to pile behind the defence line, it is also substantially more expensive. This is largely due to the number of risks which can arise. These include:

- the presence of services (often surface water sewer outfalls) which might need to be diverted
- backfill behind the original defence not providing suitable material to drive piles through
- issues in mobilising contaminated land

Local backfill will be required to enable the integration of the defence into the existing defence line. This option may create additional usable land above the flood level where the existing sloping defence can be replaced by a vertical defence. The sheet pile wall could facilitate the creation of floating pontoons which could have gangway access from the top of the defence which could not be achieved with sloped revetment type defences. Alternatively the sheet piling can be designed to allow the integration of stepped quays or hards. Consequently, this would give more boat storage space on the water and combined with the additional usable land could enable expansion of the yachting activities.

By bringing the defence line forward, approval from the Environment Agency will be required before construction can occur and it is likely that compensatory inter-tidal habitat will be required to be provided elsewhere.

A tie-in between the pile cap and the proposed Parcelforce site flood wall would be required. If the detailed assessment of the pile condition at the Parcelforce site requires they be replaced it would be more cost effective to construct a continuous line of sheet piles along the entire frontage. These could then be joined to the existing pile wall along the Riverside Business Centre to Kingston Beach frontage.

2.5.2 Riverside Business Centre to Kingston Beach

This is the longest frontage and is comprised of a number of sites under different ownership. It is not appropriate to discuss them all on a case-by case basis as the overarching principles are applicable to all. However two parts of the frontage: the Riverside Business Centre and the former Minelco site (land adjacent to Ham Business Centre) require additional consideration.

The Riverside Business Centre is an existing development comprising a number of small business units. It is located to the east of Surry Hard and adjoins Tarmac Wharf. The site is currently defended by steel sheet piles with a crest level of 4.1-4.2mAOD. These piles are severely affected by Microbially Induced Corrosion (MIC), also known as Accelerated Low Water Corrosion (ALWC), and have a residual life of only 20 years, if corrosion protection is not installed in the near future[2]. The section of the A259 along the site falls from a level of 4.5mAOD at the entrance road to the site to 3.8mAOD at the entrance to Tarmac Wharf.

At the present time there are no plans to redevelop this site and it had been assumed that it should not be part of the consideration of defence concepts. However given the condition of the piles it is likely that a significant investment in the existing defences to the site will be required in the near future and the opportunity to bring them up to the standard proposed across the WHA might exist. At present there is no public access to the site but there is potential to incorporate a riverside walkway and this could be explored further.

The requirements of a new defence for this site would be the same as for other locations along this frontage and as such the preference for this site would be to refurbish the existing piles and construct a new flood wall to the required level

[2] Refer to the Adur River – Left Bank Quay Wall Survey (SPA, 2014)

(5.25mAOD). This would also provide the opportunity to raise ground levels behind the defence as required. In light of the low residual life of the existing piles a corrosion protection system must be installed in the near future. Otherwise further corrosion of the piles will necessitate the need for replacement piles which would then make it more cost effective to raise the new piles to the design flood level. This could lead to significantly different pile heights along the frontage which would require a more complicated connection detail and may give rise to aesthetic considerations.

The land adjacent to Ham Business Centre (former Minelco site) covers Tarmac and Free Wharfs. The existing site is partially derelict and the remainder comprises warehouse units. There is no public access across the sites except at Humphrey's Gap where a public hard is located. The defences to the sites comprise steel sheet piles with the crest height varying from 3.8-4.2mAOD. The piles at Tarmac Wharf will need replacing as they have been deemed to be failing whilst those for Free Wharf should last in excess of 100 years although extending the cope is recommended[3]. The level of the A259 varies from 3.5mAOD at Humphreys Gap to 5.0mAOD at New Wharf. The main urban realm issue will be the provision of access to the waterfront and the opportunities this presents. This may ultimately determine the preferred form and location of the defence.

There is an extant planning application (AWDM/0762/13) which has been approved subject to the legal agreement being established. The plans allow for the construction of a new supermarket, a petrol station, car showroom and two residential blocks. The details have yet to be finalised but there is scope to work with the developers. The current plans show a 1.2m high flood wall along the river frontage but there would be scope to alter the alignment (if necessary) to match plans for the rest of the frontage.

The defence preference for this frontage is to refurbish the existing piles and construct a flood wall with an alignment yet to be determined. It will be necessary to replace the sheet piles at Tarmac wharf which, despite having significant residual life against corrosion, are at the point of failure due to bending[4]. If the site remains to be developed as a single entity this could make replacement of all the piles up to the flood level more cost effective than constructing a flood wall. As for the Riverside Business Centre this could pose aesthetic issues and the significantly different pile height will result in a more complicated tie-in detail.

The remainder of this frontage is currently protected by a continuous steel sheet pile wall constructed on a wharf by wharf basis. The existing defence affords a variable standard of protection against flooding and the predicted residual life estimates[5] are summarised in Appendix A. The majority of the wharfs are considered to have an acceptable residual life but are in need of a corrosion protection system to ensure their continuing life. Maintenance and corrosion protection should seek to extend the pile life to satisfy the 100 year design life required. However there are several sites (Tarmac Wharf and potentially Riverside Business Centre) where the piles will need to be replaced. Therefore the options presented for this frontage must consider both cases. Along this frontage the options will be either to:

- refurbish existing piles and a raising of defence level on the top, e.g. raised capping, flood wall, land raise; or
- new steel sheet pile wall.

[3] Refer to the Adur River – Left Bank Quay Wall Survey (SPA, 2014)
[4] Refer to the Adur River – Left Bank Quay Wall Survey (SPA, 2014)
[5] Refer to the Adur River – Left Bank Quay Wall Survey (SPA, 2014)

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form, appropriate tie in details will be required. From the perspective of engineering construction therefore it is considered more challenging to vary between the two main options (new piles and a raised defence on the top of existing piles). This is largely due to the complexities in the tie-in details that result but the potential for development of different sites to come forward at different times and select different options could result in a poor aesthetic of changing defence levels when viewed from the opposite bank of the Adur. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

2.5.2.1 Raise existing pile capping

This option requires the existing piling to remain in place and to have sufficient residual life. Consequently, further detailed investigation of the piles should be undertaken prior to development of this option to determine viability (see section 3.12.2 Appendix A). Continued maintenance of the existing sheet piles should be undertaken as part of this option.

Protective coatings and cathodic protection, through the use of sacrificial anodes, will need to be applied to the sheet piles. The recommendation in the Shoreham Port Authority's condition assessment[5] is that a 2.5m deep concrete coping should be hung from the pile capping to provide additional protection to the splash zone, this is included as part of this option.

The existing sheet pile wall will provide the main defence line with the pile capping being raised to extend the design life of the existing structure. Detailed design will determine the maximum possible pile cap raise but at this juncture an assumed maximum raising of 500mm would not be sufficient to meet the design flood level and other forms of defence would be required in combination with raising the capping beam. Those could include the provision of a flood wall or land raising.

2.5.2.2 New sheet pile

This option assumes that the existing piles do not have sufficient residual life to last the design life of the scheme. It is assumed that the existing structure will remain in place; the new steel sheet pile wall will be built in front of the existing pile wall and the gap backfilled. Backfill will be required to enable the integration of the defence into the existing defence line. Keeping the existing defence in place reduces the potential for contaminated land to impact the watercourse, which may arise during removal of the existing sheet piles, and eases construction.

If only part of this frontage is constructed then consideration would be required as to how best to tie the new piles into the existing piling. This is due to the forward offset of the new piles leaving a gap between the two old and new defence lines. There are a number of ways of achieving this connection which would ultimately be determined at the detailed design stage and could involve welding a specially fabricated clutch to the existing pile to receive the end pile of the new line. There would also need to be a connection between the capping beams made.

Bringing the defence line forward will mean approval from the Environment Agency will be required before construction can occur and it is likely that compensatory inter-tidal habitat will be required to be provided elsewhere.

Typically the increase in pile height would be 1.0-1.8m depending on the location along the frontage. This is a significant amount and would have an

impact on the relationship with the river. If the land behind the defence is raised, which would likely be preferred on aesthetic grounds to prevent the pile being visible form the site, then the river would remain visible at higher water levels but at low tides it may not be as visible and the connection could be lost.

2.5.2.3 Flood wall on existing alignment

As noted in section 2.5.2.1 the existing sheet piles have been judged to generally be in a fair condition but in need of a corrosion protection system to ensure their continuing life. This option assumes maintenance works, to extend the pile life to satisfy the 100 year design life required.

It is assumed that the existing structure will remain in place; the new flood wall will be built on top of the existing defence following the current defence alignment. The wall could be designed to be either structurally independent or integrated with the existing pile cap.

Based on the EA Design Guidance a concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key (a downward extension of a portion of the foundation) to improve sliding resistance (lateral movement of the wall when loaded e.g. under flood conditions) and also increase the flow path for potential flood water which will help minimise seepage of floodwater through the ground underneath the defence. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements.

Of the two flood wall options this would maximise the area of the site protected potentially yielding a greater developable area. Although this will depend on how a riverside walkway and other urban realm considerations are addressed.

Typically the wall will have a height of 1.0-1.8m on top of the existing defence which will pose a number of considerations for the urban realm and interaction with the river. If land is not raised the wall could present a significant visual impact. Therefore it is expected that to enable improved integration with the urban realm some land raising will be required. With the wall constructed on the top of the existing defence there is also the possibility of losing the connectivity with the river in a similar way to the option of the new piles.

A flood wall is relatively straightforward to tie-in with other forms of defence and it is possible to design connections with other flood walls, pile capping beams, areas of raised land, etc.

2.5.2.4 Flood wall, set back

Again this option assumes that the existing sheet piles are generally in a fair condition but in need of a corrosion protection system to ensure their continuing life. This option assumes maintenance works, which should be accounted for as part of this option, can extend the pile life to satisfy the 100 year design life required.

The flood wall will be constructed landward of the existing defence line. At this stage no specific alignment has been considered but it could be set back as little as the width of a riverside walkway or intrude further into the site depending on the public realm aspirations for the site.

Based on the EA Design Guidance a reinforced concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key (a downward extension of a portion of the foundation) to improve sliding resistance (lateral movement of the wall when loaded e.g. under flood conditions) and also increase the flow path for potential flood water which will help minimise seepage of floodwater through the ground underneath the

defence. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements.

Typically the wall will have a height of 1.0-1.8m above the existing defence height which will pose a number of considerations for the urban realm and interaction with the river. If land is not raised the wall could present a significant visual impact. Therefore it is expected that to enable improved integration with the urban realm some land raising will be required. By allowing the flood wall to be set back from the existing defence line the loss of connectivity with the river is minimised as it potentially allows for a riverside walkway at existing levels on the riverward side of the defences.

This does however pose constraints for accessing the riverside walkway from the north / A259 as if the walkway is at a lower level then ramps will need to be included to provide step free access. The alternative would be to provide access from the road at the same level as the walkway although this would require flood gates to ensure a continuous defence line. In general ramps would be preferred as flood gates have a risk of failure however if other benefits can be realised the use of flood gates may be appropriate.

A flood wall is relatively straightforward to tie-in with other forms of defence and it is possible to design connections with other flood walls, pile capping beams, areas of raised land, etc.

2.5.2.5 Land raising to provide flood defence

Again this option assumes that the existing sheet piles are generally in a fair condition but in need of a corrosion protection system to ensure their continuing life. This option assumes maintenance works, which should be accounted for as part of this option, can extend the pile life to satisfy the 100 year design life required.

Land raising as a flood defence in this option assumes that the level of the site at the riverside is not raised above the pile capping beam and that the levels rise up to provide the required flood level closer to the A259. In practice this would require a significant land take to accommodate the relatively shallow gradient (e.g. 1 in 3) that would be required to transition for existing ground levels to the design level (5.4mAOD in this instance) or even finished floor levels given that the levels will need to be raised by 1-2m across the sites. Given the relatively small distance between the River Adur and the A259 land raising as a defence is unlikely to be a viable option.

However raising the land behind another form of defence remains a viable option and will likely be required to ensure that connectivity with the river and a high quality urban realm can be delivered.

The Environment Agency has confirmed the requirement on finished floor levels for residential properties to be above a level of 5.77mAOD. This could be achieved by raising the platform level of the development site, having buildings on stilts, including ground level car parking, and by having commercial uses or water compatible uses on the ground floor level. Requirements on safe access and egress may also require part of the site to be raised.

The form of flood defence will also impact on the necessity for land raising. Where the defence is proposed to be new sheet piling or where existing piles need to be replaced and it is intended to pile up to the design flood level of 5.25mAOD then raising the land along the waterfront so that piles are not visible from the land could be desirable aesthetically. Where the defence comprises a flood wall it is possible to clad the wall to make it more aesthetically pleasing and

raising land on the landward side to mask its appearance may not be necessary although it may be beneficial in maintaining connectivity with the river.

The riverside frontage levels along the Western Harbour Arm are typically around 4.0mAOD although they reduce to as little as 3.4mAOD towards Kingston Beach and where higher ground is encountered at New Wharf and Kingston Railway Wharf the ground levels are typically above 4.5mAOD. The A259 displays variable levels ranging from 3.5mAOD in front of the Civic Centre up to 5.9mAOD at the Cyril Richings Business Centre.

Raising the entirety of a site up to the design flood level or higher still to the residential finished floor level would be an extensive undertaking. The majority of sites are 1-1.8m below the design flood level so a significant volume of fill would be required. This is less feasible in areas where the levels along the A259 are significantly lower as it would sever the connection with the road and provide challenges for the provision of level access to the site.

Raising the land by a significant height could also have impacts on the overall height of buildings and could result in the loss of a storey thus impacting on the capacity for housing numbers on the site.

Land Raising can be considered a more viable option where contaminated land is present as it may prove more cost effective to cap the site with a suitable fill material rather than treating the contamination.

Where other defences particularly flood walls are provided there remains the option to consider only partially raising sites or to create interesting aesthetics by providing changes in level along the frontage as long as accessibility is maintained through ramped access. There is no optimum level for a partial raising of a site and this will form a material consideration in determining the public realm, riverside walkways and connectivity between adjacent sites.

2.5.3 Kingston Beach

Kingston Beach is exposed to the sea and therefore, wave action on the defences will occur. Consequently, defences subject to settlement or erosion e.g. embankments are impractical. Defences in this location should have the capability to dissipate wave energy. In addition a physical barrier is required to stop overtopping by the waves.

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form, appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required. At Kingston Beach there are two areas where the defence will require a tie-in.

A tie in to the higher ground, located along the line of the A259 (Brighton Road), is required to close off the flood cell. Without this, flood water may inundate defended areas and may cause flood water to flow along the road. The levels along the A259 in the vicinity of Kingston Beach are high enough that a landward return of the flood defence could be connected into the pavement along the A259. There are a number of potential routes for this return to follow and they are presented in Section 4.3.2.

The second tie in related to the connection at Howard Kent Wharf where any new defence would have to connect with the pile capping beam or flood wall proposed for that site.

The effect of any new defence scheme on the RNLI lifeboat station needs to be considered and checked to ensure that flood risk is not increased. As the lifeboat station is a water compatible site it is not considered that it should be

affected. Construction of new defences should not impede the operation of the lifeboat station in anyway.

Decisions at the Kingston Beach site is affected by the fact that the existing defence has failed and will be replaced as part of funding from the Environment Agency's Asset Recovery Programme. It is understood that the Asset Recovery funds can only be used to construct a like-for-like defence i.e. no betterment in the standard of protection afforded or change in defence type. In each of the options considered below it is considered that the failed revetment will have been replaced by a similar revetment. The preferred solution at this site will be the provision of rock armour mainly for its ability to dissipate the wave energy.

2.5.3.1 Rock armour revetment with upstand wall

It is assumed that the revetment will be demolished and a new rock armour defence will be constructed in its place.

Due to the location of Kingston Beach, which is exposed to wave activity, the option should be able to withstand wave action on the defence. Using rock armour will protect against this. The primary armouring layer will be placed on a smaller filter layer, underlain by a geotextile. This is to prevent washout of material beneath the defence. Rock armour is permeable so an impermeable wall should be placed to the rear of the defence, up to the design height of 5.25mAOD. Assuming the ground level behind the defence is not raised the wall would be approximately 1.5m above ground levels, although the wall may extend some distance below ground to provide an effective cut off to flow.

2.5.3.2 New concrete revetment and flood wall

It is assumed that the revetment constructed as part of the Asset Recovery Programme will be retained. The proposed flood wall would be at the top of the concrete revetment defence to provide the required design height of 5.25mAOD.

Due to the location of Kingston Beach, which is exposed to wave activity, the option should be able to withstand wave action on the defence. The replacement concrete revetment will provide protection against this, but will be subject to more detailed analysis during future design stages.

The flood wall will be constructed on the existing defence line. Based on the EA Design Guidance a reinforced concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key (a downward extension of a portion of the foundation) to improve sliding resistance (lateral movement of the wall when loaded e.g. under flood conditions) and also increase the flow path for potential flood water which will help minimise seepage of floodwater through the ground underneath the defence. It is envisaged that the wall will be clad with either bricks or stone, dependent on architectural design and the local planning authority requirements.

2.5.3.3 Sheet piles and removal of existing concrete blockwork revetment

For this option the new line of piling will be constructed to the rear of the existing defence, therefore allowing demolition of the revetment without loss of defence. It is assumed that the existing revetment will be demolished after completion of the piling, although it could be left in place to provide sacrificial protection and additional wave protection to the new defence.

Due to the location of Kingston Beach, which is exposed to wave activity, the option should be able to withstand wave action on the defence. Rock armour should be placed at the base of the sheet pile wall to provide scour protection. This will help dissipate wave energy and prolong the life of the pile wall.

This option is easily tied into the existing sheet pile defences to the west although it is more technically challenging to pile behind the existing revetment. A return wall would still need to be provided to connect the capping beam of the piles with the high ground along the A259 to close the flood cell.

3 Concept design

3.1 Design process

The concept design was progressed from the short list of options (see Table 2-3). During the concept design process, Design Technical Notes (DTN) (see Appendix D), Designers Hazard Inventory (DHI) (see Appendix E), technical drawings (see Appendix F) and cost estimates (see Appendix G) were compiled for all options.

Dimensions of structures were estimated based on engineering judgement to enable costing of defence options. Similarly, materials were assumed to enable a cost to be attributed. Both structural dimensions and materials may change based on further design stages.

3.1.1 Design levels (see Sections 3.5, 3.8 and 3.9, Appendix A)

The defence design level is calculated using the UK Climate Projections (UKCP09) for the 1 in 200 year still water level for 2115. This gives a sea level of 5.08mAOD. Freeboard allowances are given in the Design Input Statement (DIS) (see Appendix A) as a minimum of 150mm for hard defences and 300mm for soft defences. Hard defences are those considered not to suffer settlement of their crest level e.g. concrete or masonry walls, sheet piling, etc. Soft defences are those which are subject to settlement of their crest level over time e.g. earth embankments, land raising, etc. Consequently the design levels used are as follows:

- 5.25mAOD for hard defences; and
- 5.40mAOD for soft defences

Sea levels can be portrayed using two distinct datums; Ordnance Datum (OD) and Chart Datum (CD). The drawings outlined within the report show levels as metres above ordnance datum (mAOD) which is a national standard measurement, whereas metres above chart datum (mACD) is specific to the low water mark in a specific locality. For Shoreham Harbour mAOD can be converted to mACD by adding 3.27m. *All new defences will require ongoing*

3.1.2 Assumptions

The following assumptions have been used during the development of the concept design.

3.1.2.1 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This assumption leads to a conservative approach in the development of concept designs which may mean that reductions in pile length, wall foundation size, etc. could be reduced at a detailed design stage.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. Geotechnical Investigation and analysis should be undertaken prior to further development of outline designs and their submission for planning approval.

3.1.2.2 Services information

Available services information has been made available as part of this study but there may be limitations to its completeness. Services information was provided

by Southern Water, UK Power Networks, British Gas, BT, and Virgin. The information was collated and is presented in Figure 3-1

Most of the major services run along the A259 and don't directly impact the WHA. A number of the sites have incoming utilities infrastructure which would need to be avoided during construction. The only major service likely to have an impact on the provision of defences will be the surface water sewer system which has a number of outfalls through the existing sheet piling and beneath Surry Hard. These sewer outfalls will have need to be extended, if a line of new sheet piling is installed with an outlet through the new pile provided. In all other instances the only concern would be in ensuring access chambers and inspection points are altered appropriately if the site level is raised. Based on the information available there is no obvious need to divert any existing services.

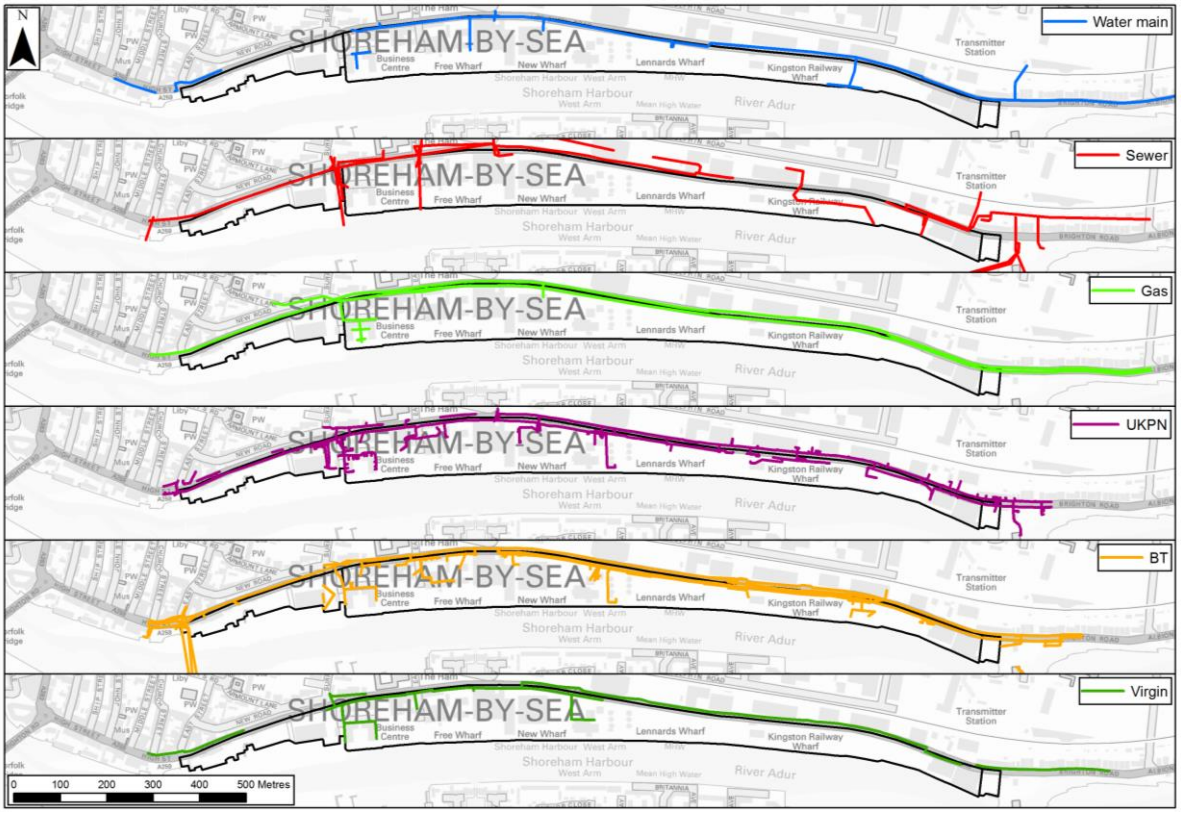

Figure 3-1: Services information for the Western Harbour Arm

All designs of defence structures have been progressed assuming that services do not conflict with the design. Cost estimates are subject to significant variation should diversion of services be needed. A services investigation should be undertaken prior to further development of outline designs and their submission for planning approval. All concept designs are subject to service investigation results.

3.1.2.3 Contaminated land

A desktop study was completed in March 2009 by WSP Environmental Ltd[6]. The report highlighted that the underlying soils have evidence of hydrocarbons, metals and inorganic contamination with evidence to suggest migration of contaminants between sites via groundwater.

No further investigation of contamination issues at individual development sites has been undertaken in support of concept design. Cost estimates do not include specific mitigation of contaminated land issues.

[6] WSP Environmental Ltd. (2009). Desk Study Review, Shoreham Harbour, Shoreham-by-Sea, West Sussex

Across the former industrial area, some level of contamination is likely and development of flood defence designs and construction will require some contaminated land treatment.

To reduce the risk of encountering contaminated land defence options that reduce the need for excavation on site would be preferred. Depending on the type of contamination present, land raising can often be considered a useful tool as it can enable the contaminant to be capped well beneath the finished site level.

3.1.2.4 Structural Design

The scope of works is for the development of concept design options. Structural design has not therefore been included within this study. A full structural analysis could not be completed without relevant ground condition information. Details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

3.1.2.5 Reinstatement and finish details

The development of landscape and architectural enhancements are outside the current scope of the study. It is assumed that, following construction, the surrounding area will be re-instated in accordance with planning requirements. The integration of flood defence and mitigation measures within the redevelopment is considered further however in the Guide (SPD). Materials and finishes are subject to outline and detail design.

3.2 Design parameters

All defences that were considered during the identification of options (see Section 2.5) have had Design Technical Notes (see Appendix D) and Hazard Inventories (see Appendix E) prepared. These state the assumptions made, the design development and the technical risks associated with each option. Four key assumptions have been utilised in all options:

- A ground condition survey should be undertaken prior to the detailed design stage.
- A full services information survey should be undertaken prior to the detailed design stage to ensure the currency and completeness of the available information.
- A site focused contaminated land survey should be undertaken prior to the detailed design stage. This may require intrusive surveys where a site is considered to be higher risk.
- A full structural assessment should be undertaken as part of the detailed design stage. Concept options are liable to change based on the results of structural analysis.

3.3 Environment

A preliminary appraisal of environmental constraints and opportunities presented by each of the defence options has been undertaken. The appraisal can be found in Appendix H.

The first task of the appraisal was to undertake a desk study to obtain baseline environmental information on key environmental features that have the potential to be affected by the project. Information was collected through a literature review and from online sources.

Secondly a high-level qualitative appraisal of the flood risk management options was undertaken to identify potential significant environmental impacts (positive

and negative). The outcomes of this process have been summarised in appraisal matrices, which identifies the environmental features that have the potential to be affected by each of the project options and the potential significance of the effects identified. This report also outlines the potential scope of the environmental surveys and studies that would be required as part of the subsequent environmental assessment process should the project be taken forward to through the consenting process.

The findings of the appraisal are reflected in the scoring for the environmental aspects with the MCA.

3.4 Concept drawings

Concept engineering drawings have been produced for all 12 options outlined in Section 2.5. These drawings are shown in Appendix F with details of each option and its corresponding drawing given in Table 3-1 below.

Table 3-1: Drawing register

Section	Option	Drawing number
Shoreham Harbour footbridge to Riverside Business Centre	Concrete blockwork revetment	2014s0848 - 001
	Flood wall, set back	
	Flood wall, on existing defence	
	Sheet piles, in front of existing defence	
Riverside Business Centre to Kingston Beach	Raise existing pile capping	2014s0848 - 002
	New sheet pile	
	Flood wall on existing alignment	
	Flood wall, set back	
	Land raising to provide flood defence	
Kingston Beach	Rock armour revetment with upstand wall	2014s0848 - 003
	New concrete blockwork revetment and flood wall	
	Sheet piles and removal of existing concrete blockwork revetment	

3.5 Cost estimates

Estimated construction costs of the defence concepts are shown in Appendix G and summarised in Table 3-2 below. The Costs were calculated based on the following references:

- Environment Agency. (2011). Long term costing tool (Cost estimation for fluvial defences)
- Spons. (2014). Civil Engineering and Highway Works Price Book
- Contractor priced estimates

Costs were developed per linear metre with annual maintenance costs approximated as being 0.5% of the construction cost per year.

The costs of the various defence concepts also require an optimism bias to be applied. Optimism bias is not a contingency and should not be treated as such. It is intended to account for a systematic underestimate of costs in engineering schemes due to an overly optimistic outlook on the ease of construction, ground conditions, material requirements, etc.

Selecting an optimism bias is not straightforward. The Environment Agency's FCERM appraisal guidance[7] recommends an optimism bias of 60% for strategies and 30% for schemes in the absence of a more comprehensive analysis. If this study had been costed by the components of each design an optimism bias of 60% would have been applied. With the majority of costs having come from a cost database (a record of the actual costs of a large number of Environment Agency schemes) it is not straightforward as to what optimism bias should be applied. On the basis of the level of design undertaken and the lack of information on ground conditions we have applied a 60% optimism bias.

Cost estimates are subject to further design stages and significant variation arising from service locations, contaminated land, ground condition and structural assessments. Further assessment of cost should be completed once more detailed design has been developed.

Where the approach to providing a defence requires a combination of options then a scheme cost is required. As a conservative approach the costs presented in Table 3-2 can be summed although in practice there are likely to be efficiencies realised in some shared components such as site start-up costs and plant hire.

Table 3-2: Capital cost ranges of components of individual flood defence options

Component	Final cost range		Final cost range (including 60% optimism bias)	
	Min (£/m)	Max (£/m)	Min (£/m)	Max (£/m)
Revetment	781	3,423	1,250	5,477
Backfill to support revetment	1,138	1,138	1,821	1,821
Food wall (height = 1.2 - 2.1m)	2,144	3,660	3,430	5,856
Flood wall (height = 2.1 - 5.3m)	2,848	5,382	4,557	8,611
Sheet piles	8,525	8,525	13,640	13,640
Sacrificial anodes for sheet piles	295	295	472	472
Raised pile capping (500mm raise)	128	286	205	458
2.5m concrete cope on existing piles	1,429	1,429	2,286	2,286
Land raise (1.5m raise)	2,279	5,998	3,646	9,597
Rock armour	1,621	7,206	2,594	11,530
Rock armour scour protection for sheet piles	1,600	1,600	2,560	2,560

3.6 Maintenance

Maintenance activities required for each of the defence options have been identified and are described within Appendix G. Annual maintenance costs are approximated as being 0.5% of the construction cost per year.

All new defences will require ongoing maintenance throughout their life. Provision for future maintenance would be the responsibility of the developer or riparian owner. The maintenance requirements and provisions would need to be agreed with the local planning authority and in consultation with the Environment Agency and Shoreham Port Authority, prior to construction, and adequate funds

[7] Environment Agency (2010) Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG)

set aside. The design of defences will need to ensure safe access for inspection and maintenance.

The completed defence line is unlikely to consist of a single alignment and will variously be at the riverside or set back. Consequently, in some locations the riverside walkway may be in front of the defences and below the flood level. In these instances there will need to be agreed procedures for ensuring that when flooding was predicted that the undefended sections were closed in the interest of safety.

The accessibility of the redevelopment to all users is paramount. To this end the provision of step free access is required throughout the development area and the alignment and positioning of the defences will need to make allowance for ramps where changes in level are envisaged. If access through a defence is required then any flood gates should be specified with accessibility in mind.

3.6.1 Maintenance of existing piles

Maintenance works will be required to keep the existing piles in good order throughout the design life of the development. The cost of refurbishing the piles from their current condition to in line with the recommendation of Shoreham Port's condition assessment has be included as a capital cost

Defence options that require the existing piles to remain are only feasible if maintenance works can extend the pile life to satisfy the 100 year design life required. These options rely on the existing sheet piles to have sufficient residual life to continue to form an effective defence. Consequently, maintenance of the existing piles should be taken as a requirement for further development of options in these circumstances. Protective coatings and cathodic protection applied to protect against the effects of Accelerated Low Water Corrosion (ALWC) should be inspected periodically and refurbished as required. It is estimated that on average the sacrificial anodes will need to be replaced every 25 years.

Further analysis of the piles will be required to determine the level of repair and maintenance required to satisfy the required design life on a case by case basis and may vary from wharf to wharf.

3.6.2 Maintenance of new piles

Maintenance of the new piles should include, but not be limited to, protective coatings and cathodic protection to protect against the effects of ALWC. Again it is considered appropriate that the sacrificial anodes be replaced every 25 years.

3.6.3 Maintenance of flood walls

Maintenance activities should be considered during the detailed design stages to ensure that access is enabled. Flood walls must have a clear inspection and maintenance instructions to address maintenance issues which, if ignored or neglected, may lead to deterioration in the defence. The deterioration may compromise the effectiveness of the wall as a flood defence (for example, through the loss of joint sealer) or its appearance (for example, proliferation of graffiti or deterioration of planting schemes incorporated in the wall design).

Gates in floodwalls require regular attention to ensure they operate effectively in a flood event. Maintenance works include oiling of hinges and inspection of seals. The asset management regime should include at least one trial closure of each gate every year to be incorporated into the councils' emergency planning programme.

Built-in parts for demountable defences should be inspected and cleaned out regularly to ensure there are no delays to the erection procedure in a flood event.

Table 3-3: Comparative cost of options by frontage

Frontage	Option	Components	Cost range		Cost range including 60% optimism bias	
			Min (£/m)	Max(£/m)	Min (£/m)	Max(£/m)
Shoreham Harbour footbridge to Riverside Centre	Concrete blockwork revetment	Revetment	781	3,423	1,250	5,477
		Backfill to support revetment	1,138	1,138	1,821	1,821
		TOTAL	1,919	4,561	3,070	7,298
	Flood wall, set back	Flood wall (height = 2.1 - 5.3m)	2,848	5,382	4,557	8,611
		TOTAL	2,848	5,382	4,557	8,611
	Flood wall, on existing defence	Flood wall (height = 2.1 - 5.3m)	2,848	5,382	4,557	8,611
		TOTAL	2,848	5,382	4,557	8,611
	Sheet piles in front of existing defence 1	Sheet piles	8,525	8,525	13,640	13,640
		Sacrificial anodes for sheet piles	295	295	472	472
		TOTAL	8,820	8820	14,112	14,112
Riverside Centre to Kingston Beach	Raise existing pile capping (Does not meet design criteria)	Raised pile capping (500mm raise)	128	286	205	458
		2.5m concrete cope on existing piles	1,429	1,429	2,286	2,286
		Sacrificial anodes for sheet piles	295	295	472	472
		TOTAL	1,852	2010	2,963	3,216
	New sheet pile 1	Sheet piles	8,525	8,525	13,640	13,640
		Sacrificial anodes for sheet piles	295	295	472	472
		TOTAL	8,820	8820	14,112	14,112
	Flood wall on existing alignment	Flood wall (height = 1.2 - 2.1m)	2,144	3,660	3,430	5,856
		2.5m concrete cope on existing piles	1,429	1,429	2,286	2,286
		Sacrificial anodes for sheet piles	295	295	472	472
		TOTAL	3,868	5384	6,189	8,614
	Flood wall, set back	Flood wall (height = 1.2 - 2.1m)	2,144	3,660	3,430	5,856
		2.5m concrete cope on existing piles	1,429	1,429	2,286	2,286
		Sacrificial anodes for sheet piles	295	295	472	472
		TOTAL	3,868	5384	6,189	8,614

Frontage	Option	Components	Cost range		Cost range including 60% optimism bias	
			Min (£/m)	Max(£/m)	Min (£/m)	Max(£/m)
	Land raising to provide flood defence - self supported without retaining wall	Land raise (1.5m raise)	2,279	5,998	3,646	9,597
		2.5m concrete cope on existing piles	1,429	1,429	2,286	2,286
		Sacrificial anodes for sheet piles	295	295	472	472
		TOTAL	4,003	7,722	6,405	12,355
Kingston Beach	Rock armour revetment with upstand wall	Rock armour	1,621	7,206	2,594	11,530
		Flood wall (height = 1.2 - 2.1m)	2,144	3,660	3,430	5,856
		TOTAL	3,765	10866	6,024	17,386
	New concrete blockwork revetment and flood wall	Revetment	781	3,423	1,250	5,477
		Flood wall (height = 1.2 - 2.1m)	2,144	3,660	3,430	5,856
		TOTAL	2,925	7083	4,680	11,333
	Sheet piles and removal of existing concrete revetment	Sheet piles	8,525	8,525	13,640	13,640
		Sacrificial anodes for sheet piles	295	295	472	472
		Rock armour scour protection	1,600	1,600	2,560	2,560
		TOTAL	10,420	10420	16,672	16,672
1 Sheet piles would require local backfill between new and existing defences quantity to be determined; this has not been accounted for in costs						
2 Flood gates may be needed where access need to be maintained. Costs of gates are dependent on the gate size. Estimates are based on figures included in the Environment Agency's Temporary and Demountable Flood Protection Guide, Draft Report (2010).			2,625	10,143	4,200	16,229
3. Demountable defence systems may be required to ensure the continuity of defences as development is ongoing. There are too many types of demountable defences to provide a range of costs. Indicative costs are included in the Environment Agency's Temporary and Demountable Flood Protection Guide, Draft Report (2010).						
4. The provision of pontoons has been considered within the SPD but they do not constitute a flood defence and have therefore not been costed.						

4 Bringing forward development

4.1 Flood defence and phasing of development

Land parcels are under separate ownership.

Until a continuous defence frontage is formed it may be necessary to construct demountable or temporary defences to the sides of a land parcel being redeveloped to stop inundation from land that has, as yet, not had defences constructed. The aspiration of the regeneration scheme is for complete closure of the flood cell and continuation of the line of new defences being provided via the EA's Adur Tidal Walls Scheme. It is desirable that all new flood defence works will be integrated with "a high quality public realm environment that promotes a positive inter-relationship with the river[8]". Flood defences that inhibit permeability and the ability to pass through the Western Harbour Arm are not desirable. Development of defences should be able to be progressed in phases if required, with the overarching aim of a continuation of the line of defences and complete closure of the flood cell being prioritised. The two most critical areas in that respect are the connection with the Adur Ferry Bridge and at Kingston Beach. To that end, concept options have been developed to allow individual parcels of land to be developed, whilst maintaining a uniform design that will potentially link between developments.

4.2 Funding considerations

Local Authorities can derive funding from a variety of sources including capital receipts and loans, and potentially contributions from developers via planning instruments such as Section 106 and the Community Infrastructure Levy. Other public sector sources include national opportunities such as the Growing Places Fund and Defra Growth and Acceleration Funding.

Private sector contributions may be secured from developers or private companies that will gain a direct benefit from a flood protection scheme. The main opportunity for 'mandatory' contributions from the private sector is via the development process (S.106 and CIL).

Other external funding sources include European and National Lottery programmes and from charitable grant bodies.

Many funding bodies describe themselves as 'match funders', which reflects their desire to see projects developed in partnership with organisations. With limited exceptions no external funders will fund a project at 100%, alternatively applications may be regarded as having a reduced risk if other match funding supports a bid. For example, Distributive Environmental Bodies (DEBs) will require a minimum of 10% cash commitment. Funders would usually expect the project lead or promoter to be significantly committed to the project, both financially and through other resources. Some funding programmes have a two stage approach, with a simple stage one outline submission which, if successful, will provide funds to develop a detailed business case at stage two.

It should be noted that some funders will only fund or favour funding communities or community groups, therefore project activities seeking funding from these sources must be progressed through local partnership working.

The location of a programme of work and specific project activity must be considered in relation to funder requirements.

Funder priorities and eligibility criteria change over time and this should always be considered when developing bids.

[8] Shoreham Harbour Joint Area Action Plan (2014)

The details contained within this Technical Annex and within the Guide (SPD) should inform the preparation of work programmes. Details contained herein should also be used to support partnership negotiations where demonstration of scheme context and aspirations are beneficial in engagement activities.

The Partnership Funding approach to the funding of capital projects to reduce flood and coastal erosion risks was introduced by Defra in May 2011. This makes Defra flood and coastal erosion risk management grant-in-aid (GiA) available for schemes in relation to the benefits that will be realised from the investment. Schemes with sufficient benefits are eligible for 100% GiA funding. Other schemes are offered funding proportionate to their planned benefits if funding from other sources can be secured to meet the remaining costs or ways can be found to reduce the costs of projects. In the case of the Shoreham Harbour Regeneration Area it should be noted that benefits in relation to new properties (or existing buildings converted to housing after 1 January 2012) will not be counted in benefit-cost assessments undertaken in support of GiA applications.

Case studies compiled as part of Defra research project: Coastal Schemes with Multiple Funders and Objectives FD2635 of potential relevance to the Shoreham Harbour Regeneration area are:

- Cleveleys Coastal Defence Improvement and Promenade Enhancement Scheme
- Redcar Flood Alleviation Scheme
- Weston-super-Mare Seafront Enhancement

The case studies provide an overview of coastal schemes delivered through partnership working, with funding from a range of sources. They also highlight many valuable lessons learned.

4.3 Construction considerations

4.3.1 Contaminated land

A desktop study was completed in March 2009 by WSP Environmental Ltd[9]. The report highlighted that the underlying soils have evidence of hydrocarbons, metals and inorganic contamination with evidence to suggest migration of contaminants between sites via groundwater. The groundwater also appears to be contaminated and there is limited evidence of remedial action of these issues. The report states that it is the opinion of Adur District Council that "the majority of the area has significant pollutant linkages."

[9] WSP Environmental Ltd. (2009). Desk Study Review, Shoreham Harbour, Shoreham-by-Sea, West Sussex

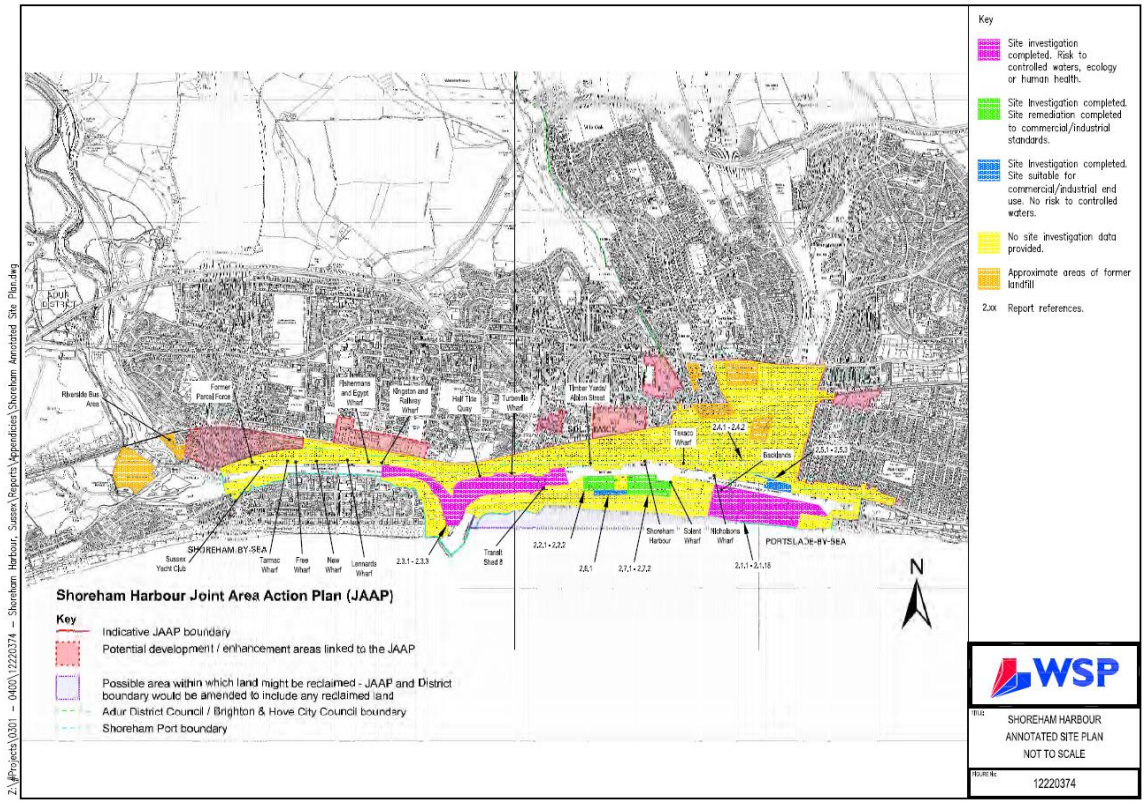

Figure 4-1: WSP Environmental Ltd. (2009). Desktop Study Review, Shoreham Harbour. p.32

Figure 4-1 shows where contaminated land information was available in relation to the JAAP area. A large proportion of the area did not have site information available for the study (shaded yellow on the map). An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of both suitable flood defence construction techniques and the wider regeneration. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination.

A review of historic maps and land ownership maps of the Shoreham Harbour Regeneration area undertaken as part of the current study has not added to the understanding of contamination issues. Consideration of contaminated land issues will be required as defence options are further designed and may impact the selection of preferred choices. Figure 4-1 should inform a risk-based approach to these considerations.

The selection of a defence type will have an impact on the relative risk of mobilising contaminants. An individual site risk assessment should be undertaken if the presence of contaminants are determined, however it is possible to provide a general overview of the risks of encountering contaminants relating to difference defence types (Table 4-1).

Table 4-1: Overview of risks for different defence types

Defence type	Risks
Revetment	Main risks are associated with removal of existing revetments or in excavation required for a new revetment. There is the potential to mobilise contaminants in the near surface or trapped behind the existing defence.
Flood wall	Flood walls are unlikely to have significant risk unless contaminant is close to the surface and encountered during excavation for foundations.
Sheet piles	Steel sheet piles are required to be driven and whilst they from an impermeable cut-off which prevents future migration of contaminants they can disturb existing contaminants and potentially allow them to migrate deeper during the construction phase. This is considered to be a more significant issue when piling behind the line of the existing defence.
Raised pile capping	Highly unlikely to encounter contaminants as works are all above ground level.
Land raising	Very low risk of disturbing contaminants as additional material is being placed on top. With the placement of a suitable fill material land raising can be used to cap known contamination risks.
Rock armour	Placing of rock armour is generally low risk. The construction of the cut-off wall behind presents the biggest risk during the excavation of foundations
Demountable defences	Highly unlikely to encounter contaminants as works are all above ground level.

4.3.2 Tie-in of defences

A continuous defence line will be required across the Western Harbour Arm to protect new development coming forward and existing development currently subject to flood risk, to the design standard. The alignment of the defence line will be subject to its integration with development and public realm and the relative phasing of each development parcel as they come forward.

Construction of a continuous defence line will require consideration of the tie-in:

- between neighbouring flood defence assets
- with existing ground levels; and
- with new ground levels arising through regeneration

Locations requiring consideration include zones in the immediate vicinity of:

1. Adur Ferry Bridge to Sussex Yacht Club: *in this zone continuity of defence line between the abutment of the footbridge and new defence at the Sussex Yacht Club is required. Subject to design the new defence should extend close to the abutment, with concrete and flexible joint infill. There are several possible defence alignments depending on whether new sheet piles or a floodwall on top of / set back from the existing defence are delivered, these are presented in Figure 4-2.*
2. Sussex Yacht Club to the former Parcelforce site: *tie-in between existing/new defences at the yacht club and defences permitted under the extant planning permission at the former Parcelforce site are discussed in more detail within Section 2.5.1 but should consider the opportunity to provide flood defence to the design standard (i.e. a uniform standard). At present the Tarmount and Surry hards present a low spot which enable flooding of the A259 as witnessed in the winter of 2013/14.*
3. Parcelforce site to Riverside Business Centre: *tie-in at the juncture between the two frontages will be important particularly as there is currently a change in the alignment occurring at this point with the Riverside Business Centre defence set further into the River Adur. The options for tie-in are likely to consist of connecting pile capping beams or flood wall through the use of dowels and grouting depending on the defence type selected (which will be heavily influenced by the condition of*

the existing piles). There are a number of potential alignments which are illustrated in Figure 4-3*.*

4. Riverside Business Centre to the former Minelco site (land adjacent to Ham Business Centre): *tie-in between the existing sheet piled defence at the Riverside Business Centre and the new defences permitted by the extant planning permission at the former Minelco site are discussed in more detail within Section 2.5.2. Opportunity to provide a continuous flood defence to the design standard should be sought.*
5. Howard Kent site / Kingston Wharf (at the transition between the Riverside Business Centre to Kingston Beach frontage and the Kingston Beach frontage): *at this juncture the preferred connection will require that the wall behind the rock armour from the Kingston Beach defence should be connected to either a flood wall or pile capping beam at the Howard Kent site / Kingston Wharf. Rock armour should be lapped for an appropriate distance in front of new piling for continuity and to prevent scour and outflanking (See* Figure 4-4*).*
6. Kingston Beach to the A259: *this is probably the most critical tie-in in order to close the flood cell as the portion of Kingston Beach outside of the WHA is not defended to the same standard. It will also form an important entrance / exit way for the new riverside route. The tie-in will require the wall behind the rock armour defence to return landwards and connect with the A259. The levels on the A259 are sufficiently high that the return wall can potentially terminate across a considerable length of this road which gives flexibility on the flood defence alignment (see* Figure 4-5*).*

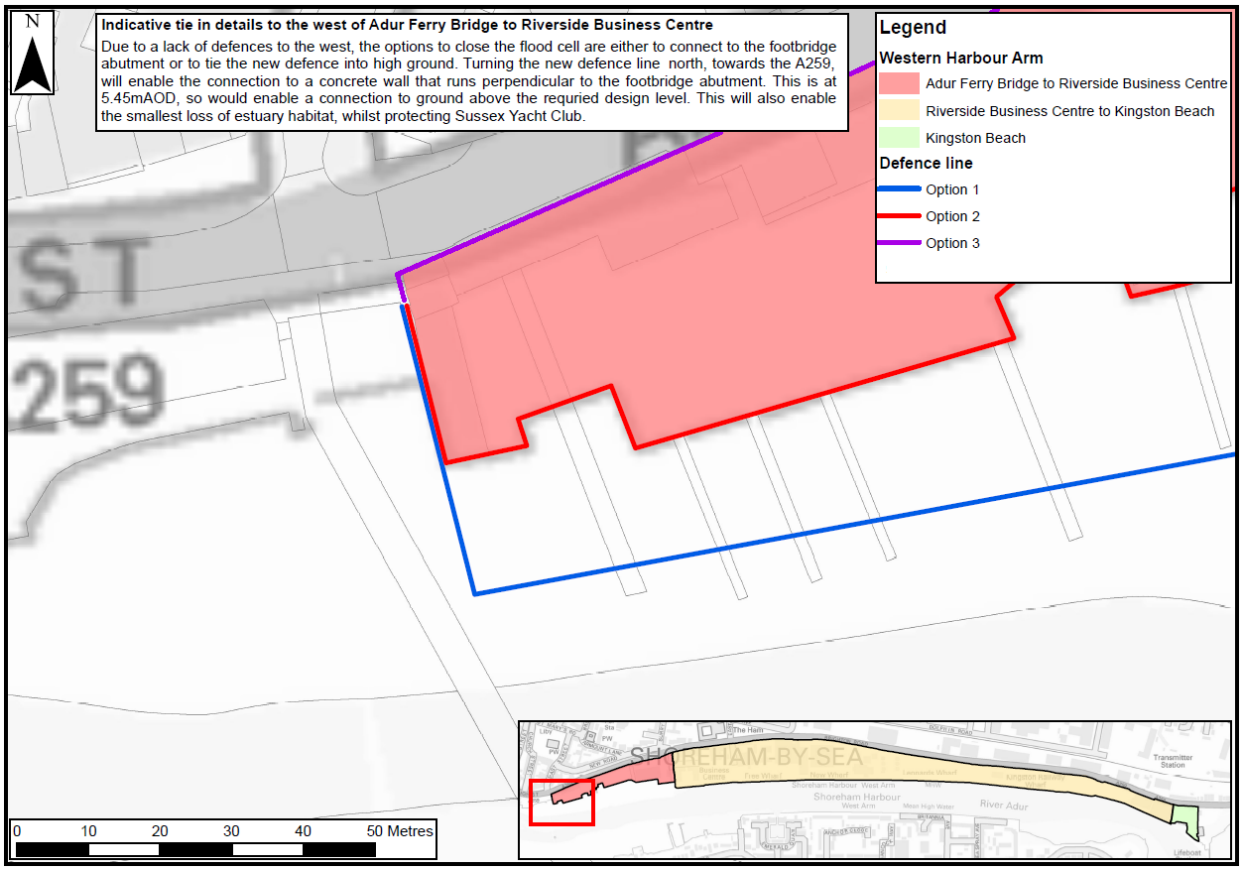

Figure 4-2: Tie-in details at Adur Ferry Bridge

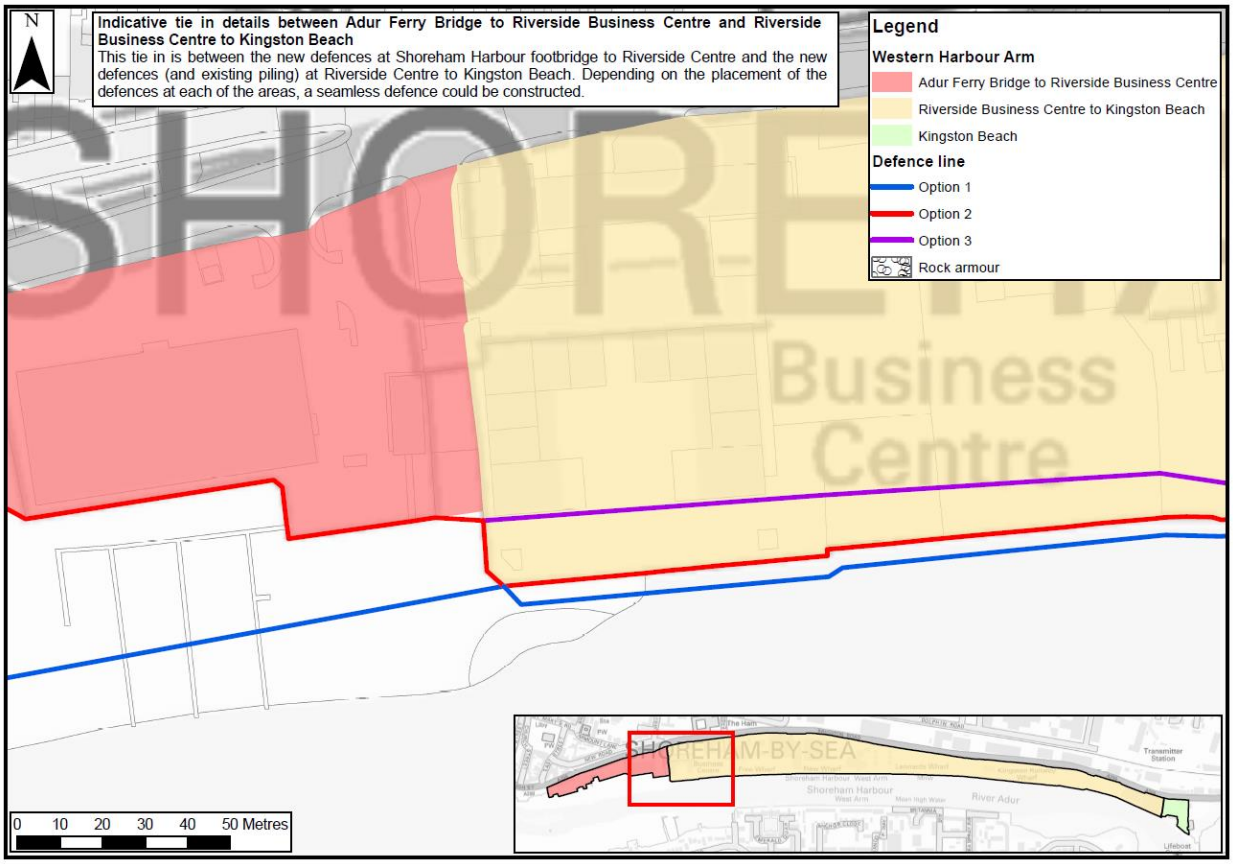

Figure 4-3: Tie in details at Riverside Business Centre

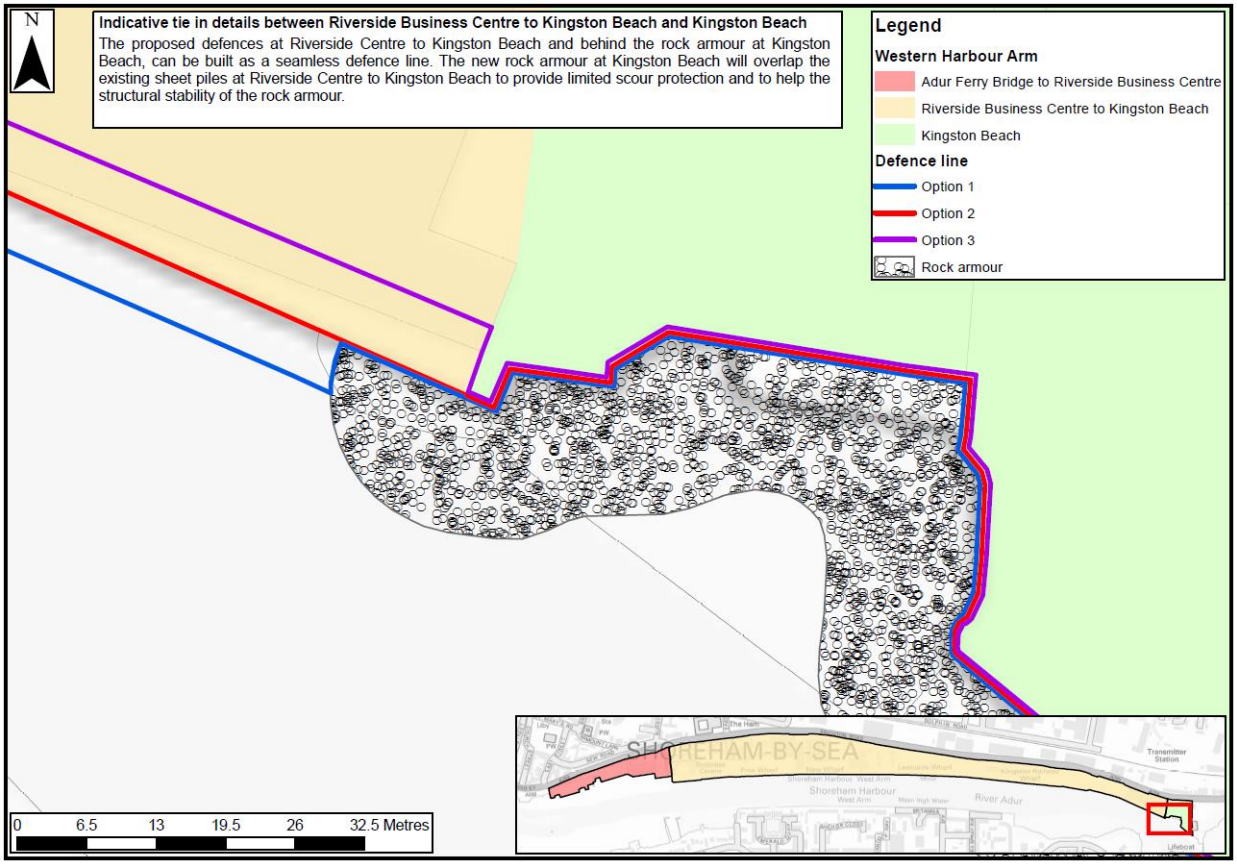

Figure 4-4: Tie-in details at Howard Kent wharf

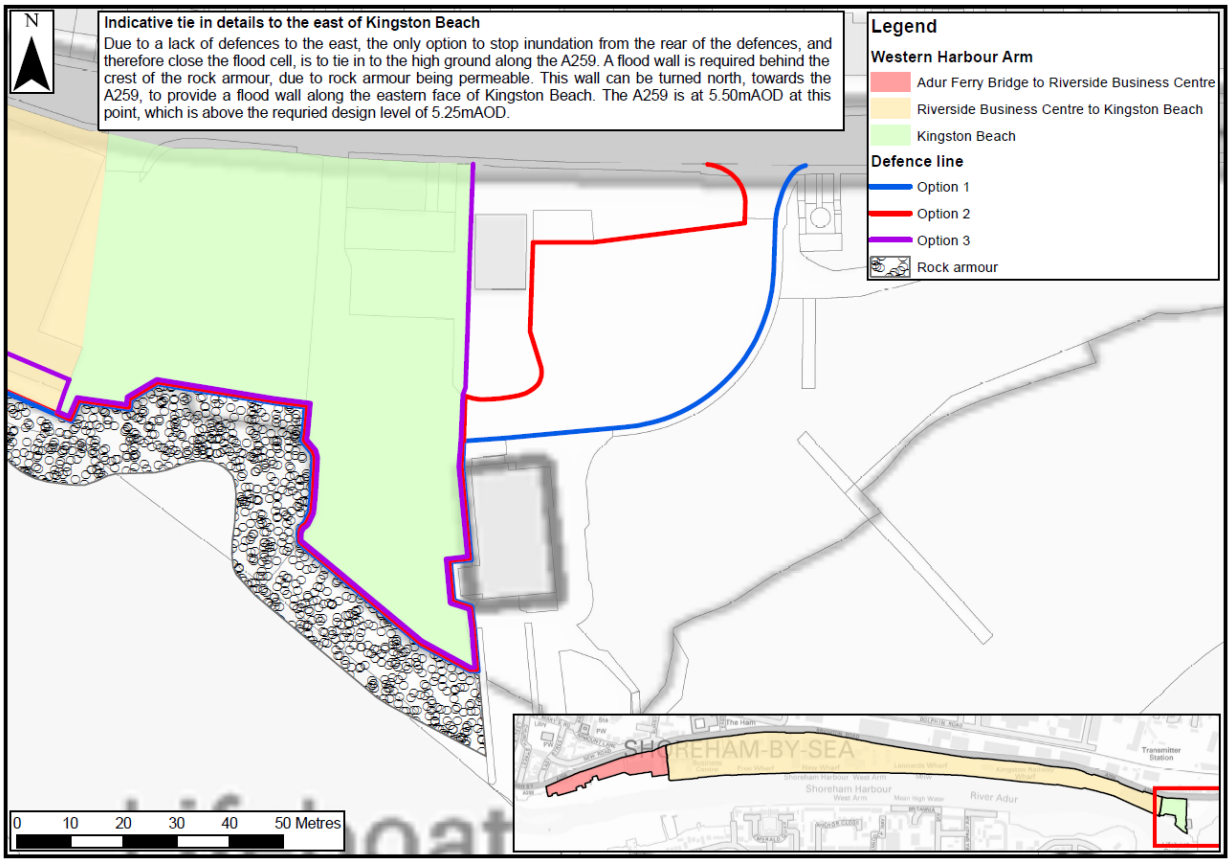

Figure 4-5: Tie-in details at Kingston Beach

4.3.3 Residual life of existing sheet piling

Corrosion rates and losses of pile section vary considerably along the Western Harbour Arm. There is widespread evidence of the recent onset of Microbially Induced Corrosion (MIC), though the severity of the damage appears to be limited as yet[10].

The Adur River – Left Bank Quay Wall Survey (SPA, 2014) noted that the maximum anticipated residual life for piling within the Western Harbour Arm is in excess of 100 years and the minimum anticipated residual life for some sections is 20 years. A critical assumption used in determining the residual life is the assumed factor of safety used in original design. The factor of safety is a factor used to multiply the anticipated loads within a structural design which can be used to account for variability in the strength of construction materials and minor defects occurring in construction. Without the original design calculations it is not possible to determine the factor of safety selected when design the piles. In the Quay Walls Survey a factor of safety of 2.0 and 1.5 were applied. The lower factor of safety significantly reduces the residual life for a number of frontages and further underlines that a detailed structural analysis of the piles on each wharf prior to redevelopment is essential.

The condition assessment also notes that:

"There are, of course, many other factors that can result in a shorter service life such as inadequate original strength for the loads imposed, damage to tie rods, localised perforation and the on-set of MIC."

These other factors are likely to be highly significant in determining a best estimate of residual life and should be taken into account as part of a more comprehensive assessment.

[10] Refer to the Adur River – Left Bank Quay Wall Survey (SPA, 2014). A summary of the life expectancy of the piles and recommendations for remediation is made in this report.

The residual life of the existing piles is an important consideration in the selection of defence options, particularly along the Riverside Business Centre to Kingston Beach frontage, where some options assume the continued presence of existing piles.

Appendices

A Design Input Statement

Shoreham Harbour Flood Risk Management Technical Guidance

Design Input Statement - Western Harbour Arm

V5.0 January 2015

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
V1.0	Issued as Draft	Sam Sykes
V2.0	Updated details following revised condition assessment and minor changes advised by ADC	Sam Sykes
V3.0	Conformation of some design details following client meeting	As appendix to Flood Risk Management Technical Guide Annex
V4.0	Minor updates for consistency with technical annex	As Appendix A of the Flood Risk Management Guide Technical Annex
V5.0	Minor updates for consistency with technical annex	As Appendix A of the Flood Risk Management Technical Guide Annex

Contract

This report describes work commissioned by Sam Sykes, on behalf of Adur District Council, by an award notification received 31st January 2014. Adur District Council's representative for the contract was Sam Sykes. Tim Ash-Edwards and Oliver Francis of JBA Consulting carried out this work.

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Purpose

This document has been prepared as a Design Input Statement for Adur District Council. JBA Consulting accepts no responsibility or liability for any use that is made of this document other than by the Client for the purposes for which it was originally commissioned and prepared.

JBA Consulting has no liability regarding the use of this report except to Adur District Council.

Acknowledgements

JBA would like to thank Sam Sykes for providing all of the background data to support this document.

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JBA is aiming to reduce its per capita carbon emissions.

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Abbreviations

1D ..... One-dimensional

2D ..... Two-dimensional

ADC ..... Adur District Council

AEP ..... Annual Exceedance Probability

AOD ..... Above Ordnance Datum

CDM ..... Construction Design and Management Regulations (2007)

Defra ..... Department for Environment, Food and Rural Affairs

DIS ..... Design Input Statement

EA ..... Environment Agency

EIA ..... Environmental Impact Assessment

FRM ..... Flood Risk Management

HSE ..... Health and Safety Executive

JAAP ..... Joint Area Action Plan

JBA ..... Jeremy Benn Associates

MCA ..... Multi-Criteria Analysis

MIC ..... Microbially Induced Corrosion

OS ..... Ordnance Survey

SSSI ..... Site of Special Scientific Interest

UKCP09 ..... United Kingdom Climate Predictions 2009

WHA ..... Western Harbour Arm

1 Project aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

There are four strategic development sites within Shoreham Harbour:

- Strategic Site 1 (SS1): Aldrington Basin
- Strategic Site 2 (SS2): South Portslade
- Strategic Site 3 (SS3): Southwick Waterfront
- Strategic Site 4 (SS4): Western Harbour Arm

The focus of this Design Input Statement is the Western Harbour Arm (SS4), the largest of the strategic sites and the one with the greatest challenges pertaining to flood risk. To enable suitable development of concept flood defence options, the strategic site has been divided into three sections based on the character of existing defences. These are:

- Adur Ferry Bridge to Riverside Business Centre
- Riverside Business Centre to Kingston Beach
- Kingston Beach

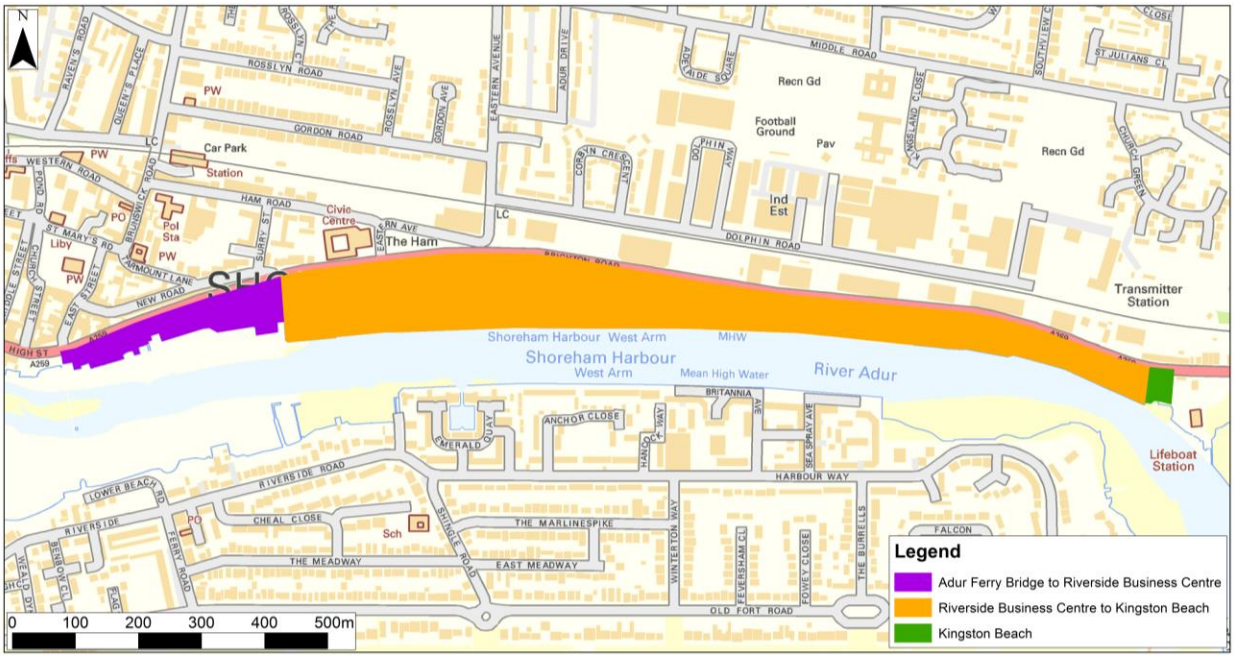

Figure 1-1: Map showing the three sections of the Western Harbour Arm (contains Ordnance Survey data © Crown copyright and database right 2014)

The Shoreham Harbour Joint Area Action Plan (JAAP) states the Western Harbour Arm (WHA) should become a sustainable, mixed-use development. It should also deliver a comprehensive flood defence solution integrated with a publically accessible riverside route including pedestrian / cycle way and facilities for boat users. The riverside route will enable future maintenance to WHA flood defences. JAAP Strategic Objective 6 is to avoid and reduce the risk of flooding and impacts on coastal processes and adapt to climate change; to ensure that coastal defences

accord with the relevant Shoreline Management Plan and the Brighton Marina to River Adur coastal strategy.

In preparing the FRM guidance three main types of flood management option will be considered:

- Raising of existing defences;
- Construction of a new line of defences (either set forward of, on top of, or backward from existing defences); and
- Raising of existing land.

Flood resilience measures may also be incorporated within the concepts either as interim or permanent measures.

2 Reference documents

1. Halcrow (for Brighton and Hove City Council). (2014). Brighton Marina to River Adur Flood and Coastal Erosion Risk Management Strategy.
2. JBA Consulting. (2011). East Sussex Coastal Modelling Study.
3. JBA Consulting. (2011). Shoreham Harbour Regeneration: Design and Flood Risk Study.
4. Shoreham Harbour Regeneration. (2013). Western Harbour Arm Development Brief.
5. Shoreham Harbour Regeneration. (2014). Shoreham Harbour Joint Area Action Plan (Draft for Consultation)
6. Shoreham Port. (2014). Adur River - Left Bank Quay Wall Survey 2014.
7. WSP Environmental Ltd. (2009). Desk Study Review, Shoreham Harbour (Contaminated Land).

3 Design input criteria

This design input statement provides details of the key assumptions used for the concept design of flood defences for the Shoreham Harbour Flood Risk Management Technical Guidance Study. The document will be supported by individual design technical notes that will list all assumptions and record the design methodology and decision making process.

3.1 Datum

All levels are given in metres Above Ordnance Datum (mAOD), based on the OS GPS Network.

3.2 Design life

The scheme design life will be the lifetime of the proposed development assumed to be 100 years for this study, i.e. to 2115. Some development coming forward may have a shorter design life, for example, 50 years for commercial development. At this stage the scheme design life is set to the residential design life of 100 years.

3.3 Level of design detail

This study will constitute concept design commensurate with RIBA Plan of Work 2013 Stage 2. Therefore the following apply:

- No detailed structural analysis and design has been undertaken;
- No geotechnical analysis has been undertaken;
- No material analysis has been undertaken;
- Assumptions have been used, and stated, where necessary;
- Typical sections and alignments are indicative; and
- Final designs may differ, based on variables that are outside the scope of this work.

3.4 Tidal level

The baseline extreme still water level for the 1 in 200-year event is shown in Table 3-1. The extreme still water level is a combination of the astronomical tide and a surge component.

Table 3-1: Tidal levels for Shoreham Harbour

Extreme still water level	Baseline Year	Source	Where data has been used
4.30mAOD	2000	Extreme Sea Levels: Kent, Sussex, Hampshire and Isle of Wight, Updated Summary Report (JBA/EA 2004)	Shoreham Harbour Regeneration: Design and Flood Risk Study (2010/11)
4.30mAOD	2008	Coastal Flood Boundary dataset (EA 2011)	Assessment of Eastern Adur Tidal Walls for EA [as part of East Sussex Coastal Modelling] (2012)

A more detailed breakdown of water levels can be found in Appendix A.

3.5 Climate change

The current guidance on addressing sea level rise as a result of climate change is provided in a 2011 Environment Agency note[2]. The guidance makes use of the UK Climate Projections (UKCP09) user interface which can provide climate information at a specific location to help plan for adaption to a changing climate. The change factor for the increase in relative sea level uses the 95% estimate from the medium emissions scenario. Predicted sea levels can be used to design flood defences that will be suitable throughout their design life. The UKCP09 sea level projections result in a 2115 water level that is approximately 400mm lower than the levels obtained using the 2006 DEFRA guidance which was current during the 2011 modelling study. That guidance made use of the previous UK climate change estimates. Climate change water level predictions for the 1 in 200-year event are shown in Table 3-2. A graphical representation of the 1 in 20-year and 1 in 200-year water levels is shown in Figure 3-1.

Table 3-2: 1 in 200-year water levels with climate change predictions

Year	Sea level (mAOD)	Increase from baseline (m)	Sea level (mAOD)	Increase from baseline (m)
Source	Defra supplementary note October 2006[1]		UKCP09[2]	
Baseline	4.30[3]		4.30[4]	
Present Day[5]	4.34	0.04	4.33	0.03
2035	4.45	0.15	4.45	0.15
2070	4.84	0.54	4.69	0.39
2082	4.98	0.68	4.79	0.49
2115	5.47	1.17	5.08	0.78

[1] Defra. (2006). Flood and Coastal Defence Appraisal Guidance, FCDPAG3 Economic Appraisal, Supplementary Note to Operating Authorities - Climate Change Impacts.

[2] Environment Agency. (2011). Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities.

[3] 2000 Baseline used in Shoreham Harbour Regeneration: Design and Flood Risk Study (2011)

[4] 2008 Baseline sea level from Coastal Flood Boundary dataset (EA 2011)

[5] Present day was taken as 2010 for the 2011 modelling work and 2014 Technical Guidance

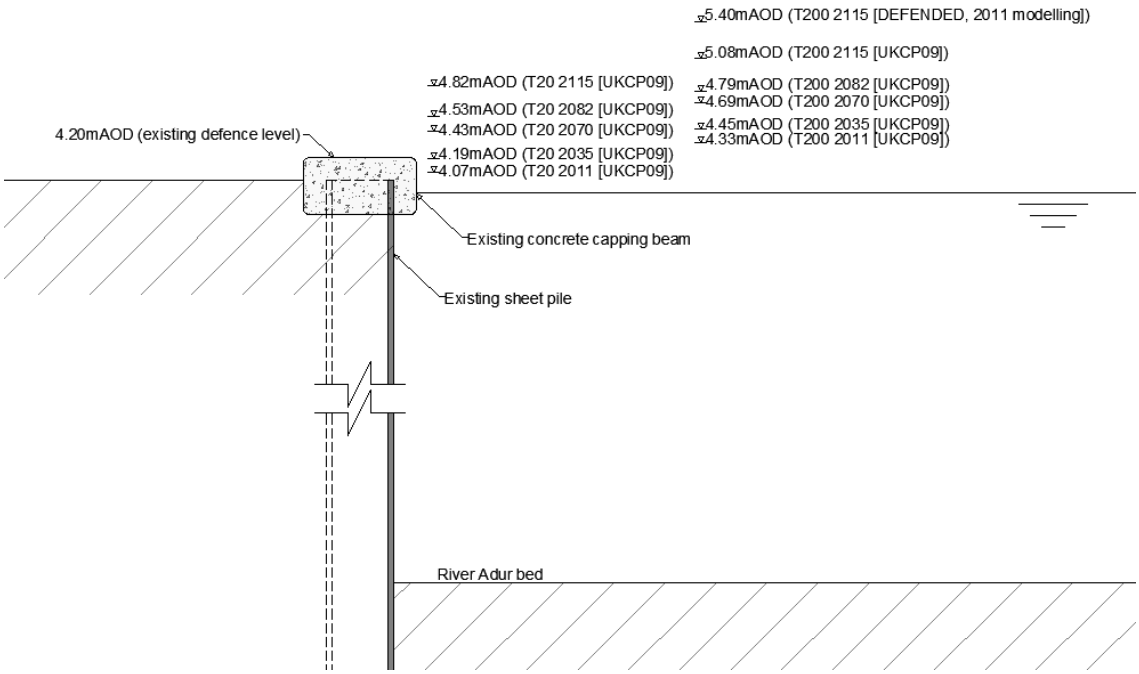

Figure 3-1: Water levels w ith climate change predictions

3.6 Previous modelling studies

The 2011 Shoreham Harbour Regeneration: Design and Flood Risk Study was used to determine outline design defence crest heights for use in this Design Input Statement. The design heights have been taken from the highest water levels in the Western Harbour Arm from the 1 in 200-year tidal flood event using 2115 sea levels, which are between 5.3m and 5.5m (see Section 3.8.2). All proposed defences will have a freeboard allowance added (see Section 3.9). The assumed heights used in the modelling study were as follows:

- 5.53m Adur Tidal Walls;
- 6.00m Western Harbour Arm Walls; and
- 5.60m Ropetackle Walls.

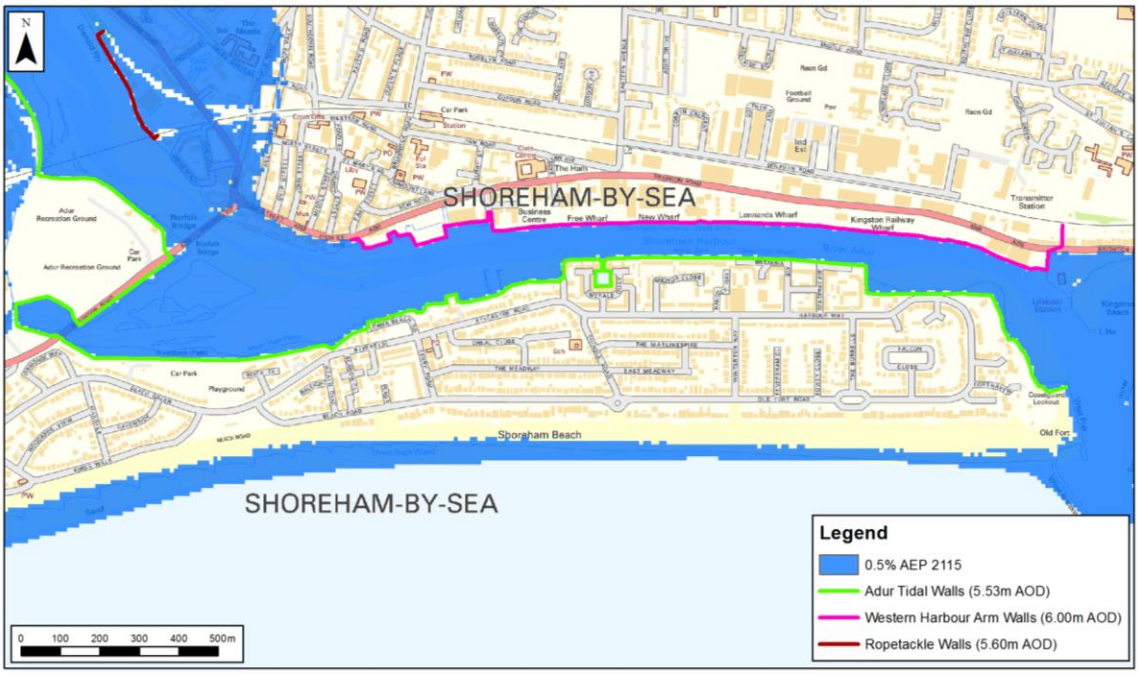

Figure 3-2: Defence lines used for the design model (0.5% AEP with 2115 sea levels) (contains Ordnance Survey data © Crown copyright and database right 2013)

The 2011 East Sussex Coastal Modelling study for the Environment Agency was used to test the eastern walls. However, they have never been considered in conjunction with the walls to support the Shoreham Harbour regeneration.

For a visual representation of the planned alignment for the East Adur Tidal Walls see Figure 3-4.

3.7 Future model runs

Consideration should be given to undertaking further modelling as several changes have occurred since the 2011 study:

- Sea level rise for 2115 is 0.38m lower when using the UKCP09 estimates; and
- Proposals for additional defences on the east bank of the Adur as part of the tidal walls scheme have now been developed.

The biggest change to design levels is expected to be due to the reduced predicted sea level rise for 2115 and if no additional model runs are undertaken the design levels will be conservative.

3.8 Design levels

3.8.1 Performance standard

All scheme elements will be designed to withstand a 1 in 200-year plus climate change (2115 sea level) event. This is the standard criteria used for the majority of tidal flood defence schemes in the UK.

A number of different estimated water levels are available for this event arising from the different methods of derivation (see Appendix A). With reference to Appendix A design water levels could be set based on:

- Modelled water levels taken from the 2011 study (Reference Document 3).
- Extreme still water levels derived from methods used to inform the 2011 study.
- Extreme still water levels derived from current up to date methods.

The method and final design water levels to be used requires discussion and agreement.

3.8.2 Design water levels

A common design water level has been used across the three sections of the Western Harbour Arm. This level excludes freeboard allowance.

- 1 in 200-year 2115: 5.08mAOD

3.8.3 Ultimate limit state

The ultimate limit state for the defences will be calculated during the detailed structural design (which is outside this scope of work). This is the point at which the defences fail structurally and will constitute a 1 in 200-year event plus a Factor of Safety.

3.8.4 Finished floor levels

JAAP Policy 11 (p.86) states that the development should be safe for the 1 in 200-year tidal flood level to 2115 for residential and to 2082 for commercial development. The JAAP states that a breach scenario should be protected against through the application of finished floor levels:

- 5.77m for residential development; and
- 4.94m for commercial development.

3.9 Freeboard

There is no generally accepted definition of freeboard in relation to flood defences. At its most simple freeboard represents a safety margin to ensure that a flood defence performs with a high degree of certainty to the standard it was defined for. Freeboard is the height of the top of a flood defence structure, above the design water level. This additional height is intended to account for: physical processes that affect the defence but have not been accounted for in the design water level (e.g. settlement of the crest of an embankment) and; adverse uncertainties in estimating the physical process that affect the defence level (e.g. the accuracy of modelled water levels).

By convention a minimum freeboard allowance of 150mm for hard defences and 300mm for soft defences is used in many situations[1]. Additional allowances for wave overtopping will be required for locations at critical risk e.g. Kingston Beach. This will be included within the final proposed defence crest height (please refer to concept design drawings and defence frontage plans for details of individual crest heights). In the case of flood defence walls the defence height will be assumed as the top level of the core of the structure. The coping of any walls will not be included within the freeboard allowance, due to the uncertainties of structural fixings, and would therefore provide an additional nominal level of protection.

No additional allowance for flood defence settlement has been included.

3.10 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs. No allowance for settlement has been included within the concept design development.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

3.11 Contaminated land

A desktop study was completed in March 2009 by WSP Environmental Ltd[2]. The report highlighted that the underlying soils have evidence of hydrocarbons, metals and inorganic contamination with evidence to suggest migration of contaminants between sites via

[1] N.B. New guidance relating to freeboard allowances will be issued autumn 2014 through Defra Science Project SCI20014 - The role of freeboard in flood risk management.

[2] WSP Environmental Ltd. (2009). Desk Study Review, Shoreham Harbour, Shoreham-by-Sea, West Sussex

groundwater. The groundwater also appears to be contaminated and there is limited evidence of remedial action of these issues. The report states that it is the opinion of Adur District Council that "the majority of the area has significant pollutant linkages."

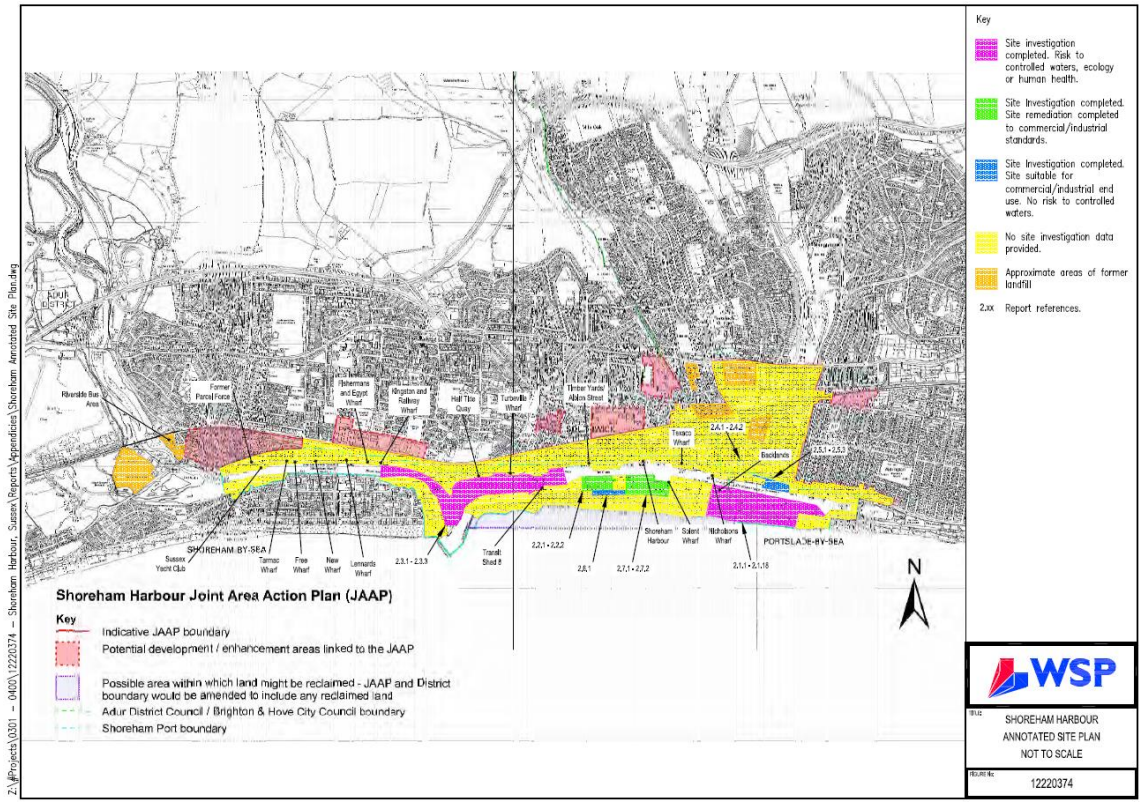

Figure 3-3: WSP Environmental Ltd. (2009). Desktop Study Review , Shoreham Harbour. p.32

Figure 3-3 shows where contaminated land information was available to the JAAP. A large proportion of the area did not have site information available for the study (shaded yellow on the map). An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- No investigation of contamination issues at individual development sites; and
- Development of flood defence options will require some contaminated land treatment

3.12 Existing defences

3.12.1 Defence levels

The following are existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]):

Adur Ferry Bridge to Riverside Business Centre

- Minimum level: 3.18m
- Maximum level: 3.95m
- N.B. low areas at Sussex Yacht Club, such as slipways and hards, had spot levels surveyed at the top of the structure and therefore at similar levels to the surrounding defences.

Riverside Business Centre to Kingston Beach

- Minimum level: 3.34m
- Maximum level: 4.24m

- N.B. Kingston Railway Wharf (used as scrap yard), has lower levels than the rest of the pile wall (between 3.34m and 3.82m). The rest of this area is predominantly over 3.90m.

Kingston Beach

- Minimum level: 3.83m
- Maximum level: 4.21m

3.12.2 Condition Assessment

Shoreham Port was commissioned by the Shoreham Harbour Regeneration Partnership to undertake a condition survey of existing defences along the Western Harbour Arm. The survey included a visual inspection of the interlocking steel sheet piling, concrete cope and associated fendering above water and all features protruding through the wall.

The study showed that the corrosion rates and losses of pile section vary considerably across the Western Harbour Arm. There is widespread evidence of the recent onset of Microbially Induced Corrosion (MIC), though the severity of the damage appears to be limited as yet. Safety access ladders along the defence line, originally at 50m intervals to enable individuals to climb out if they fell into the river, are in poor condition. The condition report recommends that these should be replaced on all sections of the quay at the earliest opportunity.

A summary of the life expectancy of the piles and recommendations for remediation as made in the condition assessment report are reproduced in Table 3-3.

Table 3-3: Summary of pile conditions, reproduced from Adur River - Left Bank Quay Survey 2014

Area	Pile type	Installed (year)	Average thickness loss (mm)	Loss of section modulus	Estimated remaining life (years) FOS = 2.0	Estimated remaining life (years) FOS = 1.5	Recommendations
Parcelforce	Frod 1A	~1980	1.5	21%	50	20	Formal technical assessment
Riverside Business Centre	Frod 3N	~1976	3.8	34%	20	0	Corrosion protection (near future)
Tarmac Wharf	Krupp K2	1939	3.0	23%	90	30	Replacement due to perforation and approaching point of bending failure
Free Wharf	Frod 3N	1970	1.6	11%	>100	90	Extend cope to cover top 2.5m
New Wharf	Frod 3N	1978	1.6	11%	>100	70	Extend cope to cover top 2.5m
Fisherman's Wharf	Frod 3N	1978	3.2	28%	30	6	Corrosion protection (urgent)
Lennard's Wharf	Frod 4N	1966	3.1	22%	60	25	Extend cope to cover top 2.5m
Egypt Wharf (West)	Frod 4	1961	3.0	22%	60	25	Extend cope to cover top 2.5m
Egypt Wharf (Centre)	Frod 3N	1983	1.4	11%	>100	60	Corrosion protection
Kingston Railway Wharf (West) / Egypt Wharf (East)	Frod 3N	1982	1.6	20%	80	20	Corrosion protection, extend cope to cover top 2.5m (medium term)
Kingston Railway Wharf (East)	Larssen 3	1951	2.5	23%	70	25	Corrosion protection
Kingston Wharf (West)	Frod 2	1937	0.6	5%	>100	>100	Corrosion protection (near future)
Kingston Wharf (Centre)	Frod 3N	1981	1.4	17%	60	30	Corrosion protection (near future)
Kingston Wharf (Howard Kent)	Frod 2+	1939	-0.9	Unknown	-	-	Corrosion protection

The results present consider the design life for two different factors of safety. Factor of safety is a weighting applied to loadings at the design stage to account for variability in material performance, construction tolerances, etc. In the absence of the original calculations it is not possible to know the factor of safety used in the design and assumptions need to be made. It is evident that the factor of safety has a significant implication for the residual pile life.

As can be seen from the table above that when assuming a factor of safety of 2.0 the maximum anticipated residual life for piling within the Western Harbour Arm is more than 100 years and the minimum anticipated residual life for some sections is 20 years. Using a lower factor of safety of 1.5 results in significantly reduced residual life with Riverside Business Centre having no residual life and only Kingston Wharf (West) having a life in excess of 100 years. The effect of changing the factor of safety assumption is significant and demonstrates the need for an individual structural assessment at each wharf as redevelopment proceeds.

The assumptions used in determining the residual life within the condition assessment have changed between the draft version (issued February 2014) and the final version (issued May 2014). The condition assessment notes that:

"There are, of course, many other factors that can result in a shorter service life such as inadequate original strength for the loads imposed, damage to tie rods, localised perforation and the on-set of MIC."

These other failure modes are likely to be highly significant in determining a best estimate of residual life and should be taken into account as part of a more comprehensive assessment.

The residual life of the existing piles is an important consideration in the preparation of the concept design and requires further consideration particularly as it is unclear as to how much the residual life would be extended if the recommended measures were to be undertaken.

Correspondence with Shoreham Port Authority on behalf of the client raised the issue that the designed factor of safety could not be resolved as part of this study and it has been recommended that destructive support and detailed structural analysis is undertaken prior to any further design, i.e. as development comes forward.

3.12.3 Refurbishment

Any defence concept that seeks to make use of the existing defences will need to be mindful of the estimated life reported in Table 3-3. Provision should be made to refurbish the existing piles and provide adequate protection against future deterioration.

3.12.4 Existing defence design

The existing sheet piled walls are of different types and section with capping beams of different depths. Increasing the height of the existing beam would enable a higher protection standard. However, based on engineering judgement is has been assumed that the maximum height that the existing capping beams on the sheet piles could be raised is 500mm. Increases of more than 500mm above existing levels might be possible but in the absence of a detailed structural assessment it has been judged to increase risk of premature failure by damaging the existing structure.

3.12.5 Encroachment

If construction of a new defence line is required to be in front of the existing line then there will be encroachment into the channel. This may cause issues that would need to be addressed during the detailed design including:

- Loss of estuary habitat; and
- Reduction of channel capacity.

It is the Environment Agency's view that any loss of inter-tidal habitat would need to be replaced at an alternative location.

3.13 Other defence schemes

Other proposed local defence schemes, and their heights (including an allow ance for freeboard), are listed in

are listed in

Table 3-4. This shows a variation in design height. A graphical representation of the planned defences is shown in Figure 3-4.

Table 3-4: Planned defence schemes

Defence	Design height (mAOD)	Design height for climate change (mAOD)	Includes Freeboard?	Proposed Construction date	Data source
Ropetackle[1]	5.40	As design height	Yes	Unknow n	Ropetackle North Flood Risk Assessment (Hemsley Orrell Partnership 2013)
Adur tidal w alls (w est)	4.84	5.53	Yes	Commencing 2015/6	Shoreham Adur Tidal Walls (West Bank) Draw ings October 2010
Adur tidal w alls (east)	4.85[2]	As design height	Yes	Commencing 2015/6	Shoreham Adur Tidal Walls (East Bank) Draw ings June 2012
Morrisons site flood w all	5.40	As design height	Yes	Unknow n	Minelco Wharf/Frosts site, Brighton Road FRA (Peter Brett Associates, 2013)
Parcelforce site, 79-81 Brighton Road (flood w all)	5.57	As design height	Yes	Unknow n	79-81 Brighton Road FRA (Dixon Hurst Kemp, 2012)

[1] Adur planning application ref: AWDM/0935/13

[2] Embankments upstream of A27 to be at a height of 5mAOD

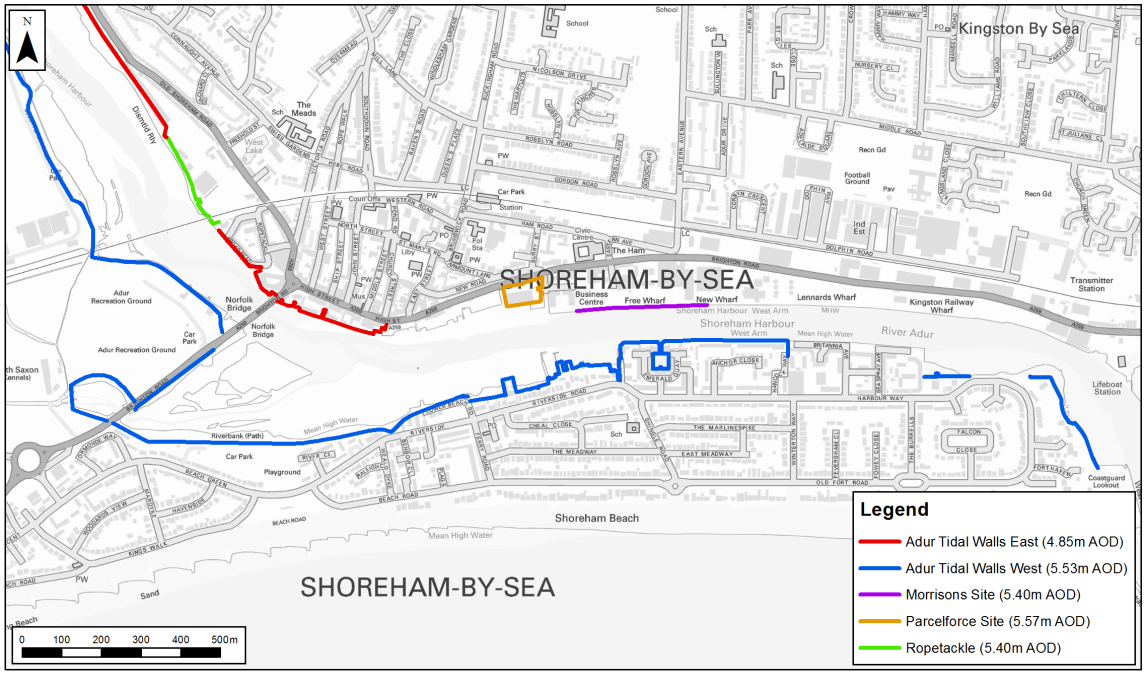

Figure 3-4: Planned defence schemes

The design heights of other proposed defences along the Adur which include freeboard are similar to the proposed design levels for the Western Harbour Arm (without a freeboard allowance). This raises the possibility of issues surrounding tie-in with other defences. It is also necessary to observe that at present the Eastern Tidal Walls do not have a climate change design height which may require the Western Harbour Arm defences to tie in to higher ground at their western end to prevent flood water from coming round the back of the defences. The Morrisons and Parcelforce (79-81 Brighton Road) sites form part of the area covered by this design statement. Their defences are already consented and their form will need to be considered when devising concepts for adjacent frontages.

3.14 Services information

No services information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected.

3.15 Structural design

Structural design of concept options has not been included within this commission. As stated in Sections 3.10 and 3.14, a full structural analysis could not be completed without relevant ground condition and services information. All concept designs will be reviewed by a structural engineer to assess the general design principles. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

3.16 Design standards

The following material will be used as a point of reference for all design assumptions unless specifically advised otherwise:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- CIRIA. (2013). The International Levee Handbook (C731).
- CIRIA. (2007). The Rock Manual: The use of rock in hydraulic engineering (2nd edition) (C683).
- Environment Agency. (2010). Fluvial Design Guide.

The following will form the design standards:

3.16.1 Flood walls

- Must have impermeable core e.g. concrete
- Coping will not be included in the determination of the defence crest height
- A sheer key / flow path cut off will be included
- All foundations must have a physical tie to the vertical wall stem
- Corrosion resistance measures will be taken
- Minimum freeboard allowance of 100mm (hard defence)

3.16.2 Flood embankments

- Maximum gradient of side slopes 1:3
- Minimum crest width 1m to allow maintenance (non vehicular)
- Impermeable core material
- A flow path cut off will be included
- To reduce riverbank scour either: embankment to be set back from the edge of the river; or scour protection to be provided on the embankment
- Minimum freeboard allowance of 300mm (soft defence)

3.16.3 Raising of capping beams

- Maximum raising by 500mm
- Must provide suitable tie with existing structure e.g. dowel bars
- Minimum freeboard allowance of 100mm (hard defence)

3.16.4 Land raising

- Land raising may be supported by another defence option, for example flood walls
- Floor levels to be set higher than raised ground levels, in accordance with finished floor levels set out in Section 3.8.3

3.16.5 Demountable flood defences

- Built into permanent defences and, where possible, only used when permanent defences are impractical such as on slipways and where flood walls cross roads
- Removable components must be able to be stored nearby to enable mobilisation at short notice

3.17 Flood Risk Management

The JAAP section on Flood Risk Management (2.10.14 to 2.10.18, p.75) states that sites along the Western Arm are vulnerable to surface water, fluvial and tidal flooding. A complete closure of the flood cell and continuation of the line of new defences being provided via the Adur Tidal Walls Scheme is required. It is desirable that all new flood defence works will be integrated with "a high quality public realm environment that promotes a positive inter-relationship with the river." Consequently, the JAAP states that flood defences that divide the Western arm are not desirable. Consequently, concept options will be designed to allow individual parcels of land to be developed, whilst maintaining a uniform design that will potentially link between developments.

3.17.1 Surface water

In developing defence concepts for the Western Harbour Arm, surface water flood risk has not been considered explicitly. However, the concepts will have to make sure that if they impede existing overland flow routes that adequate allowance is made to ensure that this flow can either be discharged via a drainage system through the defence, or attenuated on-site to prevent any increase in risk to third parties. All development proposals will also need to be mindful of the requirement to adequately manage runoff generated on-site.

3.18 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment will be completed for the design elements of each management unit. The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible. Information about project specific significant residual risks will be communicated through design notes and drawings.

3.18.1 Health and Safety Executive zones

The JAAP states that there are two Health and Safety Executive Consultation Zones within the Western Harbour Arm which are situated at the following locations:

- Lennard's Wharf (Gas); and
- Texaco Wharf (Oil).

3.19 Environment

This commission does not include a preparation of a formal Environmental Impact Assessment (EIA) or environmental site surveys. However, during the design process environmental impacts will be considered and eliminated and/or minimised where ever possible. All concept designs will be reviewed to consider their environmental and visual impacts and this will be fed into the options appraisal.

3.19.1 Environmental constraints

The Western Harbour Arm is subject to the following environmental constraints:

- Proximity to nationally designated Site of Special Scientific Interest (SSSI) stretching into the Adur Estuary;

- A locally designated nature reserve and site of Nature Conservation Importance at Shoreham Beach;
- An Air Quality Management Area that covers the western part of the Western Harbour Arm;
- Two waste management sites;
- The presence of contaminated land; and
- An HSE Consultation Zone which determines boundary zones for development at a distance from a "major hazard" based on the current gas storage use (see Figure 3-5)

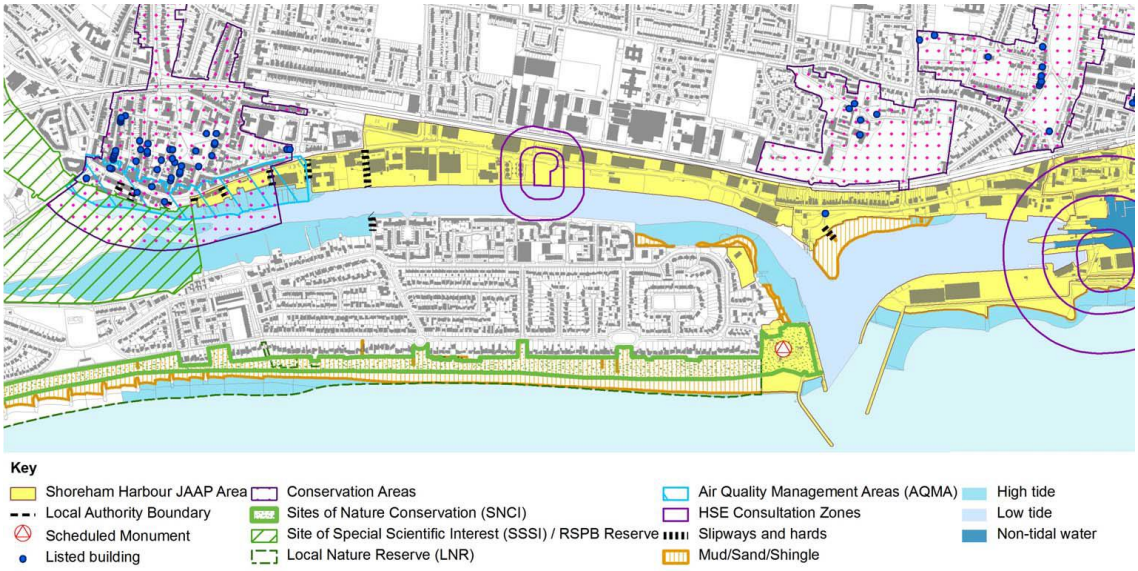

Figure 3-5: Shoreham Harbour Environmental Constraints (JAAP, Figure 1.5, p.18)

3.20 Sustainable development

Design adaptability is a key consideration due to the current uncertainties regarding the future impacts of climate change. Therefore, wherever possible the designs developed will aim to include an element of adaptability. The intention will be to allow the proposed designs to be modified in the future to best suit the climatic conditions. This will take the form of developing designs that could be raised in the future.

3.21 Construction cost assessment and buildability advice

Construction cost estimate and buildability advice will be broken down as follows:

- Each section will be broken down into frontages, which will be based on land ownership and existing defence design.
- Three concept options will be designed for each frontage.
- A unit cost estimate per linear metre will be calculated for each of these options. This will include contractor involvement to assess realism in costing and contribute to buildability of concept.

3.22 Phasing of development

Development within the Western Harbour Arm will be phased. The standard of protection required will be in accordance with the JAAP / Flood Risk Management Guidance. However, as each individual development parcel comes forward it may be appropriate for a lower standard of protection or for flood risk management to be provided by temporary defences adjacent to neighbouring parcels and in lieu of the frontage being completed to the agreed design standard.

Appendices

A Shoreham Water Levels

				Year																
				Present Day			Climate Change													
				2010	2010	2014	2035			2070			2082			2115				
		Extreme Still Water Level (mAOD)		Extreme Still Water Level (2010 Study)	River Adur Modelled Water Level[4] (Footbridge to Kingston Beach) - Existing Defences	Extreme Still Water Level	Extreme Still Water Level (2010 Study)	River Adur Modelled Water Level[4] (Footbridge to Kingston Beach) - Existing Defences	Extreme Still Water Level	Extreme Still Water Level (2010 Study)	River Adur Modelled Water Level[4] (Footbridge to Kingston Beach) - Existing Defences	Extreme Still Water Level	Extreme Still Water Level (2010 Study)	River Adur Modelled Water Level[4] (Footbridge to Kingston Beach) - Existing Defences	Extreme Still Water Level	Extreme Still Water Level (2010 Study)	River Adur Modelled Water Level (Footbridge to Kingston Beach) - Existing Defences	River Adur Modelled Water Level[4] (Footbridge to Kingston Beach) - Proposed Defences[5]	Extreme Still Water Level
				Climate Change Source[6]																
Event	Tidal Statistics[1]	Used in 2010 Study[2] Base Year = 2000	Recommended values based on current up to date advice[3]. Base Year = 2008	DEFRA 2006	DEFRA 2006	UKCP09	DEFRA 2006	DEFRA 2006	UKCP09	DEFRA 2006	DEFRA 2006	UKCP09	DEFRA 2006	DEFRA 2006	UKCP09	DEFRA 2006	DEFRA 2006	DEFRA 2006	UKCP09
LAT	-3.27																			
MLWS	-2.67																			
MLWN	-1.37																			
MSL	0.11																			
MHWN	1.53																			
MHWS	3.03																			
HAT	3.63																			
T1		3.9	3.72	3.94		3.75	4.05		3.87	4.44		4.11	4.58		4.21	5.07			4.50
T2		3.9	3.79	3.94		3.82	4.05		3.94	4.44		4.18	4.58		4.28	5.07			4.57
T5			3.89			3.92			4.04			4.28			4.38				4.67
T10		4.1	3.96	4.14		3.99	4.25		4.11	4.64		4.35	4.78		4.45	5.27			4.74
T20		4.1	4.04	4.14	4.1-4.2	4.07	4.25		4.19	4.64		4.43	4.78		4.53	5.27			4.82
T25		4.2	4.06	4.24		4.09	4.35		4.21	4.74		4.45	4.88		4.55	5.37			4.84
T50		4.2	4.14	4.24		4.17	4.35		4.29	4.74		4.53	4.88		4.63	5.37			4.92
T75		4.2	4.19	4.24		4.22	4.35		4.34	4.74		4.58	4.88		4.68	5.37			4.97
T100		4.3	4.22	4.34		4.25	4.45		4.37	4.84		4.61	4.98		4.71	5.47			5.00
T150			4.23			4.26			4.38			4.62			4.72				5.01
T200		4.3	4.30	**4.34**	4.3	**4.33**	4.45		4.45	**4.84**	4.5-4.8	**4.69**	4.98		4.79	**5.47**	5.1-5.4	5.3-5.5	**5.08**
T250			4.33			4.36			4.48			4.72			4.82				5.11
T300			4.35			4.38			4.50			4.74			4.84				5.13
T500		4.4	4.41	4.44		4.44	4.55		4.56	4.94		4.80	5.08		4.90	5.57			5.19
T1000		4.4	4.49	4.44		4.52	4.55		4.64	4.94		4.88	5.08		4.98	5.57			5.27
T10000			4.78			4.81			4.93			5.17			5.27				5.56

Notes:

All levels are in mAOD

Conversion to Chart Datum is +3.27m

Extreme Still Water Levels are taken at a general point close to the Harbour Mouth (see note (2) and (3))

(1) Tidal statistics from Total Tide using 0081 SHOREHAM (a harmonic port)

(2) Extreme Still Water Level used in 2010 study is from Extreme Sea Levels: Kent, Sussex, Hampshire and Isle of Wight, Updated Summary Report (JBA/EA 2004) using Shoreham location

(3) Extreme Still Water Levels from Coastal Flood Boundary dataset (EA, 2011) using Chainage 4548

(4) Shoreham Harbour Regeneration: Design and Flood Risk Study (2010/11). The model includes a 2 yr fluvial flow in the Adur

(5) Proposed defences scenario tested in 2010 model include: Adur Tidal Walls (West), Ropetackle, and Shoreham Harbour Redevelopment Walls

(6) Denotes climate change guidance used to elevate Extreme Still Water Level from base year. Sources are:

DEFRA 2006 - Defra. (2006). Flood and Coastal Defence Appraisal Guidance, FCDPAG3 Economic Appraisal, Supplementary Note to Operating Authorities - Climate Change Impacts. [Also Table B.1 in PPS25]

UKCP09 - Environment Agency. (2011). Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities. [Annex 1 specifies the use of the medium emmisions scenario (95% estimate) for the location taken from the UKCP09 user interface]

Offices at

Coleshill

Doncaster

Edinburgh

Haywards Heath

Limerick

Newcastle upon Tyne

Newport

Saltaire

Skipton

Tadcaster

Thirsk

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B Multi Criteria Analysis

Scoring Criteria 0 = Does Not Meet Criteria 5 = Fully Meets Criteria

Please Note: All options are ranked comparatively

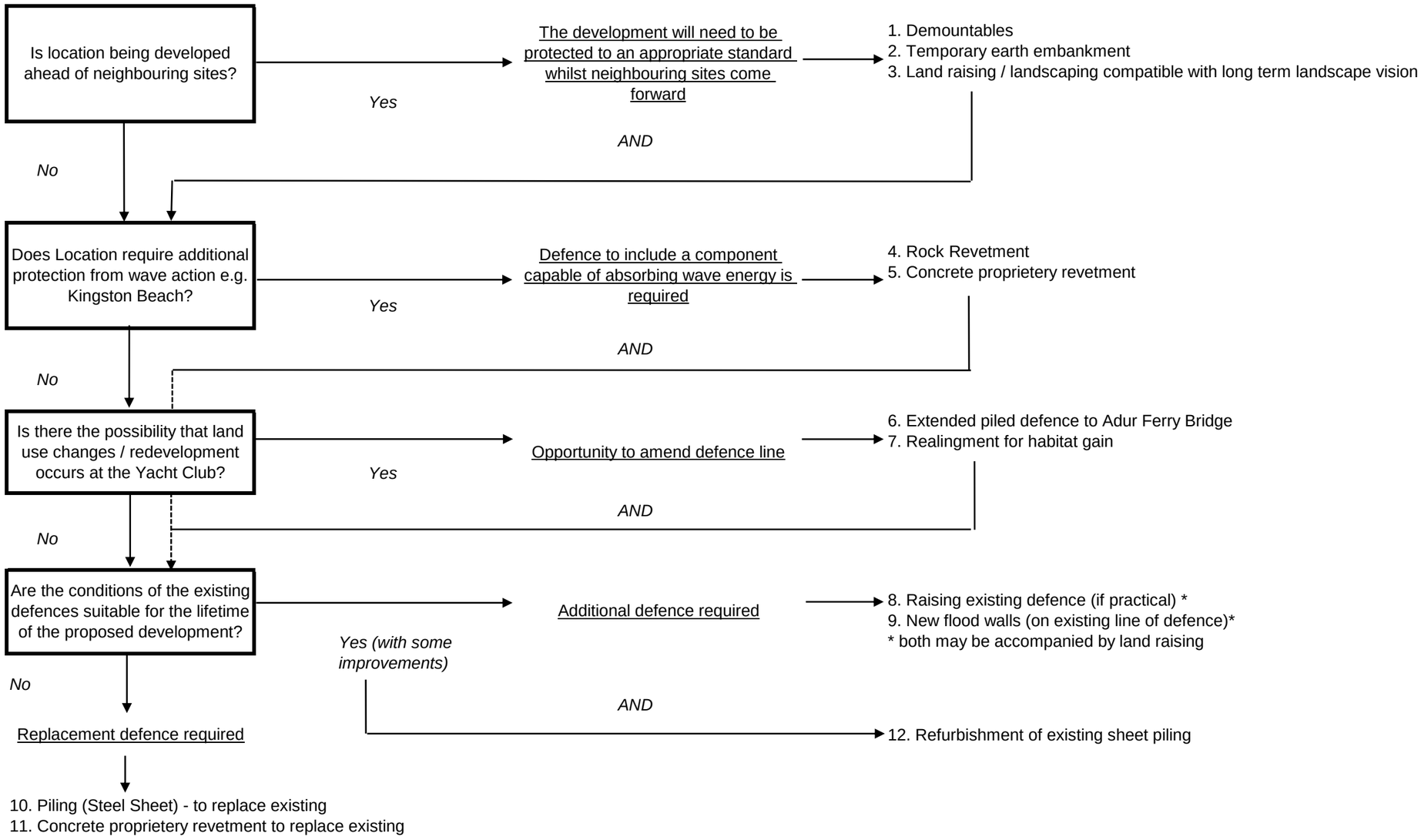
FLOOD RISK MANAGEMENT TECHNICAL GUIDE - OPTIONS APPRAISAL ANNEX: MCA APPENDIX B

				Adur Ferry Bridge to Riverside Business Centre				Riverside Business Centre to Kingston Beach					Kingston Beach		
				Option 1	Option 2	Option 3	Option 4	Option 1*	Option 2	Option 3	Option 4	Option 5	Option 1	Option 2	Option 3
				Revetments - concrete blockwork (modular)	Flood walls - reinforced concrete (set back alignment)	Flood walls - reinforced concrete (existing alignment)	Piling - steel sheet piles (new piling)	Piling - steel sheet piles (raise existing)	Piling - steel sheet piles (new piling)	Flood walls - reinforced concrete (existing alignment)	Flood walls - reinforced concrete (set back alignment)	Land raising - self supported	Revetments - rock armour	Flood walls - reinforced concrete	Piling - steel sheet piles (set backward)
Assessment Criteria	Technical	Design	Capable of providing standard of protection to required level	5	5	5	5	5	5	5	5	5	5	5	5
			Maximised protected area	3	4	4	5	5	5	4	4	4	3	3	3
			Design longevitiy - material properties	4	4	4	5	3	5	4	4	5	5	3	3
			Low land take requirements	3	5	5	5	5	5	5	5	4	3	3	4
			Protection of infrastructure	5	5	5	5	5	5	5	5	5	5	5	5
			Protection from wave energy										5	1	2
		Construction & Maintenance	Design is simple to construct	4	3	3	3	3	3	3	4	3	3	3	3
			Future maintenance requirement is minimised	4	4	4	4	2	4	4	4	4	4	4	4
	Environmental & Social	Public amenity	Low impact on public amenity (General)	3	3	3	5	5	5	3	3	4	4	3	5
			Low impact on recreational / commercial water users	2	3	3	4	4	4	5	5	5	2	4	4
		Natural Environment	No adverse impact on tidal habitat	1	5	5	3	4	3	5	5	4	2	5	3
			Capable of incorporation of additional habitat features that benefit flora and fauna	1	0	0	0	0	0	0	0	3	2	0	0
			Low impact of contaminated land	4	4	4	3	4	3	3	3	3	4	3	2
		Landscape & Visual Amenity	Minimise impact on landscape character and visual amenity of the local environment	3	4	4	5	5	5	4	4	3	3	3	3
			Public acceptability and potential for adverse public opinion	3	4	4	5	5	5	4	4	2	3	3	3
		Heritage	Minimise impact on fabric and setting of historic structures	5	5	5	5	5	5	5	5	5	5	5	5
	Economic	Cost	Low capital investment required	3	4	4	1	2	1	4	4	1	2	5	1
			Low maintenance costs	3	4	4	4	5	4	4	4	4	4	4	3
	Climate Change Adaptation		Design can be easily adapted to accommodate climate change impacts	3	4	4	4	1	4	4	4	1	5	5	4
			Design minimises carbon footprint during construction (concrete & steel usage and delivery)	2	3	3	2	2	2	3	3	4	2	3	2
			Total (out of 95, Kingston Beach out of 100)	**61**	**73**	**73**	**73**	**70**	**73**	**74**	**75**	**69**	**71**	**70**	**64**

*NB: Non compliant - does not meet the design water level

C Decision Tree

Shoreham Harbour Regeneration Area Flood Defence Options Decision Tree



D Design Technical Notes

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	Demountable and temporary defences

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: Demountable and temporary defences			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for demountable and temporary defences.

2 Assumptions

The following assumptions have been used during the development of the concept design.

2.1 Types of defences

2.1.1 Demountable

A demountable flood protection system is a moveable flood protection system that is fully pre-installed and requires operation during a flood event, or a system that requires part-installation into pre-installed guides or sockets within a pre-constructed foundation.

2.1.2 Temporary

A temporary flood protection system is formed by removable flood protection products that are wholly installed during a flood event and removed completely when flood levels have subsided.

2.2 Ground conditions

Ground conditions are not applicable for temporary defences as they are situated above ground. Demountable defences such as flood gates and walls will require foundations and therefore ground conditions are relevant.

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Services information is not applicable for temporary defences as they are situated above ground. Demountable defences such as flood gates and walls will require foundations and therefore services information is relevant.

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected.

2.4 Contaminated land

Contaminated land issues are not applicable for temporary defences as they are situated above ground. Demountable defences such as flood gates and walls will require foundations and therefore issues with contaminated land are relevant.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

2.5.1 Demountable

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and concept design stages when more ground condition information is available.

2.5.2 Temporary

The structural design will be completed by the manufacturer. Temporary defences units are not bespoke and the defence chosen should satisfy the required structural criteria.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with permanent structure

2.7.1 Demountable

It is assumed that the demountable defence will be designed to tie in to any permanent defence structure; the same design level should be used.

2.7.2 Temporary

Temporary defences should be chosen that enable a tie in to permanent defences. Manufacturer's specifications should be checked to see if the defence is designed as standalone or can be tied into an existing defence line. If a tie into a defence line is not possible then the defence should be constructed up to high ground.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- Environment Agency. (2011). Temporary and demountable flood protection guide (SC080019).

4 Design development

The following provides a brief summary of the demountable defence options available.

4.1 Demountable defences

4.1.1 Flood wall

A demountable flood wall will require provision of built in foundations; columns may be either permanent or temporary. Wall panels must be stored near to the site to reduce risk of delays once the decision has been made to construct the defence or be suitably robust to remain in place.

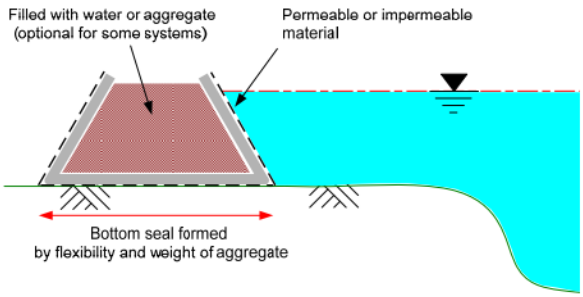
4.1.2 Flood gate

Where access is required through a flood wall, or at locations where defences are inappropriate such as slipways, a flood gate may be utilised. The gate will be required to be designed such that they perform in a similar manner to lock gates; the pressure of the flood water forces the gates closed to affect a good seal. The gates will have seals and a solid surface such as steel should be utilised on the ground to ensure a watertight closure.

4.2 Temporary defences

4.2.1 Filled containers

Cellular barriers filled with aggregates or water to form a barrier against floodwater. Whilst they can be filled with permeable or impermeable material they are both gravity dams; using the weight of the aggregate or water for stability.



4.2.1.1 Filled permeable containers

Advantages:

- Height of some systems can usually be increased during service by stacking.
- Can usually be installed by relatively unskilled labour.
- Small storage space required.
- Adapts to uneven formation/terrain.
- Can use readily available fill material.

Disadvantages:

- Clogging of material/effluents within the fabric can make cleaning difficult or impossible.
- Stacked defences require significant width, which may not always be available.
- Some steel supports and pins may buckle or deform beyond reuse under stacking and service loading.
- Need to dispose of large volumes of probably contaminated material after flood event.
- Seepage can be a problem, but this can be minimised by using a suitable choice of geo-textiles and fill.
- High bearing pressure on bedding surface when stacked.
- Some can be re-used, but only a limited number of times.

4.2.1.2 Filled impermeable containers

Advantages:

- Height of some systems can be increased during service by stacking.
- Does not rely on fill material for water tightness.
- Can be filled with any available material (including water).
- Easily washed and reusable.
- Minor repairs to tears or punctures can usually be made in service.

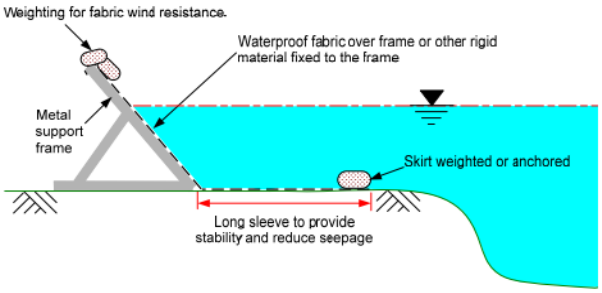
Disadvantages:

- Significant seepage may occur under the barriers in uneven terrain due to their rigidity.

- May require large storage area and transport.
- Mobilisation and demobilisation operations often significant.
- High bearing pressure on bedding surface when stacked.

4.2.2 Frame barriers

Frame barriers are rigid frames with impermeable membranes or sections spanning between them. They rely on supporting frames and the weight of the water to provide the barriers stability. They are modular and connected together to form a continuous barrier and can be either flexible or rigid sections.



4.2.2.1 Flexible frame barriers

Advantages:

- Adapt well to various terrain conditions (except hard surfaces).
- Easily cleaned and reusable.
- Minor repairs to membrane can be made under service conditions.

Disadvantages:

- Membrane is susceptible to heavy winds (especially before flood peak).
- High bearing pressure on soil.
- Susceptible to leakage at low water levels.
- Heavy transportation and storage requirement.
- Susceptible to vandalism, accidental tear and puncture damage.

4.2.2.2 Rigid frame barriers

Advantages:

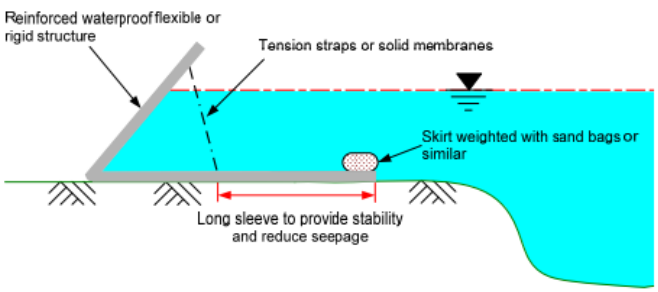
- Adapt well to various terrain conditions.
- Some systems can be increased in height during service.
- Easily cleaned and reusable.
- Minor repairs to membrane can be made under service conditions.

Disadvantages:

- Membrane is susceptible to heavy winds (especially before flood peak).
- High bearing pressure on soil.
- Susceptible to leakage at low water levels.
- Heavy transportation and storage requirement.

4.2.3 Freestanding barriers

Modular systems that are made of impermeable materials and are joined together to form a continuous barrier or wall. These are self supporting and do not rely on frames. Freestanding barriers are divided into two groups: flexible and rigid.



4.2.3.1 Flexible barriers

Advantages:

- Quick and easy to install (usually requiring only hand tools).
- No equipment or machinery required for installation.
- Small storage space required.
- Easily transportable in cars and small pick-up trucks.
- Low bearing pressure on bedding surface.
- Low mobilisation, demobilisation and clean-up requirements.
- Easily cleaned and reusable.

Disadvantages:

- Susceptible to leakage at low water levels.
- Skirt may twist or flap under heavy winds and current.
- Susceptible to vandalism and accidental tear or puncture.
- Membrane is susceptible to heavy winds (especially before flood peak).

4.2.3.2 Rigid barriers

Advantages:

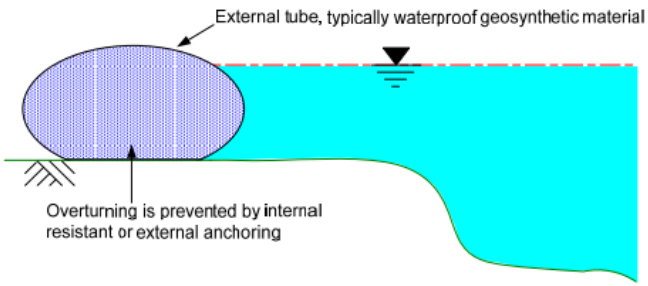
- Quick and easy to install.
- Most products do not require large equipment or machinery for installation.
- Low mobilisation, demobilisation and clean-up requirements.
- Easily cleaned and reusable.

Disadvantages:

- Significant seepage may occur under the barriers in uneven terrain due to their rigidity.
- Some units require large storage areas.
- Some units have high bearing pressure on bedding surface.

4.2.4 Tubes

Pre-fabricated geo-membrane or reinforced PVC tubes filled with either air or water to form a dam. They are suitable for long lengths of protection but are not ideal for filling small gaps.



4.2.4.1 Air filled tubes

Advantages:

- Low bearing pressure on the bedding surface.
- Very versatile – can be used for many other emergency or operational scenarios.
- Quick and easy to install.
- Small storage space required.
- Installation only requires people and mobile pumps.
- Easily cleaned and reusable.

Disadvantages:

- High width-to-height ratio is restrictive due to front extending skirt.
- Highly susceptible to vandalism or damage by sharp objects.
- Tears or punctures can rapidly lead to failure of the whole system.
- Require relatively flat surfaces.
- Improper storage or exposure to UV radiation can result in loss of strength over time.

4.2.4.2 Water filled tubes

Advantages:

- Quick and easy to install.
- Relatively small storage space required.
- Installation only requires a small team and mobile pumps.
- Tears can usually be repaired in service.
- Reusable.

Disadvantages:

- High width-to-height ratio is restrictive for larger tubes.
- Highly susceptible to vandalism or damage by sharp objects.
- Major tears or punctures can lead to failure of the whole system.
- Require relatively flat surfaces.
- Difficulty in expelling all water from tube following use can lead to deterioration.
- Risk of water freezing in tubes at low temperatures leading to failure.
- Improper storage or exposure to UV radiation can result in deterioration over time.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Tie in with existing structures

Temporary and demountable defences should either be tied into existing structures, such as a flood gate being built into a flood wall, or tied to high ground. This is easier for permanent demountable defences as they can be designed to satisfactorily interact with the defence line.

5.2 Speed of deployment

Risks associated with mobilisation are high for demountable and temporary defences. The actual time for the erection and closure process will depend on a number of factors including:

- The extent of preparation works required before closure can commence such as temporary road or path closures, erection of signage and removal of obstruction
- The type of operational activity required (whether closure of fully pre-installed system only or erection of non permanent parts)
- The length, size and ease of erection of the temporary or demountable products
- The requirement or otherwise of heavy machinery or other materials for bulk filling or stability
- The associated operational processes, skills and readiness of the operational team
- The prevailing weather and flood conditions

5.3 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed.

5.4 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element. The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible. Risks associated with deployment, such a manual handling, should be assessed for each demountable or temporary defence option. Similarly, risks of leaving temporary defences in-situ, or removing between flood events, should be assessed to determine the best course of action.

5.5 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S1O1 – Adur Ferry Bridge to Riverside Business Centre - Revetment

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S1O1 – Adur Ferry Bridge to Riverside Business Centre - Revetment			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for a concrete blockwork revetment on the Adur Ferry Bridge to Riverside Business Centre frontage (S1O1).

2 Assumptions

The following assumptions have been used during the development of the concept design.

2.1 Existing structure

The existing flood defence structure has been judged to be in a fair condition, it has been assumed that the new revetment will be constructed in front of the existing structure and then backfilled. No demolition of the existing structure is proposed, however this is subject to change during detailed design.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs. No allowance for settlement has been included within the concept design development.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to further development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to further development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is currently unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing structure will remain in place; the new revetment will be built in front of the existing structure and the gap backfilled. This avoids the requirement of breaking out concrete that may be supporting contaminated land. This is subject to change during outline and detailed design.

Existing slipways and hards will require the same standard of protection as the new defences. Consequently, crest heights must be raised to meet the 5.25mAOD design height or provision of demountable defences, such as flood gates, must be included.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. Consequently, the new defences at the yacht club should tie in with the footbridge to the west and the proposed development at the Parcelforce site to the east. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

The Parcelforce site has full planning permission for development including a 5.57mAOD flood wall around the perimeter of the site. Development of defences at Sussex Yacht Club should be designed to tie in with the proposed flood wall.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- CIRIA. (2007). The Rock Manual: The Use of Rock In Hydraulic Engineering (second edition).
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- HR Wallingford. (1998). Revetment systems against wave attack - A design manual.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

Concrete blockwork revetments are commonly used in marine environments that are not exposed to excessive wave activity. Consequently, it is considered to be a suitable form of defence at Sussex yacht Club and will be constructed in front of the existing defence line. Land raising and backfill will be required to enable the integration of the defence into Sussex Yacht Club's existing land and defences.

4.2 Defence crest level

A design level of 5.08mAOD has been set using assessments of extreme sea level plus a freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.18mAOD and 3.95mAOD.

4.4 Slope gradient

A maximum gradient of 1:2 is to be used for the revetment (HR Wallingford, 1998). It is acceptable to use this maximum value as the revetment will not be used for pedestrian access.

4.5 Backfill / land raising requirement

The permeabilities of the layers should increase moving outwards from the under-lying material to the cover layer. A cover layer which is less permeable than the under-lying material may require some form of relief holes to prevent build up of hydrostatic pressure.

4.6 Adaptability

The crest may be raised by through increasing the height of the revetment. However, this will require further land raising and will result in the crest being moved away from the river; thus loss of usable land will occur. Alternatively, a flood wall may be added at the crest of the revetment.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to further development of outline designs to accompany a planning application.

5.2 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.3 Land take / encroachment associated with new revetment

Construction of the revetment in front of the existing defence will cause encroachment into the river channel. Approval will be required by the Environment Agency before construction can occur. Land take is not an issue with this option if the defence is extended outwards from the land. However, to mitigate river encroachment and loss of inter-tidal habitat, the existing defence may be broken out and the revetment set along the original defence line. If this were to occur then there would be considerable land take required.

5.4 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.5 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.6 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.7 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S1O2 – Adur Ferry Bridge to Riverside Business Centre - Flood wall (set back)

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S1O2 – Adur Ferry Bridge to Riverside Business Centre - Flood wall (set back)			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for a flood wall (set back from the existing defence) on the Adur Ferry Bridge to Riverside Business Centre frontage (S1O2).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing flood defence structure has been judged to be in a fair condition, it has been assumed that the new flood wall will be constructed on a line set back from the existing structure. No demolition of the existing structure is proposed, however this is subject to change during detailed design. If the existing structure is to be retained then repair and maintenance activities, over the course of the new structures design life, should be considered in the development and costing of the flood wall option.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs. No allowance for settlement has been included within the concept design development.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. . It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing structure will remain in place; the new flood wall will be built on top of the existing defence. When excavating for the foundations, care must be taken when breaking out concrete that may be over contaminated land.

Existing slipways and hards will require the same standard of protection as the new defences. Consequently, crest heights must be raised to meet the 5.25mAOD design height or provision of demountable defences, such as flood gates, must be included.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. Consequently, the new defences at the yacht club should tie in with the footbridge to the west and the proposed development at the Parcelforce site to the east. In the event that the adjacent defence is not being raised or is taking a different form, appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

The Parcelforce site has full planning permission for development including a 5.57mAOD flood wall around the perimeter of the site. Development of defences at Sussex Yacht Club should be designed to tie in with the proposed flood wall.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

The flood wall will be constructed to the rear of the existing defence line; protecting the A259 but allowing Sussex Yacht Club to be inundated during flood events. The nature of Sussex Yacht Club means that it is considered to be a water compatible defence; no requirement for dry land such as would be necessary with residential development. However, the final position of the flood wall is subject to change and initial feedback shows that the potential for this site to be periodically flooded in the future is not considered favourable.

Based on the EA Design Guidance a reinforced concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key to improve sliding resistance and also increase the flow path for potential flood water. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements and architectural master plan.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the fluvial modelling outputs plus a 150mm freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.18mAOD and 3.95mAOD.

4.4 Structure dimensions

A conservative approach has been adopted to set the foundation width. A value of 1900mm has been determined relative to a wall height of 2150mm. This approach will allow for future raising of the structure. The thickness of the flood wall is 300mm and has been determined by assuming a span/depth ratio of 7[1].

4.5 Foundation cover

To aid constructability a shallow foundation is proposed, within a minimum cover of 300mm from top of foundation to ground level.

4.6 Adaptability

The crest may be raised by increasing the height of the wall; should structural stability allow it. Allowances for future increases in height (up for an additional 500mm) should be taken into account during the detailed design stage.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to the development of outline designs to accompany a planning application.

5.2 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.3 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.4 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed.

5.5 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk

[1] Cobb, F. (2009). Structural Engineer's Pocket Book (2nd edition).

cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.6 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S1O3 – Adur Ferry Bridge to Riverside Business Centre - Flood wall (on existing defence line)

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S1O3 – Adur Ferry Bridge to Riverside Business Centre - Flood wall (on existing defence line)			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 4/06/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for a flood wall (on existing defence line) on the Adur Ferry Bridge to Riverside Business Centre frontage (S1O3).

2 Assumptions

The following assumptions have been used during the development of the concept design.

2.1 Existing structure

The existing flood defence structure has been judged to be in a fair condition, it has been assumed that the new flood wall will be constructed on top of the existing structure. No demolition of the existing structure is proposed, however this is subject to change during detailed design. If the existing structure is to be retained then repair and maintenance activities, over the course of the new structures design life, should be considered in the development and costing of the flood wall option.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs. No allowance for settlement has been included within the concept design development.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing structure will remain in place; the new flood wall will be built on top of the existing defence. When excavating for the foundations, care must be taken when breaking out concrete that may be over contaminated land. A suitable connection with the existing defence will be required to prevent the risk of scour/undermining.

Existing slipways and hards will require the same standard of protection as the new defences. Consequently, crest heights must be raised to meet the 5.25mAOD design height or provision of demountable defences, such as flood gates, must be included.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. Consequently, the new defences at the yacht club should tie in with the footbridge to the west and the proposed development at the Parcelforce site to the east. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

The Parcelforce site has full planning permission for development including a 5.57mAOD flood wall around the perimeter of the site. Development of defences at Sussex Yacht Club should be designed to tie in with the proposed flood wall.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

The flood wall will be constructed on the existing defence line. Based on the EA Design Guidance a reinforced concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key to improve sliding resistance and also increase the flow path for potential flood water. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the fluvial modelling outputs plus a 150mm freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.18mAOD and 3.95mAOD.

4.4 Structure dimensions

A conservative approach has been adopted to set the foundation width. A value of 1900mm has been determined relative to a wall height of 2150mm. This approach will allow for future raising of the structure. The thickness of the flood wall is 300mm and has been determined by assuming a span/depth ratio of 7[1].

4.5 Foundation cover

To aid constructability a shallow foundation is proposed, within a minimum cover of 300mm from top of foundation to ground level.

4.6 Adaptability

The crest may be raised by increasing the height of the wall; should structural stability allow it. Allowances for future increases in height (up for an additional 500mm) should be taken into account during the detailed design stage.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Connection with existing defence

Detailed analysis will be required to determine the connection required between the new flood wall and the existing defence line. During further design stages it should be assessed how close the new wall can be placed to the existing defence without risk of structural failure of either the new, or old, defence.

5.2 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to the development of outline designs to accompany a planning application.

5.3 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.4 Interaction with yacht club

Due to the nature of the proposed wall, a large number of inlets, slipways and hards are unfeasible. Consequently, consolidation of the slipways to a smaller number, possible a single slipway, would be required. Existing slipways and hards will require the same standard of protection as the new defences. Consequently, crest heights must be raised to meet the 5.25mAOD design height or provision of demountable defences, such as flood gates, must be included. Similarly, flood gates, or other demountables, may need to be installed at entrances to the site.

[1] Cobb, F. (2009). Structural Engineer's Pocket Book (2nd edition).

5.5 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.6 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed.

5.7 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.8 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S1O4 – Adur Ferry Bridge to Riverside Business Centre - Sheet piles (in front of existing defence)

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S1O4 – Adur Ferry Bridge to Riverside Business Centre - Sheet piles (in front of existing defence)			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for steel sheet piles (in front of existing defence) on the Adur Ferry Bridge to Riverside Business Centre frontage (S1O4).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing flood defence structure has been judged to be in a fair condition, it has been assumed that the steel sheet pile wall will be constructed in front of the existing structure and then backfilled with granular fill. No demolition of the existing defence is proposed, however this is subject to change during the detailed design.

Due to the nature of the proposed sheet piles wall, a large number of inlets, slipways and hards are unfeasible. Consequently, consolidation of the slipways to a smaller number, possible a single slipway, would be required.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing structure will remain in place; the steel sheet pile wall will be built in front of the existing structure and the gap backfilled. Keeping the existing defence in place avoids the requirement of breaking out concrete that may be supporting contaminated land.

Existing slipways and hards will require the same standard of protection as the new defences. Consequently, crest heights must be raised to meet the 5.25mAOD design height or provision of demountable defences, such as flood gates, must be included.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. Consequently, the new defences at the yacht club should tie in with the footbridge to the west and the proposed development at the Parcelforce site to the east. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

The Parcelforce site has full planning permission for development including a 5.57mAOD flood wall around the perimeter of the site. Development of defences at Sussex Yacht Club should be designed to tie in with the proposed flood wall. Alternatively, the new sheet piles should be constructed along the entire frontage and tie into the existing pile wall along the Riverside Centre to Kingston Beach frontage.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- ArcelorMittal. (2008). Piling Handbook (8th edition).
- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

The steel sheet pile wall will be constructed in front of the existing defence line. Backfill will be required to enable the integration of the defence into the existing defence line. This option will create additional usable land above the flood level due to the existing sloping defence being replaced by a vertical defence. The sheet pile wall could facilitate the creation of floating pontoons which could have gangway access from the top of the defence. Consequently, this would give more boat storage space on the water and combined with the additional usable land could enable expansion of the yacht club.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the fluvial modelling outputs plus a 150mm freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.18mAOD and 3.95mAOD.

4.4 Pile length

A conservative approach has been adopted whereby two thirds of the total pile length is below the surface. Whilst the design bed level is currently unknown and pile length may be subject to change, the current predicted length is ~25m

4.5 Corrosion resistance

Protective coatings and cathodic protection, through the use of sacrificial anodes, will be applied to the sheet piles. The highest thickness available should be used to enable the design life required from the piles.

4.6 Backfill / land raising requirement

Impermeable material is not required for the backfill as the sheet pile provides the necessary flow cut off.

4.7 Adaptability

The crest may be raised by increasing the height of the capping beam. During full structural analysis, a design should be developed that would allow suitable raising of the capping beam in future.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to the development of outline designs to accompany a planning application.

5.2 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.3 Land take / encroachment associated with new pile line

Construction of the piling in front of the existing defence will cause minor encroachment into the river channel. Approval will be required by the Environment Agency before construction can occur. Land take is not an issue with this option; the defence is extended outwards from the land. Consequently, the useable land area will be increased and other options, such as the use of floating pontoons being installed against the piling, become feasible.

5.4 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.5 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.6 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.7 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S2O1 - Riverside Business Centre to Kingston Beach - Raise existing pile capping

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S201 – Riverside Business Centre to Kingston Beach - Raise existing pile capping			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for raising the existing pile capping on the Riverside Business Centre to Kingston Beach frontage (S2O1).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing sheet piles have been judged to generally be in a fair condition but in need of a corrosion protection system to ensure their continuing life. This option is only feasible if maintenance works can extend the pile life to satisfy the 100 year design life required.

A full structural assessment of each section of the frontage will be required but for the purposes of this design concept it has been assumed that the existing section is structurally sound and capable of taking the additional loading requirements of an increased pile cap. Remedial works will be required to include a corrosion protection system and rectify any other defects. Shoreham Port's Adur River - Left Bank Quay Wall Survey 2014 report states that remaining pile life varies for different wharfs with values ranging between 20 and 100 years. However, it should be noted that this is only based on loss of steel thickness and other factors may contribute to a shorter service life. Further study should be carried out during the detailed design phase.

2.2 Services information

Services information is not applicable for this option as raising the pile capping will not require excavation for foundations.

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to further development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.3 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.4 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.5 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.6 Interface with existing structure

The top surface of the existing pile cap will be scabbled and dowel bars grouted in prior to casting the new pile cap.

2.7 Tie-in with adjacent defence

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- ArcelorMittal. (2008). Piling Handbook (8th edition).
- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- Shoreham Port. (2014). Adur River - Left Bank Quay Wall Survey 2014.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

The existing sheet pile wall will provide the main defence line. The pile capping will be raised by a maximum of 500mm (determined using engineering judgement) to extend the design life of the existing structure. Detailed design will determine the maximum possible pile cap raise; the estimate may increase or decrease. This option requires the existing piling to remain in place and to have sufficient residual life. Consequently, further detailed investigation of the piles should be undertaken prior to development of this option to determine viability. Maintenance of the existing sheet piles should be undertaken as part of this option.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the assessment of extreme sea levels plus a freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level. However, it has been assumed that a maximum raise of 500mm can be utilised; providing a maximum defence level of 4.70mAOD. Whilst this option will not protect until 2115, it will however, protect until 2070 (based on predicted sea level rises). It would also be possible to combine this concept with land raising or a flood wall.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.34mAOD and 4.24mAOD.

4.4 Corrosion resistance

Protective coatings and cathodic protection, through the use of sacrificial anodes, will be applied to the sheet piles. Following advice from Shoreham Port Authority it is recommended that a 2.5m deep concrete coping will be hung from the pile capping to provide additional protection to the splash zone.

4.5 Adaptability

Current engineering judgement has determined that the pile capping will be raised by a maximum of 500mm and alternative measures will be required to provide an increased standard of protection. However, this is liable to change based on detailed design.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Requirement for sufficient residual life from existing piles

This defence option relies on the existing sheet piles to have sufficient residual life to continue to form an effective defence. Consequently, maintenance of the existing piles should be taken as a requirement for further development of this option. A detailed investigation into the remaining pile life should also be undertaken.

5.2 Ability to raise capping

Detailed design will be required to determine the maximum possible design level for the raised capping. This may alter the viability of this defence option.

5.3 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.4 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.5 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.6 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S2O2 - Riverside Business Centre to Kingston Beach - Sheet piles (in front of existing defence)

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S2O2 – Riverside Business Centre to Kingston Beach - Sheet piles (in front of existing defence)			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for steel sheet piles (in front of existing defence) on the Riverside Business Centre to Kingston Beach frontage (S2O2).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing flood defence structure has been judged to be in a fair condition, it has been assumed that the steel sheet pile wall will be constructed in front of the existing structure and then backfilled. No demolition of the existing structure is required. This option will be progressed on the assumption that the existing piles do not have sufficient residual life to last the design life of the scheme. Shoreham Port's Adur River - Left Bank Quay Wall Survey 2014 report states that remaining pile life varies for different wharfs with values ranging between 20 and 100 years. However, it should be noted that this is only based on loss of steel thickness and other factors may contribute to a shorter service life. There is also uncertainty due to the factor of safety used in the original design. Detailed analysis of the existing piles should be undertaken before progressing this option.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to further development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to further development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing structure will remain in place; the steel sheet pile wall will be built in front of the existing structure and the gap backfilled. Keeping the existing defence in place avoids any issues with contaminated land that may arise from removal of the existing sheet piles.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- ArcelorMittal. (2008). Piling Handbook (8th edition).
- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- Shoreham Port. (2014). Adur River - Left Bank Quay Wall Survey 2014.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

The steel sheet pile wall will be constructed in front of the existing defence line, if the existing piles do not have sufficient residual life. Backfill will be required to enable the integration of the defence into the existing defence line. The type and section of piles is to be determined at detailed design stage.

4.2 Defence crest level

A design level of 5.08mAOD has been set using assessments of extreme sea levels plus a freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.34mAOD and 4.24mAOD.

4.4 Pile length

A conservative approach has been adopted whereby two thirds of the total pile length is below the surface. Whilst the design bed level is currently unknown and pile length may be subject to change, the current predicted length is ~25m.

4.5 Corrosion resistance

Protective coatings and cathodic protection, through the use of sacrificial anodes, will be applied to the sheet piles. The thickest pile available is likely to be required to enable the design life required.

4.6 Backfill / land raising requirement

Impermeable material is not required for the backfill as the sheet pile provides the necessary flow cut off.

4.7 Adaptability

The crest may be raised by increasing the height of the capping beam. During full structural analysis, a design should be developed that would allow suitable raising of the capping beam in future.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to further development of outline designs to accompany a planning application.

5.2 Encroachment

Construction of the piling in front of the existing defence will cause minor encroachment into the river channel. Approval will be required by the Environment Agency before construction can occur.

5.3 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.4 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.5 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.6 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S2O3 - Riverside Business Centre to Kingston Beach - Flood wall (on existing defence line)

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S2O3 – Riverside Business Centre to Kingston Beach - Flood wall (on existing defence line)			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for a flood wall (on existing defence line) on the Riverside Business Centre to Kingston Beach frontage (S2O3).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing sheet piles have been judged to generally be in a fair condition but in need of a corrosion protection system to ensure their continuing life. This option is only feasible if maintenance works can extend the pile life to satisfy the 100 year design life required.

A full structural assessment of each section of the frontage will be required but for the purposes on this design concept it has been assumed that the existing section is structurally sound and capable of taking the required loadings. Remedial works will be required to install a corrosion protection system and rectify any other defects. Shoreham Port's Adur River - Left Bank Quay Wall Survey 2014 report states that remaining pile life varies for different wharfs with values ranging between 20 and 100 years. However, it should be noted that this is only based on loss of steel thickness and other factors may contribute to a shorter service life. Further study should be carried out during the detailed design phase.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to further development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing structure will remain in place; the new flood wall will be built on top of the existing defence. The wall may be designed to be either structurally independent or may be integrated with the existing piling. This will be determined during future design stages. During construction of the foundations, care must be taken when excavating contaminated land.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- Shoreham Port. (2014). Adur River - Left Bank Quay Wall Survey 2014.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

The flood wall will be constructed on the existing defence line. Based on the EA Design Guidance a concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key to improve sliding resistance and also increase the flow path for potential flood water. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements.

This option requires the existing piling to remain in place and to have sufficient residual life. Consequently, further detailed investigation of the piles should be undertaken prior to development of this option to determine viability. Maintenance of the existing sheet piles should be undertaken as part of this option.

Whilst the design does not require a physical connection with the existing defence, this should be reviewed during further design stages to determine if efficiencies can be achieved.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the assessment of extreme sea levels plus a freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.34mAOD and 4.24mAOD.

4.4 Structure dimensions

A conservative approach has been adopted to set the foundation width. A value of 1500mm has been determined relative to a wall height of 1350mm. This approach will allow for future raising of the structure. The thickness of the flood wall is 300mm and has been determined by assuming a minimum span/depth ratio of 7[1], whilst maintaining sufficient width to allow cover to reinforcement.

4.5 Foundation cover

To aid constructability a shallow foundation is proposed, within a minimum cover of 300mm from top of foundation to ground level.

4.6 Adaptability

The crest may be raised by increasing the height of the wall; should structural stability allow it. Allowances for future increases in height (up for an additional 500mm) should be taken into account during the detailed design stage.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Requirement for sufficient residual life from existing piles

This defence option relies on the existing sheet piles to have sufficient residual life to continue to form an effective defence. Consequently, maintenance of the existing piles should be taken as a requirement for further development of this option. A detailed investigation into the remaining pile life should also be undertaken.

5.2 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to further development of outline designs to accompany a planning application.

5.3 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.4 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.5 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that

[1] Cobb, F. (2009). Structural Engineer's Pocket Book (2nd edition).

there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.6 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.7 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S2O4 – Riverside Business Centre to Kingston Beach - Flood wall (set back)

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S2O4 - Riverside Business Centre to Kingston Beach - Flood wall (set back)			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for a flood wall (set back) on the Riverside Business Centre to Kingston Beach frontage (S2O4).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing sheet piles have been judged to generally be in a fair condition but in need of a corrosion protection system to ensure their continuing life. This option is only feasible if maintenance works can extend the pile life to satisfy the 100 year design life required.

A full structural assessment of each section of the frontage will be required but for the purposes on this design concept it has been assumed that the existing section is structurally sound and capable of taking the required loadings. Remedial works will be required to install a corrosion protection system and rectify any other defects. Shoreham Port's Adur River - Left Bank Quay Wall Survey 2014 report states that remaining pile life varies for different wharfs with values ranging between 20 and 100 years. However, it should be noted that this is only based on loss of steel thickness and other factors may contribute to a shorter service life. Further study should be carried out during the detailed design phase.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs.

No allowance for settlement has been included within the concept design development; this will be calculated during detailed geotechnical analysis.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to further development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and concept design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing structure will remain in place; the new flood wall will be built behind the line of the existing defence. During construction of the foundations, care must be taken when excavating contaminated land.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- Shoreham Port. (2014). Adur River - Left Bank Quay Wall Survey 2014.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

The flood wall will be constructed to the rear of the existing defence line. Based on the EA Design Guidance a reinforced concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key to improve sliding resistance and also increase the flow path for potential flood water. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements. This option requires the existing piling to remain in place and to have sufficient residual life. Consequently, further detailed investigation of the piles should be undertaken prior to development of this option to determine viability. Maintenance of the existing sheet piles should be undertaken as part of this option.

4.2 Defence crest level

A design level of 5.08mAOD has been set using assessments of extreme sea levels plus a freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.34mAOD and 4.24mAOD.

4.4 Structure dimensions

A conservative approach has been adopted to set the foundation width. A value of 1500mm has been determined relative to a wall height of 1350mm. This approach will allow for future raising of the structure. The thickness of the flood wall is 300mm and has been determined by assuming a minimum span/depth ratio of 7[1], whilst maintaining sufficient width to allow cover to reinforcement.

4.5 Foundation cover

To aid constructability a shallow foundation is proposed, within a minimum cover of 300mm from top of foundation to ground level.

4.6 Adaptability

The crest may be raised by increasing the height of the wall; should structural stability allow it. Allowances for future increases in height (up for an additional 500mm) should be taken into account during the detailed design stage.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Requirement for sufficient residual life from existing piles

This defence option relies on the existing sheet piles to have sufficient residual life to continue to form an effective defence. Consequently, maintenance of the existing piles should be taken as a requirement for further development of this option. A detailed investigation into the remaining pile life should also be undertaken.

5.2 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to the development of outline designs to accompany a planning application.

5.3 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.4 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.5 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed.

[1] Cobb, F. (2009). Structural Engineer's Pocket Book (2nd edition).

5.6 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.7 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S2O5 - Riverside Business Centre to Kingston Beach - Land raising to provide flood defence

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S2O5 – Riverside Business Centre to Kingston Beach -Land raising to provide flood defence			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 4/06/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for land raising to provide flood defence on the Riverside Business Centre to Kingston Beach frontage (S2O5).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing sheet piles have been judged to generally be in a fair condition but in need of a corrosion protection system to ensure their continuing life. A full structural assessment of each section of the frontage will be required but for the purposes on this design concept it has been assumed that the existing section is structurally sound and capable of taking the required loadings. Remedial works will be required to install a corrosion protection system and rectify any other defects. Shoreham Port's Adur River - Left Bank Quay Wall Survey 2014 report states that remaining pile life varies for different wharfs with values ranging between 20 and 100 years. However, it should be noted that this is only based on loss of steel thickness and other factors may contribute to a shorter service life. Further study should be carried out during the detailed design phase.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs. No allowance for settlement has been included within the concept design development.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

It should be noted that contaminated land may not be as serious an issue for this option as no excavation will occur. Existing contaminated land may be buried by the land raise. However, if the existing material has a low bearing capacity then replacement with higher bearing capacity fill may be required. Full geotechnical analysis will determine the level of contaminated land risk involved with this option.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing sheet piles will remain in place; the new raised land will be constructed on top of the existing defences. Detailed design should determine if the existing piles have sufficient strength to withstand the additional weight of the land raise.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

Due to the nature of land raising, it is advisable to raise the entire Riverside Centre to Kingston Beach frontage at the same time. Raising individual parcels of land would require retaining walls, or embankment slopes to be constructed at the edges of each developed land parcel, prior to development of the adjacent one.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- CIRIA. (2013). The International Levee Handbook.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- Shoreham Port. (2014). Adur River - Left Bank Quay Wall Survey 2014.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

Land raising will enable the defence level to be increased from the existing defences. Land raising will increase the height of finished floor levels and therefore provide the standard of protection required. This option requires the existing piling to remain in place and to have sufficient residual life. Consequently, further detailed investigation of the piles should be undertaken prior to development of this option to determine viability. Maintenance of the existing sheet piles should be undertaken as part of this option.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the assessment of extreme sea levels plus a minimum 300mm freeboard allowance. Therefore, 5.40mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.34mAOD and 4.24mAOD.

4.4 Slope gradient

A self supported land raise will require a slope from the existing ground level up to the new ground level. A maximum gradient of 1:3 is proposed for these slopes, based on EA guidance.

4.5 Backfill / land raising requirement

Impermeable material is required to prevent saturation of the raised land, leading to possible failure or flow paths. A full geotechnical analysis should be completed during the detailed design.

4.6 Quantity of material required

Whilst no detailed assessment of fill volumes has been made, it is assumed that this will be a large quantity. Consequently, there will be logistical issues relating to the importation of materials unless a local source can be found.

4.7 Adaptability

Land may be raised further, provided there is consideration given to this during the design stages. However, once the raised land has been built upon there is not an option to raise land further under building footprints. Land may still be raised elsewhere; for example as a levee in front of buildings. Alternatively, flood walls may be added on the raised land to increase the standard of protection.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Requirement for sufficient residual life from existing piles

This defence option relies on the existing sheet piles to have sufficient residual life to continue to form an effective defence. Consequently, maintenance of the existing piles should be taken as a requirement for further development of this option. A detailed investigation into the remaining pile life should also be undertaken.

5.2 Availability of suitable material

If suitable material cannot be found at a local site then importation of materials may provide logistical issues. Delivery of material by lorry may result in a large number of trips and excessive damage to the A259 may be caused in addition to causing a traffic nuisance. It may be possible for material to be brought in by sea, although this may depend on the location of the material source.

5.3 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to the development of outline designs to accompany a planning application.

5.4 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.5 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction. The large quantity of material required may determine the methods of construction required.

5.6 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.7 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.8 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S3O1 - Kingston Beach - Rock armour

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S3O1 - Kingston Beach -Rock armour			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for rock armour on the Kingston Beach frontage (S3O1).

2 Assumptions

The following assumptions have been used during the development of the concept design.

2.1 Existing structure

The existing revetment has been judged to be in a poor condition, it has been assumed demolition of any relic structures will occur before construction of new rock armour remedial defence (to the existing defence level only).

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs. No allowance for settlement has been included within the concept design development.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be

progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing revetment will be demolished and new rock armour defence will be constructed in its place.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

A tie in to the higher ground, located along the line of the A259 (Brighton Road), is required to enable a flow path cut off. Without this, flood water may inundate defended areas and may cause flood water to flow along the road.

The existing RNLI lifeboat station defences should be tied into any new defence scheme so that flood risk is not increased. Construction of new defences should not impede the operation of the lifeboat station in anyway.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2002). BS EN 13383-1:2002, Armourstone – Part 1: Specification.
- British Standards Institute. (2002). BS EN 13383-2:2002, Armourstone – Part 2: Test methods.
- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- CIRIA. (2007). The Rock Manual: The Use of Rock In Hydraulic Engineering (second edition).
- CIRIA (2010), The Beach Management Manual (second edition)
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- HR Wallingford. (1998). Revetment systems against wave attack - A design manual.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

Due to the location of Kingston Beach, which is exposed to wave activity, the option should be able to withstand wave action on the defence. Using rock armour will protect against this. The primary armour will be placed on a smaller filter layer, which will be on a geotextile. The rock armour is permeable so an impermeable wall should be placed to the rear of the defence, up to the design height of 5.25mAOD. No wave overtopping standard has been set; this should be examined in detail during further design stages.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the assessment of extreme sea levels plus a minimum150mm freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.83mAOD and 4.21mAOD.

4.4 Hydrodynamic data

No information on the expected wave conditions has been made available, therefore defence geometry has been designed using practical experience and engineering judgement.

4.5 Defence crest height

The crest height has been defined by the requirement for rock armour to be constructed with a minimum of two layers of armourstone. Therefore the defence crest height has been taken as the theoretical thickness of two rocks of D50 = 1.20m placed on top of the existing ground level. However, this gives a permeable crest and as a result an impermeable structure, such as a flood wall, must be included at the rear of the defence.

4.6 Defence crest width

No hydrodynamic data has been made available as part of this study. Therefore the crest width has been taken to represent 3 rocks of D50 = 1.20m equal to 3.6m.

4.7 Rear of defence position

The rear of the revetment has been set back 1.00m from the current crest position, to provide a solid grounding for the rear keystone while reducing encroachment onto Adur District Council land.

4.8 Primary Rock armour sizing

No hydrodynamic data has been made available as part of this study. Therefore, the rock armour has been designed based on engineering judgement and previous project experience to be stable in a medium intensity wave climate using 1:2 gradient, and with the provision of a 1.00m deep filter layer. The required rock grading will therefore be 3-6t in accordance with BS EN 18838.

4.9 Filter armour sizing

The filter armour has been sized as D50/2.35 producing a D50 of 0.71m which equates to an armourstone grading of 0.3-1t in accordance with BS EN 18838.

4.10 Foundation depth

No ground condition information has been made available as part of the study. It was assumed that the bed rock level was at a depth greater than 1.00m below the existing bed level. The revetment toe was placed 1.00m below the existing bed level to provide an allowance for scour during the design life.

4.11 Foundation form

The revetment filter layer will be placed on top of a geotextile to reduce the loss of fines through the structure. The design recommends a geotextile of HPS14 or equivalent to survive a 6t rock being dropped from 1.00m high with a safety factor of 2 built in.

4.12 Adaptability

Rock armour may be redesigned, and the rocks reused, to accommodate a higher design crest level.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Wave climate currently unknown

Currently the wave forces are unknown. Further study should be undertaken to establish wave data during the detailed design stage.

5.2 Interaction with lifeboat station

The lifeboat station has a "wave dissipation void"; constructed using a secant wall at the front of the building to avoid damage to the boat house door due to waves being accentuated by the 1 in 5 gradient slipway. During detailed design this should be taken into account and if necessary, modelling undertaken to determine the influence that this has on the new defences at Kingston Beach.

5.3 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to the development of outline designs to accompany a planning application.

5.4 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.5 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.6 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.7 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.8 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S3O2 - Kingston Beach - Flood wall

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S3O2 - Kingston Beach - Flood wall			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for a flood wall on the Kingston Beach frontage (S3O2).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing revetment has been judged to be in a poor condition, it has been assumed demolition of any relic structures will occur before construction of new concrete revetment remedial defence (to the existing defence level only).

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs. No allowance for settlement has been included within the concept design development; this may affect the new concrete revetment.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing revetment will be demolished and a replacement revetment (to existing design level) will be constructed in its place. The proposed flood wall would be at the top of the new concrete revetment defence to provide the 2115 design level.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

A tie in to the higher ground, located along the line of the A259 (Brighton Road), is required to enable a flow path cut off. Without this, flood water may inundate defended areas and may cause flood water to flow along the road.

The existing RNLI lifeboat station defences should be tied into any new defence scheme so that flood risk is not increased. Construction of new defences should not impede the operation of the lifeboat station in anyway.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- HR Wallingford. (1998). Revetment systems against wave attack - A design manual.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

Due to the location of Kingston Beach, which is exposed to wave activity, the option should be able to withstand wave action on the defence. Construction of a new concrete revetment (to replace the existing damaged defence) will provide protection against this, but its exact form will require more detailed analysis during future design stages.

The flood wall will be constructed on the existing defence line. Based on the EA Design Guidance a reinforced concrete core and foundation wall is considered as the most technically viable solution. The wall foundation includes a shear key to improve sliding resistance and also increase the flow path for potential flood water. It is envisaged that the wall will be clad with either bricks or stone, dependent on the local planning authority requirements.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the assessment of extreme sea levels plus a minimum of 150mm freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.83mAOD and 4.21mAOD.

4.4 Structure dimensions

A conservative approach has been adopted to set the foundation width. A value of 1500mm has been determined relative to a wall height of 1350mm. This approach will allow for future raising of the structure. The thickness of the flood wall is 300mm and has been determined by assuming a minimum span/depth ratio of 7[1], whilst maintaining sufficient width to allow cover to reinforcement.

4.5 Foundation cover

To aid constructability a shallow foundation is proposed, within a minimum cover of 300mm from top of foundation to ground level.

4.6 Adaptability

The crest may be raised by increasing the height of the wall; should structural stability allow it. Allowances for future increases in height (up for an additional 500mm) should be taken into account during the detailed design stage.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Wave climate currently unknown

Currently the wave forces are unknown. Further study should be undertaken to establish wave data during the detailed design stage.

5.2 Interaction with lifeboat station

The lifeboat station has a "wave dissipation void"; constructed using a secant wall at the front of the building to avoid damage to the boat house door due to waves being accentuated by the 1 in 5 gradient slipway. During detailed design this should be taken into account and if necessary, modelling undertaken to determine the influence that this has on the new defences at Kingston Beach.

5.3 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to the development of outline designs to accompany a planning application.

5.4 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.5 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

[1] Cobb, F. (2009). Structural Engineer's Pocket Book (2nd edition).

5.6 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.7 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.8 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

DESIGN – TECHNICAL NOTE

JBA Project Code	2014s0848
Contract	Shoreham Harbour Flood Risk Management Technical Guidance
Client	Adur District Council
Day, Date and Time	15/05/2014
Author	Tim Ash-Edwards
Subject	S3O3 - Kingston Beach - Sheet piles

Project Title: Shoreham Harbour Flood Risk Management Technical Guidance			Sheet No: 1
Subject: S3O3 - Kingston Beach - Sheet piles			Calc No:
Job No: 2014s0848			File:1
Developed By: Tim Ash-Edwards	Date:15/05/2014	Revised By: Tim Ash-Edwards	Date: 05/08/2014
Checked By: Graham Kenn	Date: 20/05/2014	Approved By: Oliver Francis	Date: 06/08/2014

1 Aim

JBA Consulting and Baca Architects have been tasked by the Shoreham Harbour Regeneration Partnership with preparing Flood Risk Management (FRM) Technical Guidance in support of the Shoreham Harbour Regeneration project, to include:

- An options appraisal including concept designs for technically feasible flood defence solutions and their associated cost implications;
- The compilation of the results of the appraisal in a simple, user friendly guide aimed at the potential developers and decision makers of Shoreham Harbour area to ensure the delivery of the appropriate flood defences; and
- Review to determine suitability, relating to the overall development plan.

These will form part of the evidence base for the Shoreham Harbour Joint Area Action Plan (JAAP). Before the JAAP is adopted the options appraisal and guidance will assist the prospective developers and decision makers in accessing funding streams for infrastructure.

This technical note covers the design assumptions, decision making process and methodology for steel sheet piles on the Kingston Beach frontage (S3O3).

2 Assumptions

The following assumptions have been used during the development of the concept design

2.1 Existing structure

The existing revetment has been judged to be in a poor condition, and will be demolished as part of these works. The new line of pilling will be constructed to the rear of the existing defence, therefore allowing demolition of the revetment without loss of defence.

2.2 Ground conditions

No geotechnical or ground condition information has been made available as part of this study. Therefore, all designs of defence structures will be progressed assuming poor ground conditions e.g. low bearing capacity. This should provide a conservative approach to the development of concept designs.

It should however be noted that all designs could be subject to significant change based on geotechnical investigation results. It is suggested that a Geotechnical Investigation and analysis is undertaken prior to the development of outline designs and their submission for planning approval.

2.3 Services information

Limited services information has been made available as part of this study; a full services investigation should be completed prior to detailed design work. Therefore, all designs of defence structures will be progressed assuming that services do not conflict with the design. This will allow a limitless approach to

the options appraisal. However, cost estimates may have a reduced accuracy should changes to services be needed.

It should however be noted that all designs could be subject to significant change based on service investigation results. It is suggested that a services investigation is undertaken prior to the development of outline designs and their submission for planning approval.

The JAAP (2.10.11, p.74) states that the area is crossed by several underground water mains and sewers. This infrastructure needs to be protected and new development needs to ensure its operation remains unaffected. However, at present the position of these services is unknown.

2.4 Contaminated land

Contaminated land issues are only applicable for any refurbishment options that require the rear of the pile to be accessed.

An invasive contaminated land survey should be undertaken in areas of development to enable detailed assessment of suitable construction techniques. For example, reuse of aggregate or soil from the site may not be usable if contaminated, and geotechnical work may need to be designed around contaminated groundwater. JAAP Policy 17 states that assessment of contamination should not be limited to site boundaries due to migration of contamination. To progress concept design options as part of this study the following have been assumed:

- Former industrial area, therefore some level of contamination is likely;
- No investigation of contamination issues at individual development sites has been undertaken; and
- Development flood defence options will require some contaminated land treatment.

2.5 Structural design

A full structural design has not been included within this study as the scope of works only includes the development of concept design options. A full structural analysis could not be completed without relevant ground condition information. It should be noted that the details of the concept structures are liable to change during outline and detailed design stages when more ground condition information is available.

2.6 Reinstatement and finish details

Opportunities for the consideration of the integration of flood defences within the public realm are described with the flood risk management technical guide. The development of detailed landscape and architectural enhancements, including finishes are however outside the current scope of this study.

2.7 Interface with existing structure

It is assumed that the existing revetment will demolished after completion of the piling.

2.8 Tie-in with adjacent defences

Whilst individual parcels of land are to be developed independently, a seamless defence frontage should ultimately be attained. In the event that the adjacent defence is not being raised or is taking a different form appropriate tie in details will be required. Where the adjacent site has yet to be developed the need to consider a temporary line of defence will be required.

A tie in to the higher ground, located along the line of the A259 (Brighton Road), is required to enable a flow path cut off. Without this, flood water may inundate defended areas and may cause flood water to flow along the road.

The existing RNLI lifeboat station defences should be tied into any new defence scheme so that flood risk is not increased. Construction of new defences should not impede the operation of the lifeboat station in anyway.

3 Standards, guidance & reference documents

All design assumptions have been developed using the following reference material:

- ArcelorMittal. (2008). Piling Handbook (8th edition).
- British Standards Institute. (2013). BS EN 6349-1-1:2013, Maritime works, General, Code of practise for planning and design.
- DEFRA. (2009). Adapting to climate change - UK Climate Projections.
- Environment Agency. (2010). Fluvial Design Guide.
- HR Wallingford. (1998). Revetment systems against wave attack - A design manual.

4 Design development

The following provides a brief summary of how the key design elements were selected.

4.1 General form of defence

Due to the location of Kingston Beach, which is exposed to wave activity, the option should be able to withstand wave action on the defence. Placement of rock armour at the base of the sheet piles will provide protection to dissipate wave energy.

The steel sheet pile wall will be constructed to the rear of the existing defence line. Protection of the pile from wave action will be provided by a layer of rocks armour placed at the toe for scour protection.

4.2 Defence crest level

A design level of 5.08mAOD has been set using the assessment of extreme sea levels plus a minimum of 150mm freeboard allowance. Therefore, 5.25mAOD has been used as the final defence level.

4.3 Existing crest level

The existing defence levels (surveyed by Maltby Land Services, June 2010 [JBA_2010s4031_10]) are between 3.83mAOD and 4.21mAOD.

4.4 Pile length

A conservative approach has been adopted whereby two thirds of the total pile length is below the surface. Whilst the design bed level is currently unknown and pile length may be subject to change, the current predicted length is ~25m

4.5 Corrosion resistance

Protective coatings and cathodic protection, through the use of sacrificial anodes, will be applied to the sheet piles. The highest thickness available should be used to enable the design life required from the piles.

4.6 Scour protection

Rock armour should be placed at the base of the sheet pile wall to provide scour protection. This will help dissipate wave energy and prolong the life of the pile wall.

4.7 Adaptability

The crest may be raised by increasing the height of the capping beam. During full structural analysis, a design should be developed that would allow suitable raising of the capping beam in future.

5 Technical risks summary

The following are considered to represent the key risks highlighted during the development of this concept design option.

5.1 Wave climate currently unknown

Currently the wave forces are unknown. Further study should be undertaken to establish wave data during the detailed design stage. This analysis will influence the extent of rock armour scour protection that is required.

5.2 Interaction with lifeboat station

The lifeboat station has a "wave dissipation void"; constructed using a secant wall at the front of the building to avoid damage to the boat house door due to waves being accentuated by the 1 in 5 gradient slipway. During detailed design this should be taken into account and if necessary, modelling undertaken to determine the influence that this has on the new defences at Kingston Beach.

5.3 Decommissioning of existing defence

The existing concrete revetment defence will need to be decommissioned. It is recommended that the new sheet piles are driven into the ground before any removal of the existing defence to reduce the risk of contaminated land spilling into the river.

5.4 Unknown ground conditions

Due to the unknown ground conditions and geotechnical information it is possible that the current concept design will require modification in order to achieve structural and geotechnical stability. It is advised that a ground investigation is completed prior to the development of outline designs to accompany a planning application.

5.5 Contaminated land

Contaminated ground may be a factor in the development; for example avoiding excavations where possible. Consequently, a full contaminated ground survey should be undertaken prior to detailed design so that mitigation measures can be incorporated.

5.6 Construction accessibility

Prior to the development of outline designs it would be advisable to appoint a construction contractor to provide constructability advice. Although the site is considered reasonably accessible it would be beneficial to confirm the proposed methods of construction.

5.7 Services information

Limited services information has been provided as part of this study. If the project progresses to outline and detailed design it will be essential that a full service plan is developed. Currently it is known that there are large water service pipes running near the site but the exact location of these is unknown. A complete services investigation must be carried out before undertaking detailed design.

5.8 Health and safety

In accordance with the requirements of the Construction Design and Management Regulations (2007) a designer's risk assessment has been completed for the design element (referred to as a Design Hazard Inventory). The purpose of the designers risk assessment will be to firstly eliminate all potential hazards associated with the construction, management and decommissioning of any designed elements. If a risk cannot be eliminated then measures will be considered to minimise that risk as far as is practicably possible.

5.9 Environmental impacts

No formal Environmental Impact Assessment was completed during this project stage. It is anticipated that any further development of the design concept would include an assessment of the environmental impacts. This process may result in changes being made to the proposed designs.

E Designers Hazard Inventory

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Steel sheet pile (new piling)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	Access required through yacht club	Risk to public from plant, risk to workers from yachts and other vehicles	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with yacht club Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
4	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
5	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
6	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents, business users and yacht club	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents, businesses and yacht club.		Remote compound
7	Shared use of slipways and hards	Injury to public or workers	Y	Y	Y		N	Physical separation of pedestrians and site traffic on hards and slipways - plans required to prevent public from using these whilst requried for plant	Shared use of accesses. Unauthorised access.	
8	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
9	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

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TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
10	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
11	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
12	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
13	Excavation of estuary material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
14	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
15	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
16	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
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TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
17	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
18	Demolition of any relic structures	Hand arm vibration	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
19	Piling operations	Damage to hearing, vibration damage of surrounding buildings	Y	Y	Y		Y	Piling method developed in conjunction with the client and stakeholders		
2.3 Materials										
20	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
21	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
22	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
23	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
24	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
25	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
26	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
27	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
3.1 Defence inspection										
28	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

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			Task workers	Other workers	Public	Environment				
4. Public Safety										
29	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
30	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

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Design Element:	Revetment - concrete blockwork (modular)	**Review:**	MP	16/06/2014	

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1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	Access required through yacht club	Risk to public from plant, risk to workers from yachts and other vehicles	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with yacht club Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
4	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
5	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
6	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
7	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
8	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
9	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

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10	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
11	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
12	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
13	Excavation of estuary material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
14	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
15	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
16	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

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2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
17	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
18	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
19	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
20	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
21	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
22	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
23	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
24	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
25	Placement of concrete blocks	Personal injury	Y	Y		Y	N	Staff awareness		Alternative materials
3.1 Defence inspection										
26	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Revetment - concrete blockwork (modular)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
27	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
28	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (existing alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	Access required through yacht club	Risk to public from plant, risk to workers from yachts and other vehicles	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with yacht club Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
4	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
5	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
6	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
7	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
8	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
9	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (existing alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
10	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
11	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
12	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
13	Excavation of estuary material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
14	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
15	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
16	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (existing alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
17	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
18	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
19	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
20	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
21	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
22	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
23	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
24	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
25	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
26	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
27	Reinforcement detailing	Personal injury	Y				N	All reinforcement construction to be completed by trained operatives only, rebar not be be left exposed in structure without safety caps in place		
3.1 Defence inspection										
28	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (existing alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
29	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
30	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (set back alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	Access required through yacht club	Risk to public from plant, risk to workers from yachts and other vehicles	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with yacht club Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
4	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
5	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
6	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
7	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
8	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
9	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (set back alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
10	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
11	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
12	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
13	Excavation of estuary material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
14	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
15	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
16	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (set back alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
17	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
18	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
19	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
20	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
21	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
22	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
23	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
24	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
25	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
26	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
27	Reinforcement detailing	Personal injury	Y				N	All reinforcement construction to be completed by trained operatives only, rebar not be be left exposed in structure without safety caps in place		
3.1 Defence inspection										
28	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Adur Ferry Bridge to Riverside Business Centre	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (set back alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
29	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
30	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (raise existing)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (raise existing)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
13	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
14	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (raise existing)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
15	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
16	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
17	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
18	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
19	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
20	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
21	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
22	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
23	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
24	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
3.1 Defence inspection										
25	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE		06/05/2014
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK		07/05/2014
Design Element:	Piling - steel sheet piles (raise existing)	**Review:**	MP		16/06/2014

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
26	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
27	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (new piling)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (new piling)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
13	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
14	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (new piling)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
15	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
16	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
17	Piling operations	Damage to hearing, vibration damage of surrounding buildings	Y	Y	Y		Y	Piling method developed in conjunction with the client and stakeholders		
2.3 Materials										
18	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
19	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
20	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
21	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
22	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
23	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
24	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
25	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
3.1 Defence inspection										
26	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (new piling)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
27	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
28	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (existing alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (existing alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
13	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
14	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (existing alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
15	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
16	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
17	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
18	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
19	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
20	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
21	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
22	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
23	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
24	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
25	Reinforcement detailing	Personal injury	Y				N	All reinforcement construction to be completed by trained operatives only, rebar not be be left exposed in structure without safety caps in place		
3.1 Defence inspection										
26	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (existing alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
27	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
28	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (set back alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (set back alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

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			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
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1.5 Groundwork										
12	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
13	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
14	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
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TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
15	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
16	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
17	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
18	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
19	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
20	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
21	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
22	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
23	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
24	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
25	Reinforcement detailing	Personal injury	Y				N	All reinforcement construction to be completed by trained operatives only, rebar not be be left exposed in structure without safety caps in place		
3.1 Defence inspection										
26	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Riverside Business Centre to Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete (set back alignment)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
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4. Public Safety										
27	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
28	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (set forward)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (set forward)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of beach material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
13	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
14	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
15	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (set forward)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
16	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
17	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
18	Piling operations	Damage to hearing, vibration damage of surrounding buildings	Y	Y	Y		Y	Piling method developed in conjunction with the client and stakeholders		
2.3 Materials										
19	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
20	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
21	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
22	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
23	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
24	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
25	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
26	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
3.1 Defence inspection										
27	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (set forward)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
28	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
29	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (set backward)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (set backward)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of beach material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
13	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
14	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
15	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (set backward)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
16	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
17	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
18	Piling operations	Damage to hearing, vibration damage of surrounding buildings	Y	Y	Y		Y	Piling method developed in conjunction with the client and stakeholders		
2.3 Materials										
19	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
20	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
21	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
22	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
23	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
24	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
25	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
26	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
3.1 Defence inspection										
27	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Piling - steel sheet piles (set backward)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
28	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
29	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Revetment - rock armour	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE		06/05/2014
Site:	Kingston Beach	**Check:**	GK		07/05/2014
Design Element:	Revetment - rock armour	**Review:**	MP		16/06/2014

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of beach material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
13	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
14	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
15	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Revetment - rock armour	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
16	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
17	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
18	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
19	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
20	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
21	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
22	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
23	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
24	Movement of rocks for armour	Personal injury	Y	Y		Y	N	Staff awareness		Alternative materials
3.1 Defence inspection										
25	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Revetment - rock armour	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
26	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
27	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Revetment - concrete proprietary (xbloc etc)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Revetment - concrete proprietary (xbloc etc)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of beach material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
13	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
14	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
15	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
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TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
16	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
17	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
18	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
19	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
20	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
21	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
22	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
23	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
24	Movement of rocks for armour	Personal injury	Y	Y		Y	N	Staff awareness		Alternative materials
3.1 Defence inspection										
25	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
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TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
26	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
27	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Revetment - concrete blockwork (modular)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
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Design Element:	Revetment - concrete blockwork (modular)	**Review:**	MP		16/06/2014

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of beach material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
13	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
14	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
15	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
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Design Element:	Revetment - concrete blockwork (modular)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
16	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
17	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
18	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
19	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
20	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
21	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
22	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
23	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
24	Placement of concrete blocks	Personal injury	Y	Y		Y	N	Staff awareness		Alternative materials
3.1 Defence inspection										
25	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
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Design Element:	Revetment - concrete blockwork (modular)	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard		Receptor			Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
4. Public Safety										
26	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
27	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1. CONSTRUCTION PHASE - SAFETY HAZARDS										
1.1 Access and egress										
1	Plant and delivery access to site	Restricted access from A259 (Brighton Road) only	Y	Y	Y		N	Early Contractor involvement to consider best access routes for plant and deliveries. Development of a traffic management plan. Consider design options that minimise large plant access	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
2	Movement of site traffic on public rights of way	Public struck by site traffic	Y	Y	Y		N	Traffic Management Plan. Contractors to consult with local resident groups Contractor to provide clear demarcation between pedestrian and vehicular areas. All emergency access to be maintained at all times	Traffic management plan to be developed. Risk to be identified in Pre Construction Information Pack	
3	General movement around site	Slips, trips and falls	Y	Y				All work areas to be keep clean and tidy. Designated pedestrian routes to be demarcated.	Slips, trips and falls	
4	Mud on road	Hazard to other road users	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulates between road sweeping operations.	None
1.2 Adjacent land users										
5	Location of site compound	Limited space due to site proximity to urban area. Could cause impact on local residents	Y	Y	Y		N	Careful consideration of site compound positioning. Should avoid disturbance to local residents.		Remote compound
6	Shared use of footpaths, beach access routes	Injury to public	Y	Y	Y		N	Physical separation of pedestrians and site traffic on footpaths and approaches; designated safe corridors for public to access beach area and cliff path, signage.	Shared use of accesses. Unauthorised access.	
7	Public access to areas surrounding work area	Injury to public	Y	Y	Y		N	Fencing to site compound and work areas	Trespassers	
1.3 Working at height										
8	Piling operations	Risk of falls from piling rigs / from top of piling	Y	Y			N	All workers to wear harnasses when working at height and life jackets when working at height above water		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE		06/05/2014
Site:	Kingston Beach	**Check:**	GK		07/05/2014
Design Element:	Flood wall - reinforced concrete	**Review:**	MP		16/06/2014

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
1.4 Working near water (Tidal location)										
9	Working in a tidal location during construction works	Drowning / inundation of works	Y	Y			N	Ensure careful planning of work activities around tidal cycle. Ensure daily weather monitoring and forecasting is undertaken to provide early warning of storm events Ensure temporary works are in place to mitigate the risk of tidal inundation to working areas. Provide life jackets for all personnel working in close proximity to the sea. Training and tool box talks covering working in a tidal environment	Risk to be identified in Pre Construction Information Pack	
10	General works and operations near the sea	Accidental water entry	Y	Y			N	Contractor to provide life saving equipment Toolbox talks and training to be completed	Risk to be identified in Pre Construction Information Pack	
11	Flooding of works during construction		Y	Y			N	Temporary tidal defences to be maintained during the course of construction works. Contractor to register for Environment Agency flood warning. Remove plant and materials from tidal area every shift.	Risk to be identified in Pre Construction Information Pack	
1.5 Groundwork										
12	Excavation of beach material	Subsidence	Y	Y			N	A full geotechnical investigation should be undertaken before any further design development. Contractor to ensure construction plant is sited a suitable distance from bank edges and track mats are used where appropriate	Risk to be identified in Pre Construction Information Pack	
13	Excavation of contaminated ground	Risk of disturbing contaminated ground / cross contamination	Y	Y		Y	N	A full contaminated ground investigation should be undertaken before any further design development. Excavations should be avoided where possible.	Risk to be identified in Pre Construction Information Pack	
14	Soft ground	Sinking plant	Y	Y			N	Site investigation to be undertaken prior to detailed design		
1.6 Confined Spaces										
	N/A									
1.7 Existing services										
15	Excavation	Striking unknown services - particular issues are sewer pipes running through the site	Y	Y	Y			Full services search to be completed prior to detailed design. CAT scan before excavation; hand excavation for first 0.5m.	Risk to be identified in Pre Construction Information Pack	

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
Project Name:	2014s0848 - Shoreham Harbour Flood Risk Management Technical Guidance	**Author:**	TAE	06/05/2014	
Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete	**Review:**	MP	16/06/2014	

TABLE 3-1: DESIGNER'S HAZARD INVENTORY (Revision 0.3, 17 December 2008)

Nr	Activity	Hazard	Receptor				Eliminate by design?	Mitigation measures	Residual risk	Impracticable solutions
			Task workers	Other workers	Public	Environment				
2. CONSTRUCTION PHASE - HEALTH HAZARDS										
2.1 Manual handling										
16	Manual handling of materials	Injury to personnel	Y	Y			N	Where possible all elements specified should be suitable for lifting and positioning by mechanical means. Suitable access routes to construction areas to allow delivery directly to working area with Lifting and handling equipment, competent personnel. Manual handling tool box talks and training.	Method for mechanical handling should be developed.	
2.2 Noise and vibration										
17	Demolition of any relic structures	Hand arm vibration,	Y	Y			N	Use mechanical methods for demolition wherever possible. If hand demolition is required then ensure adherence to guidance.		
2.3 Materials										
18	Biological hazards due to water (eg.Leptospirosis)	Illness to personnel	Y				N	Staff awareness, avoid contact, good hygiene practice		
19	Dust due to construction plant and vehicles	Health and visual impact to personnel and public	Y	Y	Y	Y	N	Dust-management measures: tarpaulins on lorries, water sprays		
20	Fuel spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Fuel storage remote from watercourse, all fuel storage areas to be bunded and containers located on drip trays; spill kit available	Damage to fauna or groundwater	
21	Hydraulic oil spillage	Fire hazard, damage to flora, fauna and watercourse	Y	Y	Y	Y	N	Regular maintenance of plant; biodegradable hydraulic oil in plant working near watercourses (optional); spill kit	Damage to fauna or groundwater	
22	Lime mortar (alkaline) leading to burns, esp. during mixing	Personal injury	Y	Y	Y	Y	N	Staff awareness, ensure correct PPE is used at all times, mix mortar away from public areas	Contact with exposed skin of task workers	Alternative materials
23	Mud due to construction plant and vehicles	Dangerous road conditions	Y	Y	Y	Y	N	Contract requirements to include wheel wash; road sweeper	Mud accumulation between road cleaning leading to slippery conditions	None
24	Wet concrete leading to burns	Personal injury	Y	Y		Y	N	Staff awareness, PPE		Alternative materials
25	Wet concrete spillage or surplus concrete	Damage to flora, fauna and watercourse	Y			Y	N	Spill kit; offsite disposal of surplus concrete and washing out of lorry		Alternative materials
26	Reinforcement detailing	Personal injury	Y				N	All reinforcement construction to be completed by trained operatives only, rebar not be be left exposed in structure without safety caps in place		
3.1 Defence inspection										
27	Working near water during defence inspection	Risk of sinking in soft fluvial deposits and risk of being cut off.	Y				Y	All inspections can be completed during periods of low tide or by boat.		

Client:	Adur District Council	**Design Stage**	Concept	**Date**	
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Site:	Kingston Beach	**Check:**	GK	07/05/2014	
Design Element:	Flood wall - reinforced concrete	**Review:**	MP	16/06/2014	

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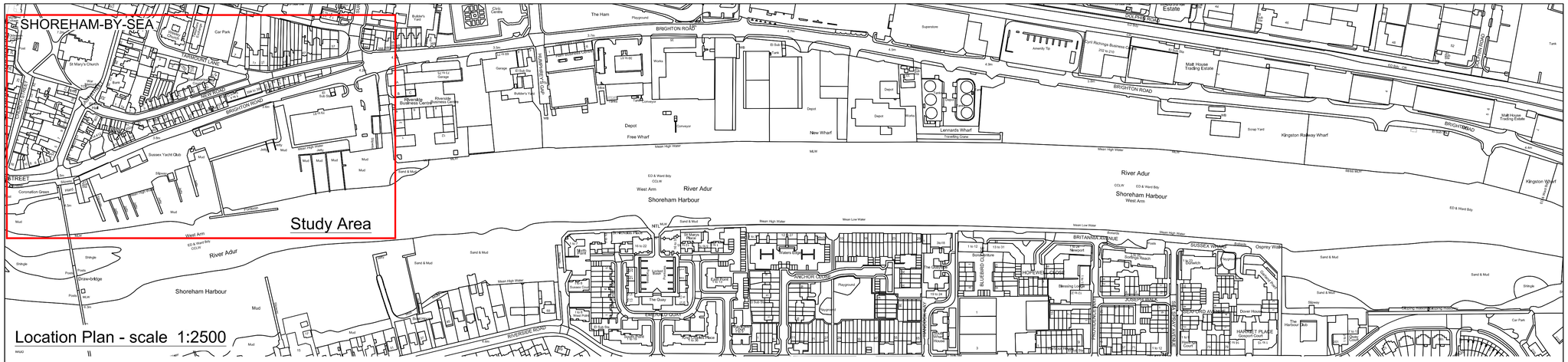
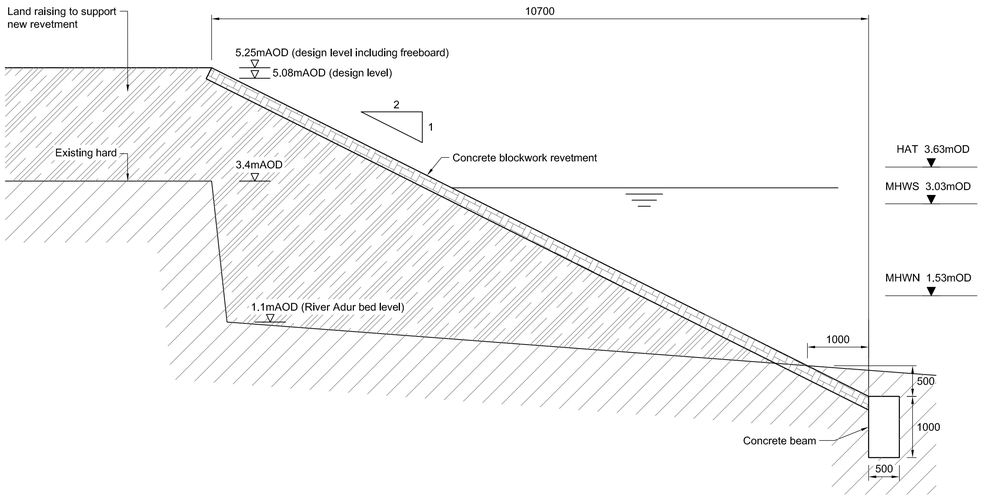
			Task workers	Other workers	Public	Environment				
4. Public Safety										
28	Walking on uneven ground	Slips, trips and falls			Y		N	Ground reinstated to a level surface following construction. No severe changes in level	Construction team to ensure all surface are reinstated appropriately	
29	Unauthorised climbing on defence wall	Falls from structure			Y		N	Defence walls to be a minimum of 1.1m above ground level to provide fall protection. If not possible then fences or other barriers should be erected. EA advised to consider warning signage	EA should consider installing warning signage	

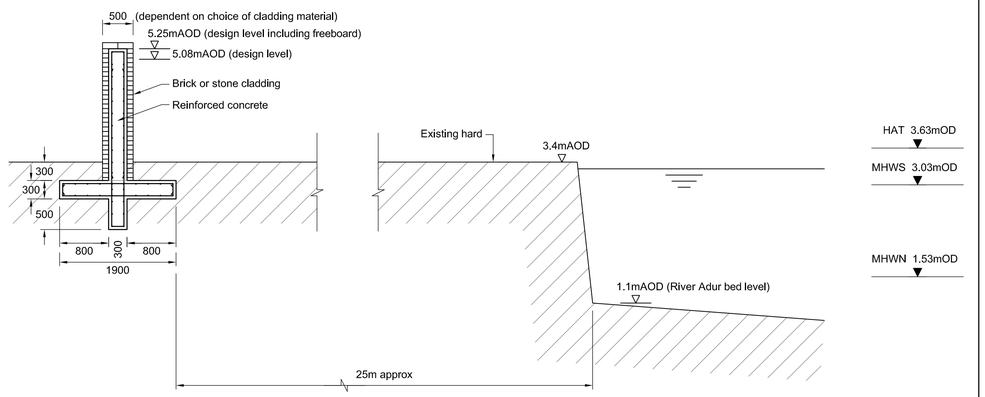
F Concept drawings



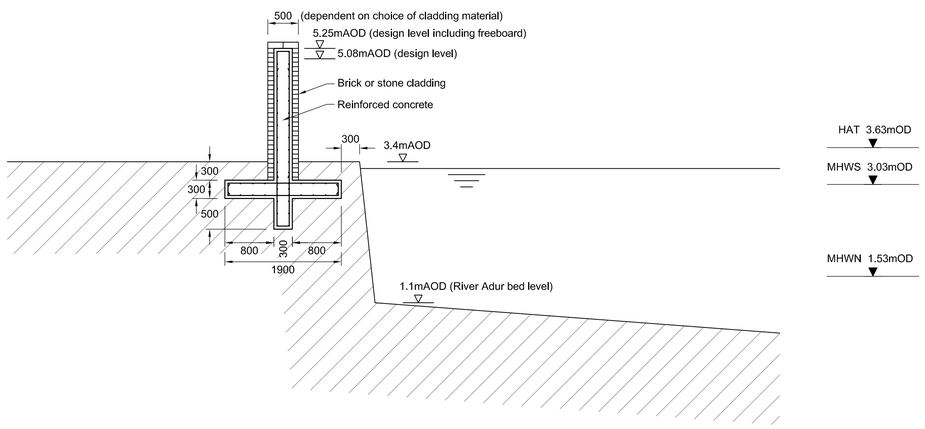
Location Plan - scale 1:2500



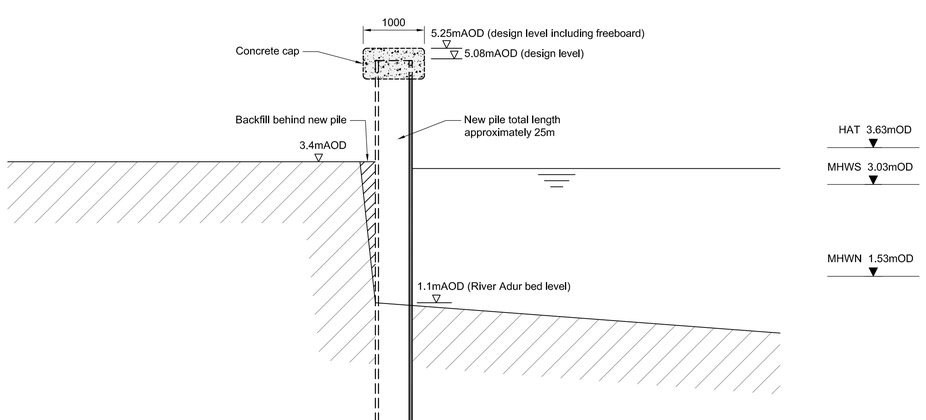
Option 1 - Concrete blockwork revetment scale 1:50



Option 2 - Flood wall, set back scale 1:50



Option 3 - Flood wall, on existing defence scale 1:50



Option 4 - Sheet piles in front of existing defence scale 1:50

General Notes

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5. The locations of any known services shown on drawing are approximate and for guidance only. The Contractor will confirm the location of any services prior to the commencement of any works.
6. The electronic model of this drawing is not to be used for setting out.

Hazards Summary

Construction & Operation:

- Working within a tidal environment
- Risk of contaminated land
- Detailed structural analysis to be completed for existing defences
- Noise and vibration during piling operations
- Unknown ground conditions
- Services information currently unknown
- Risk of flooding of works during construction

Environmental:

- Pollution hazards associated with working near an estuary
- Risk of damage to tidal habitat
- Risk of contaminated land entering tidal habitat

It is assumed that all works will be completed by a competent contractor and therefore all normal risks associated with construction works will be considered

DRAFT

Rev.	Modifications	Date	Drawn	Designed	Checked	Approved

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for

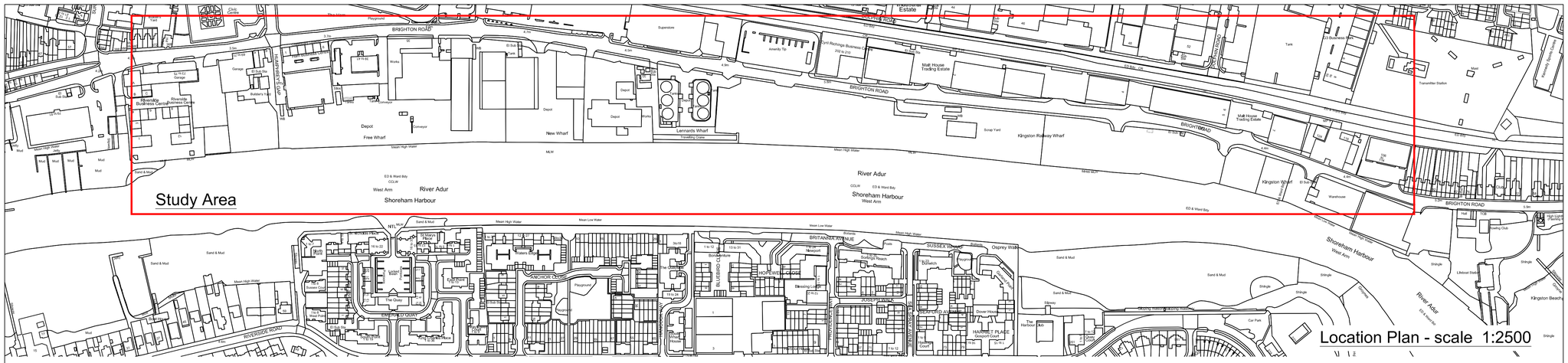
ADUR DISTRICT COUNCIL

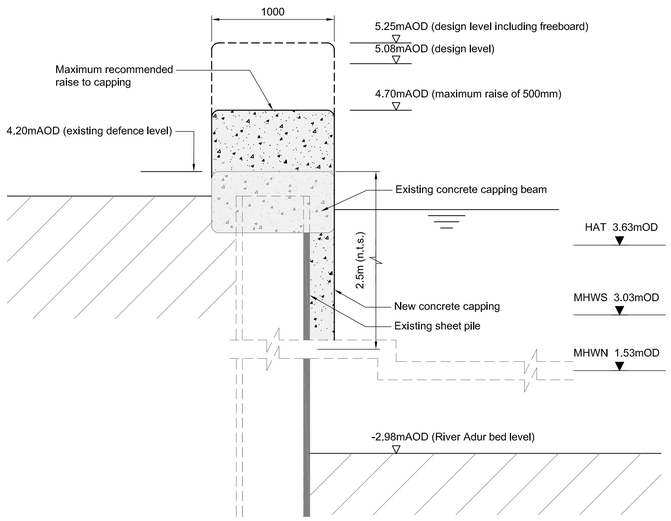
SHOREHAM HARBOUR
FLOOD RISK MANAGEMENT
SHOREHAM HARBOUR FOOTBRIDGE TO RIVERSIDE CENTRE

Scale: As shown @ A1	Drawn:	M.J. Skinner	29/4/14
	Designed:	T. Ash-Edwards	29/4/14
	Checked:	G. Kenn	7/5/14
	Approved:	M. Pinnell	7/5/14

Digital File Name: 2014s0848 - 001

Drawing Number:	Rev.:	Sheet No.:	Status:
2014s0848 - 001		1 of 1	Concept





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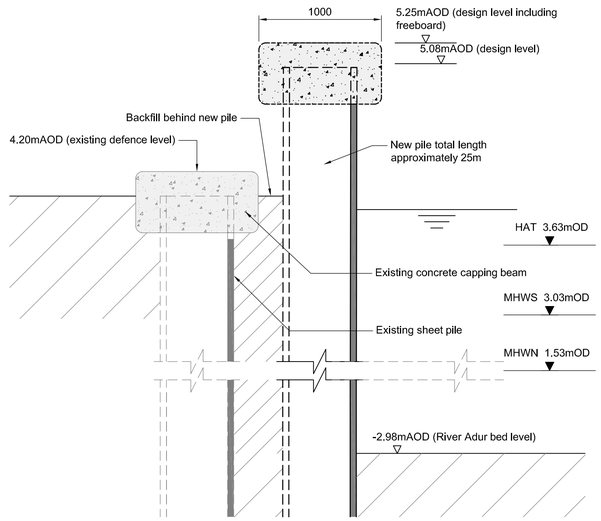

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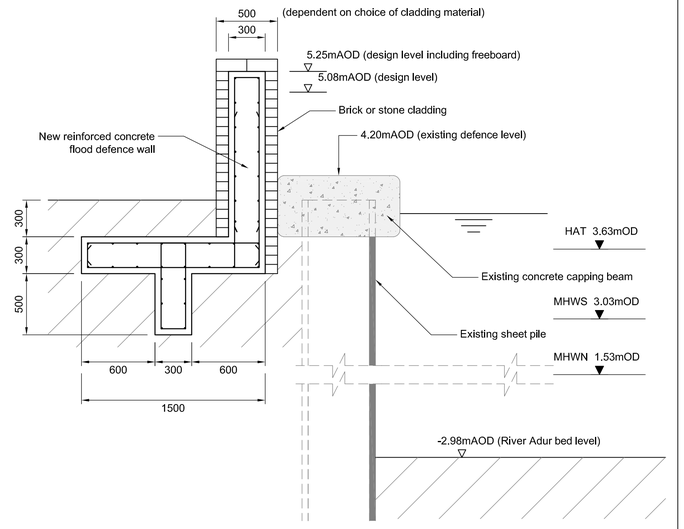
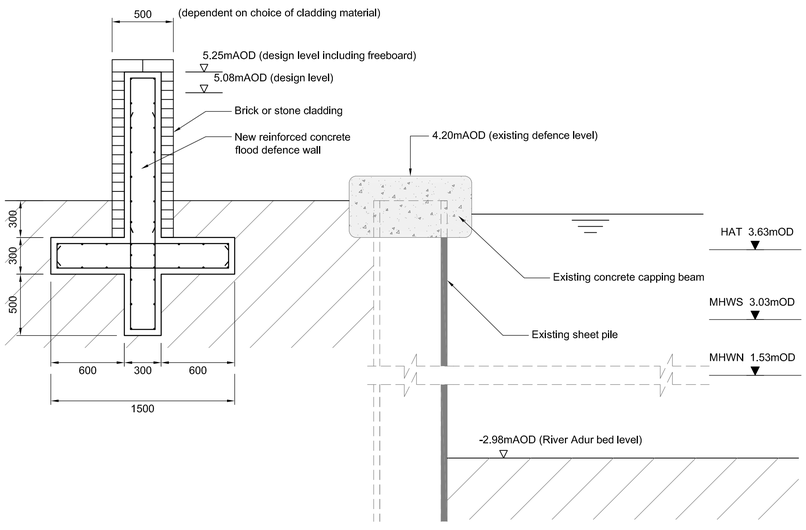
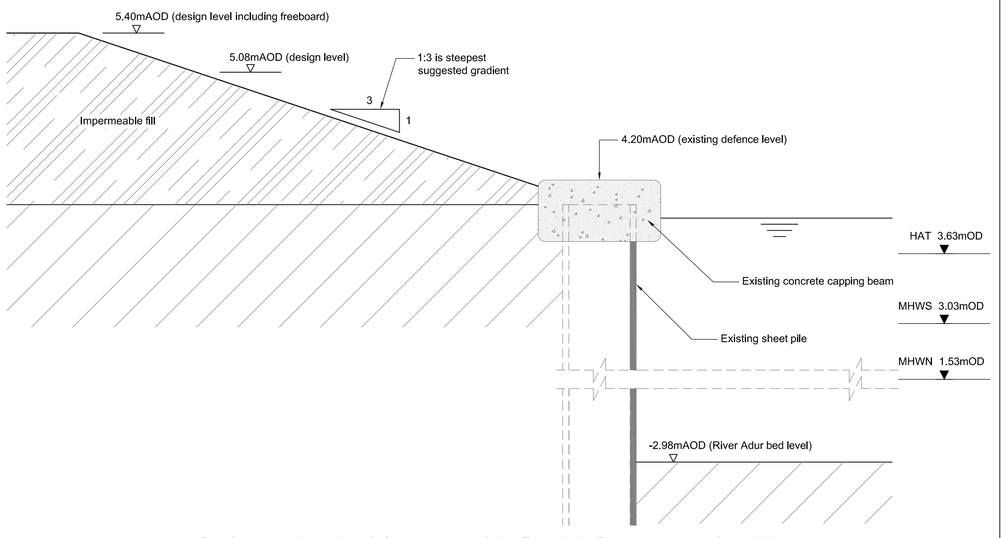


Option 3 - Flood wall on existing alignment scale 1:25



Option 4 - Flood wall, set back scale 1:25



Option 5 - Land raising to provide flood defence scale 1:25

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Hazards Summary

Construction & Operation:

- Working within a tidal environment
- Risk of contaminated land
- Detailed structural analysis to be completed for existing defences
- Noise and vibration during piling operations
- Unknown ground conditions
- Services information currently unknown
- Risk of flooding of works during construction

Environmental:

- Pollution hazards associated with working near an estuary
- Risk of damage to tidal habitat
- Risk of contaminated land entering tidal habitat

It is assumed that all works will be completed by a competent contractor and therefore all normal risks associated with construction works will be considered

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for

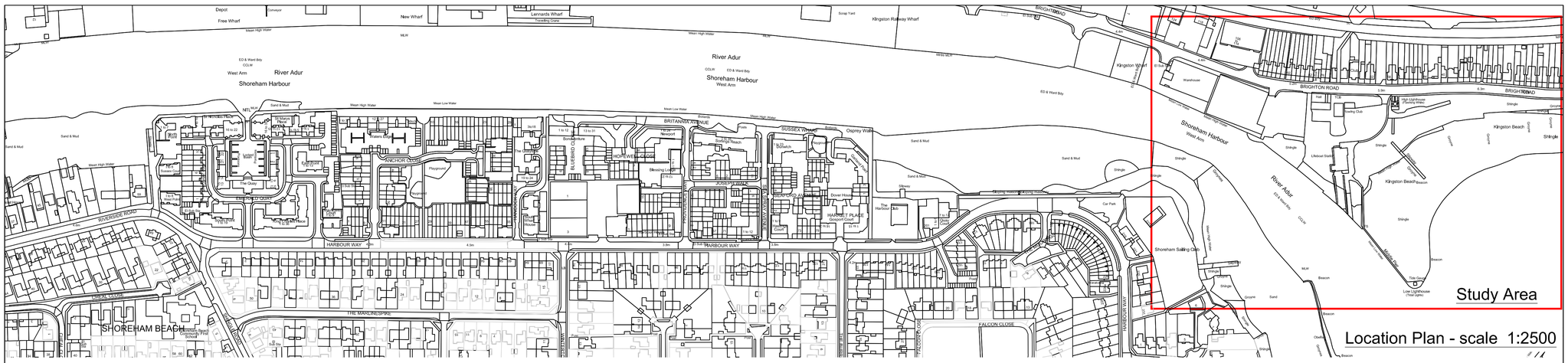
ADUR DISTRICT COUNCIL

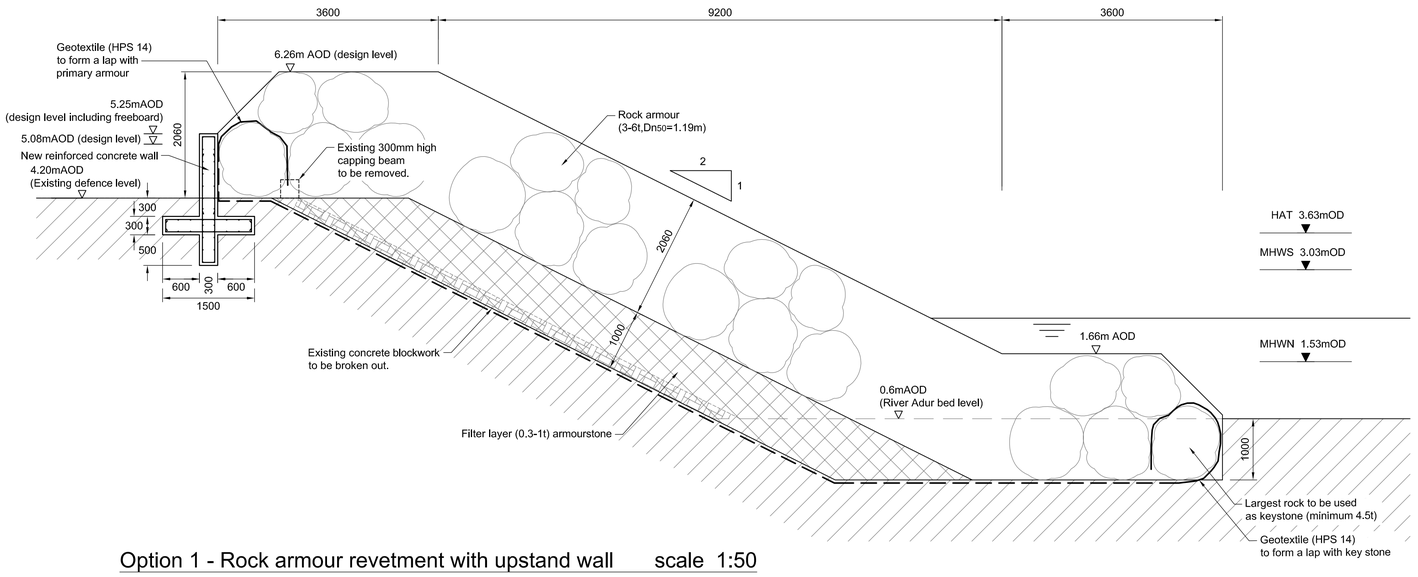
SHOREHAM HARBOUR
FLOOD RISK MANAGEMENT OPTIONS
RIVERSIDE CENTRE TO KINGSTON BEACH

Scale: As shown @ A1	Drawn:	M.J. Skinner	29/4/14
	Designed:	T. Ash-Edwards	29/4/14
	Checked:	G. Kenn	7/5/14
	Approved:	M. Pinnell	7/5/14

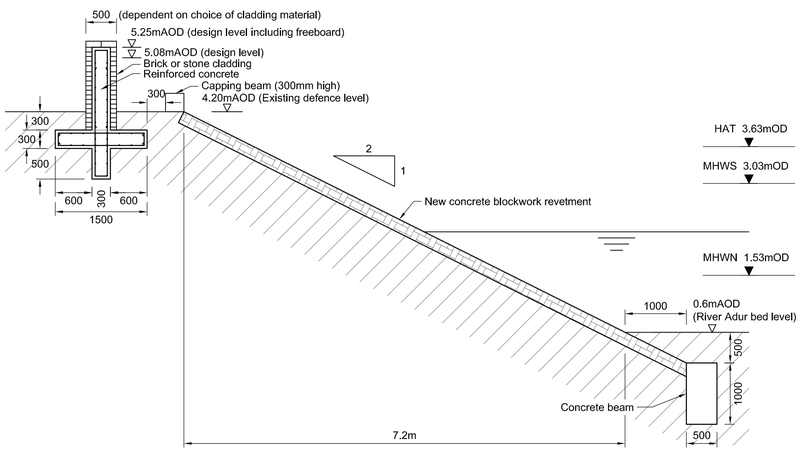
Digital File Name: 2014s0848 - 002

Drawing Number:	Rev.:	Sheet No.:	Status:
2014s0848 - 002		1 of 1	Concept

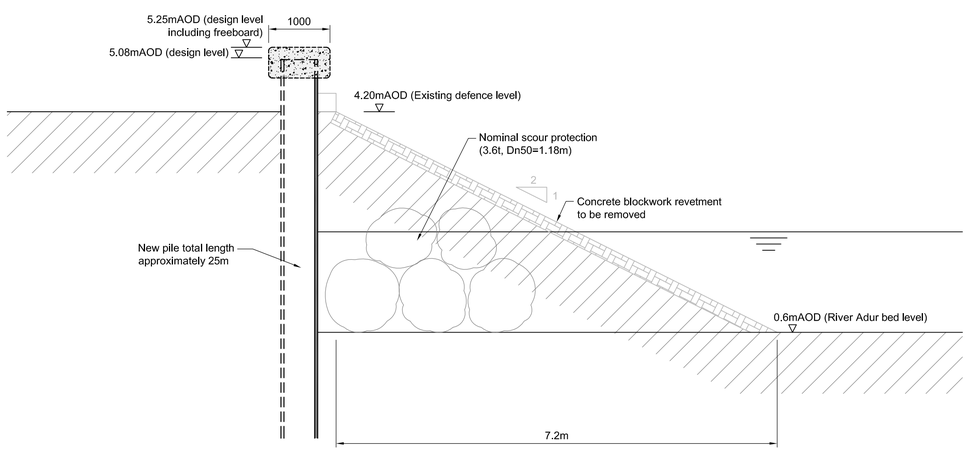




Option 1 - Rock armour revetment with upstand wall scale 1:50



Option 2 - New concrete blockwork revetment and flood wall scale 1:50



Option 3 - Sheet piles and removal of existing concrete blockwork revetment scale 1:50

General Notes

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Hazards Summary

Construction & Operation:

- Working within a tidal environment
- Risk of contaminated land
- Detailed structural analysis to be completed for existing defences
- Noise and vibration during piling operations
- Unknown ground conditions
- Services information currently unknown
- Risk of flooding of works during construction
- Risk of beach collapse

Environmental:

- Pollution hazards associated with working near an estuary
- Risk of damage to tidal habitat
- Risk of contaminated land entering tidal habitat

It is assumed that all works will be completed by a competent contractor and therefore all normal risks associated with construction works will be considered

DRAFT

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SHOREHAM HARBOUR
FLOOD RISK MANAGEMENT OPTIONS
KINGSTON BEACH

Scale: As shown @ A1	Drawn:	M.J. Skinner	29/4/14
	Designed:	T. Ash-Edwards	29/4/14
	Checked:	G. Kenn	7/5/14
	Approved:	M. Pinnell	7/5/14

Digital File Name: 2014s0848 - 003

Drawing Number:	Rev.:	Sheet No.:	Status:
2014s0848 - 003		1 of 1	Concept

G Cost estimation

Shoreham Harbour Flood Risk Management Technical Guidance
Cost estimation summary

Cost ranges of components

Component	EA long term costing tool [1]	
	Min (£/m)	Max (£/m)
Revetment	781	3,423
Backfill to support revetment [2]	1,138	1,138
Flood wall (height = 1.2 - 2.1m) [3]	2,144	3,660
Flood wall (height = 2.1 - 5.3m) [4]	2,848	5,382
Sheet piles (>100m length) [5]	1,416	3,854
Sheet piles (<100m length) [6]	4,508	16,835
Sacrificial anodes for sheet piles [7]	295	295
Raised pile capping (500mm raise) [8]	128	286
2.5m concrete cope on existing piles [9]	1,429	1,429
Land raise (1.5m raise) [10]	2,279	5,998
Rock armour [11]	1,621	7,206
Rock armour scour protection for sheet piles [12]	1,600	1,600

[1] Cost estimates other than from the EA long term costing tool are shown in blue
[2] Contractor cost estimate = £1,138, no EA cost available
[3] Spons cost estimate = £1,552
[4] Spons cost estimate = £2,220
[5] Average depth of piling in EA tool = 7m, whereas 22.5m depth used for contractor cost estimate = £8,525
[6] Average depth of piling in EA tool = 7m, whereas 22.5m depth used for contractor cost estimate = £8,525
[7] Contractor cost estimate = £295, no EA cost available
[8] Spons cost estimate = £128, contractor cost estimate = £286, no EA cost available
[9] Contractor cost estimate = £1,429, no EA cost available
[10] Spons cost estimate = £1,359, contractor cost estimate = £5,726
[11] Spons cost estimate = £5,661
[12] Contractor cost estimate = £1,600, no EA cost available
N.B . Spons costs do not include associated enabling works cost, therefore are lower estimates

Final cost range

Component	Final cost range	
	Min (£/m)	Max (£/m)
Revetment	781	3,423
Backfill to support revetment	1,138	1,138
Flood wall (height = 1.2 - 2.1m)	2,144	3,660
Flood wall (height = 2.1 - 5.3m)	2,848	5,382
Sheet piles	8,525	8,525
Sacrificial anodes for sheet piles	295	295
Raised pile capping (500mm raise)	128	286
2.5m concrete cope on existing piles	1,429	1,429
Land raise (1.5m raise)	2,279	5,998
Rock armour	1,621	7,206
Rock armour scour protection for sheet piles	1,600	1,600

Note on EA Long Term Costing Tool

Costs based on outturn costs from a large number of projects, for the purposes of flood risk management in England and Wales
The costs include associated works, temporary works and any other contractor variations, compensation events or delay costs
Prices from 2011; average 2.65% annual CPI (Source: ONS) used to calculate present day cost

Comparative cost of options

Frontage	Option	Components	Cost range	
			Min (£/m)	Max (£/m)
Adur Ferry Bridge to Riverside Business Centre	Concrete blockwork revetment	Revetment	781	3,423
		Backfill to support revetment	1,138	1,138
		TOTAL	1,919	4,561
	Flood wall, set back	Flood wall (height = 2.1 - 5.3m)	2,848	5,382
		TOTAL	2,848	5,382
	Flood wall, on existing defence	Flood wall (height = 2.1 - 5.3m)	2,144	3,660
		TOTAL	2,144	3,660
	Sheet piles in front of existing defence [1]	Sheet piles	8,525	8,525
		Sacrificial anodes for sheet piles	295	295
		TOTAL	8,820	8820
Riverside Business Centre to Kingston Beach	Raise existing pile capping *(Does not meet design criteria)*	Raised pile capping (500mm raise)	128	286
		2.5m concrete cope on existing piles	1,429	1,429
		Sacrificial annodes for sheet piles	295	295
		TOTAL	1,852	2010
	New sheet pile [1]	Sheet piles	8,525	8,525
		Sacrificial anodes for sheet piles	295	295
		TOTAL	8,820	8820
	Flood wall on existing alignment	Flood wall (height = 1.2 - 2.1m)	2,144	3,660
		2.5m concrete cope on existing piles	1,429	1,429
		Sacrificial annodes for sheet piles	295	295
		TOTAL	3,868	5384
	Flood wall, set back	Flood wall (height = 1.2 - 2.1m)	2,144	3,660
		2.5m concrete cope on existing piles	1,429	1,429
		Sacrificial annodes for sheet piles	295	295
		TOTAL	3,868	5384
	Land raising to provide flood defence - self supported without retaining wall	Land raise (1.5m raise)	2,279	5,998
		2.5m concrete cope on existing piles	1,429	1,429
		Sacrificial annodes for sheet piles	295	295
		TOTAL	4,003	7,722
Kingston Beach	Rock armour revetment with upstand wall	Rock armour	1,621	7,206
		Flood wall (height = 1.2 - 2.1m)	2,144	3,660
		TOTAL	3,765	10866
	New concrete blockwork revetment and flood wall	Revetment	781	3,423
		Flood wall (height = 1.2 - 2.1m)	2,144	3,660
		TOTAL	2,925	7083
	Sheet piles and removal of existing concrete revetment	Sheet piles	8,525	8,525
		Sacrificial annodes for sheet piles	295	295
		Rock armour scour protection	1,600	1,600
		TOTAL	10,420	10420

[1] Sheet piles would require local backfill between new and existing defences quantity to be determined; this has not been accounted for in costs

H Environmental Scoping Study

Shoreham Harbour Regeneration

Environmental Scoping Study

Final Report
July 2014

Adur District Council
Adur Civic Centre
Ham Road
Shoreham-by-Sea
West Sussex
BN4 6PR

JBA Project Manager

Marc Pinnell
JBA Consulting
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Revision history

Revision Ref / Date Issued	Amendments	Issued to
Draft v1 / 3 July 2014		Marc Pinnell
Final v1 / 3 August		Client

Contract

This report describes work commissioned by Adur District Council. Rachel Drabble and David Revill of JBA Consulting carried out this work.

Prepared by ..... Rachel Drabble BSc (Hons)
Environmental Consultant

Reviewed by..... David Revill BSc MSc CEnv MIES
Principal Environmental Consultant

Purpose

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Executive summary

The purpose of this environmental scoping study report is to identify potential significant environmental opportunities and constraints associated with the flood risk management (FRM) options for Western Harbour Arm (WHA) section of the Shoreham Harbour Regeneration project. Shoreham harbour is located at the mouth of the River Adur, approximately 80km south of London on the south coast of England, midway between Worthing and Brighton.

The Shoreham Harbour Regeneration project aims to create high-quality, mixed use developments and sustainable communities around a modern port. The regeneration is implemented by the Shoreham Harbour Joint Area Action Plan (JAAP). There are four key development opportunity areas within Shoreham Harbour identified in the JAAP (Shoreham Harbour Regeneration, 2014):

- Strategic Site 1 (SS1): Aldrington Basin
- Strategic Site 2 (SS2): South Portslade
- Strategic Site 3 (SS3): Southwick Waterfront
- Strategic Site 4 (SS4): WHA.

The focus of this environmental scoping study is the flood defence concept options for WHA (SS4), the largest of the strategic sites. Three main FRM options have been considered:

- Raising of existing defences;
- Construction of a new line of defences (either set forward of, on top of, or backward from existing defences);
- Raising of existing land.

A desk study was carried out to obtain baseline environmental information on key environmental features that have the potential to be affected by the project. Information was collected through a literature review and from online sources.

A high-level qualitative appraisal of the flood risk management options was undertaken to identify potential significant environmental impacts (positive and negative). The outcomes of this process have been summarised in appraisal matrices, which identifies the environmental features that have the potential to be affected by each of the project options and the potential significance of the effects identified. This report also outlines the potential scope of the environmental surveys and studies that would be required as part of the subsequent environmental assessment process should the project be taken forward to through the consenting process.

Options 1.1, 1.4 and 3.1 would cause the permanent loss of inter-tidal Biodiversity Action Plan (BAP) habitats and would be likely to have the greatest long term impact on these areas due to the risk of sea level rise causing coastal squeeze. Option 2.2 will also extend the defence line seaward and has the potential to cause coastal squeeze. Such impacts would in turn have the potential to adversely affect the special interest of the Adur Estuary SSSI (Options 1.1 and 1.4) and would conflict with a wide range of legislation and strategic objectives focused on the protection and enhancement of such sites. These potential impacts are closely linked to the Water Framework Directive (WFD) objectives for the waterbody and as such, it is possible that all of the options could conflict with achieving these objectives.

Each of these options could also cause a range of landscape and visual impacts affecting local landscape character, historic features and important views in Shoreham. Option 1.1 in particular, which involves large revetment structure extending into the estuary and associated ground raising behind could have a significant adverse impact on landscape character and could affect the setting of Shoreham Conservation Area.

Option 2.4 would involve setting the flood defence line landward and this could have a range of benefits; most notably in terms of reducing the future impacts of coastal squeeze and potentially through a positive contribution to local landscape character.

The construction programme should take the local community and economy into consideration as it could provide disruption, thus having a temporary negative effect. Each of these options is also likely to lead to a range of environmental benefits. The new defences would increase protection for people and property in Shoreham and could reduce flood risk to sensitive historic sites such as listed buildings in the town centre. The defences would reduce the impacts of sea level rise caused

by climate change on these aspects and would also make a positive contribution to the local economy by reducing the risk of flooding to the town.

Contents

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Abbreviations

AOD ..... Above Ordnance Datum
AQMA ..... Air Quality Management Area
BAP ..... Biodiversity Action Plan
BOA ..... Biodiversity Opportunity Area
CRoW Act 2000 ..... Countryside and Rights of Way Act 2000
EIA ..... Environmental Impact Assessment
EcIA ..... Ecological Impact Assessment
FRM ..... Flood Risk Management
GEP ..... Good Ecological Potential
GVZ ..... Groundwater Vulnerable Zone
HSI ..... Habitat suitability index
IEEM ..... Institute of Ecology and Environmental Management
JAAP ..... Shoreham Harbour Joint Area Action Plan
JNCC ..... Joint Nature Conservation Committee
LCA ..... Landscape Character Area
LNR ..... Local Nature Reserve
LVIA ..... Landscape and Visual Impact Assessment
MAGIC ..... Multi-Agency Geographic Information for the Countryside
MMO ..... Marine Management Organisation
NCA ..... National Character Area
NERC ..... Natural Environment and Rural Communities Act 2006
NPPF ..... National Planning Policy Framework
NVZ ..... Nitrate Vulnerable Zone
PEA ..... Preliminary Ecological Appraisal
RBMP ..... River Basin Management Plan
RSPB ..... Royal Society for the Protection of Birds
SAC ..... Special Area of Conservation
SEO ..... Statement of Environmental Opportunity
SNCI ..... Sites of Nature Conservation Interest
SPA ..... Special Protection Area
SPEC ..... Species with European Conservation Concern
SPZ ..... Source Protection Zone
SS1 ..... Strategic Site 1
SS2 ..... Strategic Site 2
SS3 ..... Strategic Site 3
SS4 ..... Strategic Site 4
SSSI ..... Site of Special Scientific Interest
UK BAP ..... United Kingdom Biodiversity Action Plan
UKCP09 ..... UK Climate Projections

WFD..... Water Framework Directive

WHA..... Western Harbour Arm

WHO ..... World Health Organisation

1 Introduction

1.1 Purpose of this report

The purpose of this environmental scoping study report is to identify potential significant environmental opportunities and constraints associated with the flood risk management (FRM) options for the Western Harbour Arm (WHA) section of the Shoreham Harbour Regeneration project. The report contains a description of the local baseline environment and identifies notable environmental features in the study area that have the potential to be affected by the proposed FRM options. Information has been obtained through a desk study exercise undertaken using readily available data sources. Consultation has been undertaken with several organisations that hold information of relevance to this review. This information was then used to appraise the potential environmental benefits and impacts associated with the FRM options.

This report also outlines the potential scope of the environmental surveys and studies that would be required as part of the subsequent environmental assessment process should any of the FRM options be taken forward to through the consenting process, together with the likely planning and environmental consenting requirements of relevance.

In summary, this report covers the following aspects:

- Identifies the existing key baseline environmental conditions of the study area;
- Appraises the potential significant environmental impacts of the FRM options on notable environmental features;
- Sets out further environmental assessment work required FRM options be taken forward into the design phase and
- Identifies the organisations that would need to be consulted with to inform the detailed design phase.

1.1.1 Limitations

This commission does not include the preparation of any formal Environmental Impact Assessment (EIA) or carrying out any environmental site surveys. All information used in this review has been obtained from a desk study exercise incorporating readily available online data sources, a literature review and through information provided by Adur District Council.

1.2 Project description

The Shoreham Harbour Regeneration project aims to create high-quality, mixed use developments and sustainable communities around a modern port. The regeneration proposals are implemented by the Shoreham Harbour Joint Area Action Plan (JAAP), which has been developed by Adur District Council, Brighton & Hove City Council and West Sussex County Council. The JAAP sets out a 15 to 20 year plan to guide the regeneration of Shoreham Harbour (Shoreham Harbour Regeneration, 2014), and provides the framework and guidelines for developers. There are four key development opportunity areas within Shoreham Harbour identified in the JAAP (Shoreham Harbour Regeneration, 2014):

- Strategic Site 1 (SS1): Aldrington Basin
- Strategic Site 2 (SS2): South Portslade
- Strategic Site 3 (SS3): Southwick Waterfront
- Strategic Site 4 (SS4): WHA.

The focus of this environmental scoping study is a series of flood defence concept options identified for the WHA (SS4), which is the largest of the four key development opportunity areas. These FRM options are set out in detail in the *Shoreham Harbour Flood Risk Management Guide – Technical Report* (JBA Consulting, 2014), to which this study forms a technical

appendix. The WHA represents the greatest challenge pertaining to flood risk of all the strategic sites in Shoreham Harbour (JBA Consulting, 2014).

The JAAP requires the WHA to become an area of sustainable, mixed-use development. Development proposals for the WHA should also deliver a comprehensive flood defence solution integrated with a publically accessible riverside route including pedestrian/cycle way and facilities for boat users. Three main FRM options have been considered:

- Raising of existing defences;
- Construction of a new line of defences (either set forward of, on top of, or backward from existing defences); and
- Raising of existing land.

To enable suitable development of concept flood defence options, the WHA has been divided into three frontages based on the character of its existing defences (see Figure 1-1). These are:

- Adur Ferry Bridge to Riverside Business Centre – revetments provide the defence with hards and slipways allowing for access to the water. A short section of piles can be found at the former Parcelforce site.
- Riverside Business Centre to Kingston Beach – steel sheet pile wall, with concrete coping, provides the defence
- Kingston Beach – blockwork revetment and tetrapod protection provide the defence.

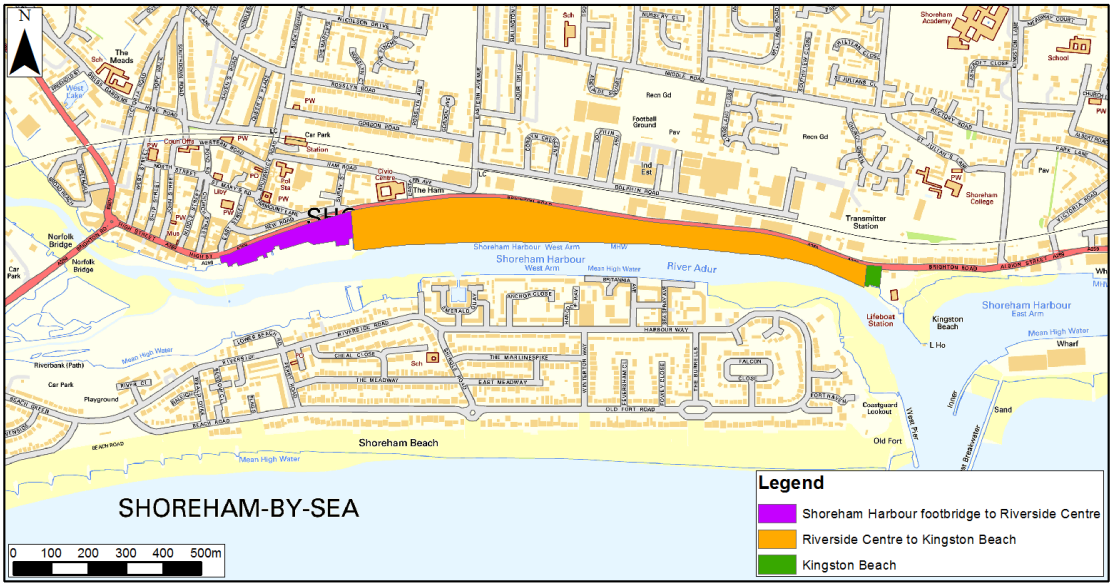

Figure 1-1: Map showing the three frontages of the Western Harbour Arm (contains Ordnance Survey data © Crown copyright and database right 2013)

Figure 1-1 shows the entire development area of the WHA as identified in the JAAP. However, this study only considers the works necessary to deliver the flood defence options developed for these areas. It does not consider the wider development proposals for the WHA.

A total of 12 concept flood defence options have been developed, which are described further in Section 3. These options are based on the following types of flood defences:

- Piling;
- Revetments;
- Reinforced concrete flood walls; and
- Land raising.

1.3 Study area

The Adur District forms part of the coastal plain of West Sussex. The South Downs National Park borders the area to the north, with the sea to the south (Sheilsflynn, 2012). The River Adur cuts through the chalk downlands, before curving across the coastal plain to meet the sea at Shoreham.

Shoreham harbour is located at the mouth of the River Adur, approximately 80km south of London on the south coast of England, midway between Worthing and Brighton. The harbour stretches for five kilometres of waterfront bounded to the north by the A259 south coast road, the West Coastway railway line and the coastal communities of Shoreham-by-Sea, Kingston-by-Sea, Southwick, Fishersgate, South Portslade and Hove.

The harbour has an important economic role in the area as an operational port. There is a strong commitment from the local authorities (Adur District Council, Worthing Borough Council and Brighton & Hove City Council) to realise the economic opportunities offered by the harbour area and as such Shoreham Harbour has been identified as a 'Broad Location' for change in both the Adur Local Plan and the neighbouring Brighton & Hove City Plan (Allies and Morrison, 2013).

From the mouth of the River Adur, the WHA section of the harbour extends for approximately 2km along the northern bank of the estuary to the west as far as Shoreham Harbour Footbridge, which crosses the river and connects Shoreham-by-Sea town centre to Shoreham Beach. To the east of this, the harbour extends for approximately 4km to the Aldrington Basin (the Eastern Arm).

The study area for this scoping study focused on the WHA and a search area of 500m around this area. The exception to this search buffer area was for biodiversity, as described in Section 2.1.

1.4 Sources of information

A desk study was carried out to obtain baseline environmental information on key environmental features that have the potential to be affected by the proposed flood defence concept options.

Where available, information has been collected in relation to the following topic areas:

- Biodiversity and nature conservation;
- Historic environment
- Water quality and water resources
- Landscape and visual amenity
- Contaminated land
- Population
- Recreation and amenity.

The following online information sources were searched for relevant information:

- Multi-Agency Geographic Information for the Countryside (MAGIC) (http://www.magic.gov.uk/)
- English Heritage, Heritage Gateway (http://www.heritagegateway.org.uk/gateway/)
- Adur Revised Draft Local Plan 2013 (http://www.adur-worthing.gov.uk/adur-local-plan-consultation/2013-consultation/)
- Ancient Monuments (http://www.ancientmonuments.info)
- Joint Nature Conservation Committee (JNCC) (http://jncc.defra.gov.uk/page-162)

- Adur & Worthing Councils Planning Services website, (http://www.adur-worthing.gov.uk/planning/applications/view/)
- Environment Agency - What's in your backyard? (http://apps.environment-agency.gov.uk/wiyby/default.aspx)
- Natural England (http://www.naturalengland.org.uk/).

A literature review was also undertaken to obtain published information of relevance to the project. The following are the key documents used:

- Revised Draft Adur Local Plan (Adur District Council, 2013)
- Shoreham Harbour Western Arm Development Brief (Allies and Morrison, 2013)
- River Basin Management Plan South East River Basin District (Environment Agency, 2009a)
- Shoreham Harbour Flood Risk Management Technical Guidance Annex to Flood Risk Management (JBA Consulting, 2014)
- Western Harbour Arm Development Brief Sustainability Appraisal and Strategic Environmental Assessment Consultation Draft (Shoreham Harbour Regeneration, 2013)
- Shoreham Harbour Joint Area Action Plan Draft for Consultation (Shoreham Harbour Regeneration, 2014).

Consultation was also undertaken with the following organisations to obtain information of relevance to this project:

- West Sussex Council - Environmental and Heritage
- Adur District Council - Technical Services.

1.5 Potential environmental benefits and impacts appraisal

A high-level qualitative appraisal of the flood risk management options was undertaken to identify potential significant environmental impacts (positive and negative). The outcomes of this process have been summarised in a series of appraisal matrices (see Section 4), which identify the environmental features that may be affected by each of the flood defence options and the potential significance of the effects identified.

2 Baseline review

This chapter provides a summary of the protected and notable environmental features present in the study area. It includes important flora and fauna, heritage features and aspects of the environment including water quality, landscape character and quality, recreation and amenity value.

2.1 Biodiversity and nature conservation

A desk study search was undertaken to identify the presence of sensitive species and habitats in the study area. This includes a search of Natural England website for designated nature conservation sites. The general study area used to inform this information search was 2km, which was extended to 10km in relation to internationally and nationally designated sites.

2.1.1 Statutory designated sites

There are no European designated sites (Special Areas of Conservation (SAC), Special Protection Areas (SPA) or Ramsar sites) within 10km of the WHA. The closest SAC is the Castle Hill SAC, located approximately 13km to the east of the WHA, whilst the closest SPA and Ramsar site are the Arun Valley (also designated a SAC), which is 20km to the north west.

The Adur Estuary Site of Special Scientific Interest (SSSI) borders the WHA development area (see

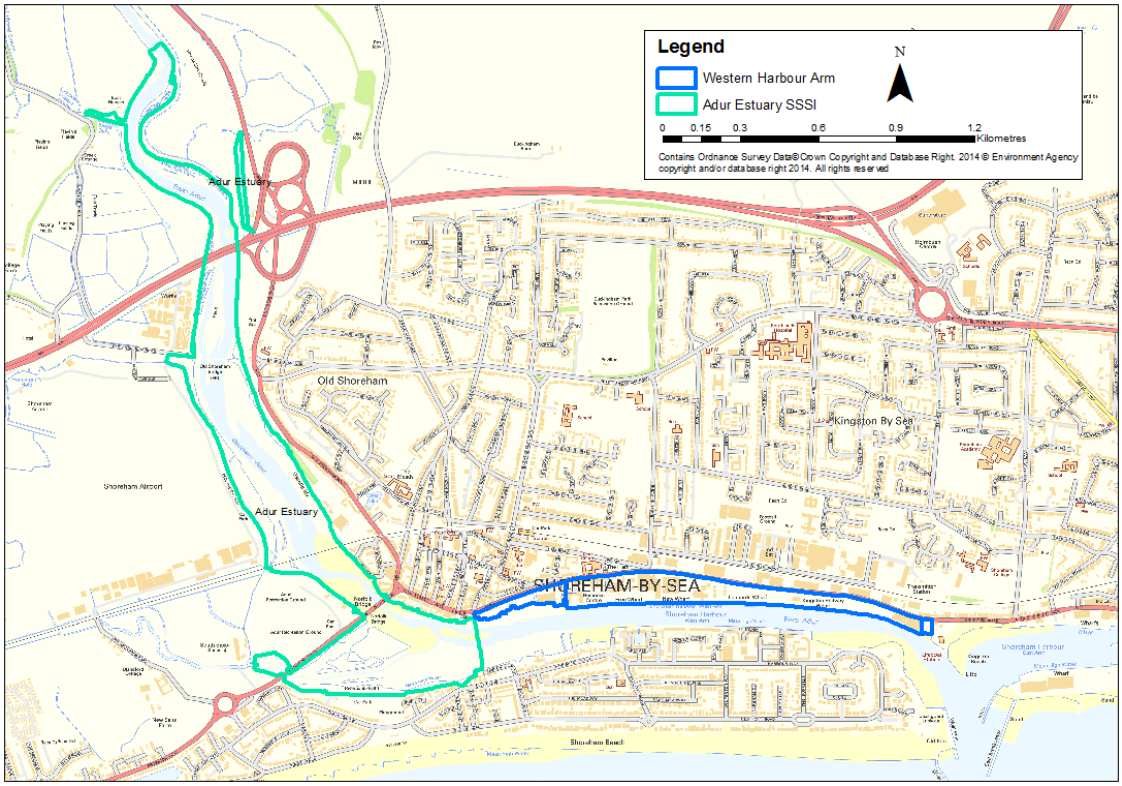

Figure 2-1). Together with Rye Harbour further to the east, the Adur Estuary represents the only significant area of saltmarsh between Chichester and Pagham Harbours in West Sussex and Sandwich Bay in Kent (Natural England, 1987). In addition, the estuarine plant communities within the SSSI are unusual due to the relative scarcity of cord-grass, *Spartina spp*. The SSSI also contains a large area of intertidal mudflats within the estuary, which is important for a variety of wading birds, and is considered to be of national importance for the Ringed Plover *Charadrius hiaticula* (Shoreham Harbour Regeneration, 2014). Numbers of the Ringed Plover regularly exceed 1% of the total British population (Natural England, 1987). Within the SSSI, the estuary embankment close to the Shoreham Toll Bridge (over 1.5km

upstream of Shoreham Harbour footbridge) supports a large colony of viviparous lizards, *Lacerta vivipara* (Natural England, 1987).

SSSIs are protected under a range of UK legislation. Section 28G of the Wildlife and Countryside Act 1981 (as amended) states that public bodies (including local authorities) must *'take reasonable steps, consistent with the proper exercise of their functions, to further the conservation and enhancement of SSSIs'*. This protection is extended under the Countryside and Rights of Way Act 2000 (CRoW Act 2000), which places a duty on Government Departments to have regard for the conservation of biodiversity and includes provisions to further the conservation and enhancement of SSSIs. In addition, the Natural Environment and Rural Communities Act (NERC) 2006 states that *'Every public authority must, in exercising its functions, have regard, so far as is consistent with the proper exercise of those functions, to the purpose of conserving biodiversity.'*

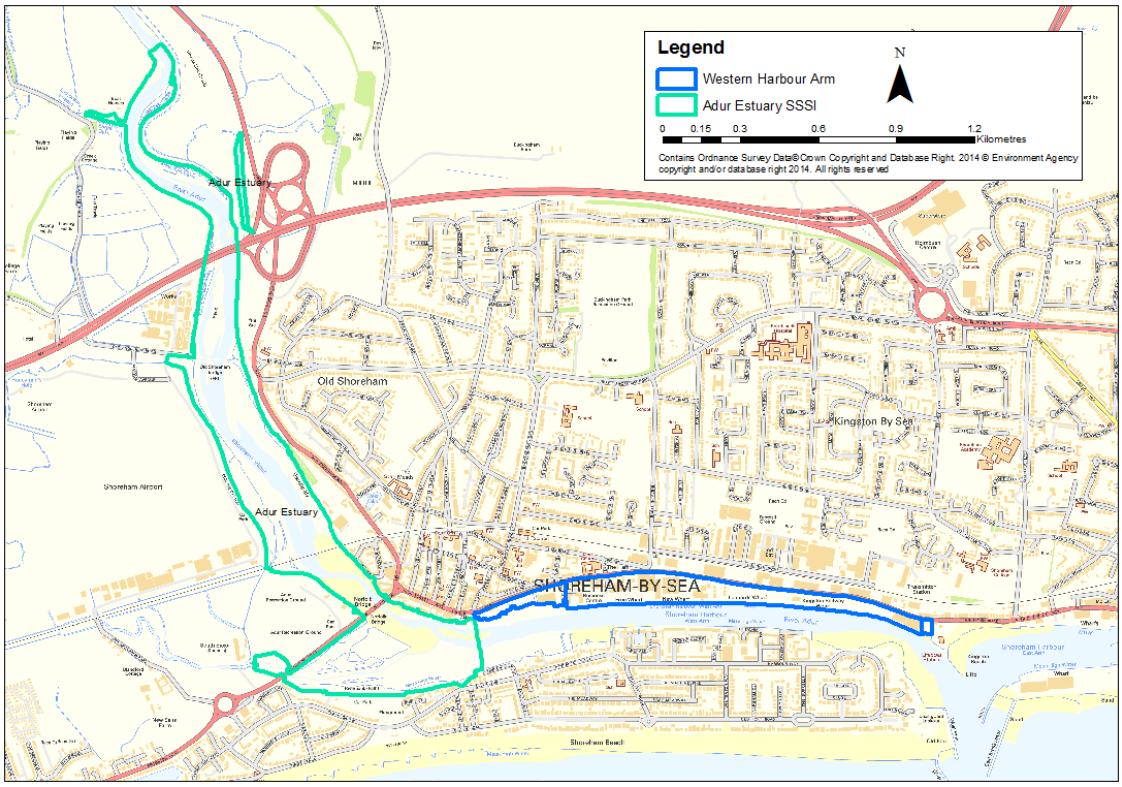

Figure 2-1: Location of the Adur Estuary SSSI

The Adur Estuary management plan includes a list of operations identified as likely to damage the special interest of the site. Relevant operations identified include the following:

- Erection of sea defences or coast protection works, including cliff or landslip drainage or stabilisation measures.
- Modification of the structure of watercourses (e.g. rivers, streams, springs, ditches, dykes, drains), including their banks and beds, as by re-alignment, re-grading and dredging.
- Management of aquatic and bank vegetation for drainage purposes.
- Reclamation of land from sea, estuary or marsh.
- Construction, removal or destruction of roads, tracks, walls, fences, hardstands, banks, ditches or other earthworks, or the laying, maintenance or removal of pipelines and cables, above or below ground.

- Erection of permanent or temporary structures, or the undertaking of engineering works, including drilling.
- Use of vehicles or craft likely to damage or disturb features of interest.

The Adur Local Plan (Adur District Council, 2013) highlights the importance of the SSSI for biodiversity and as a key area of green infrastructure. The Plan provides protection for the site and identifies that proposed development that would adversely affect a SSSI will not normally be permitted, with exceptions only where the benefits of the development clearly outweigh the impacts that it would have on the features of the SSSI (Adur District Council, 2013). The Plan also identifies the threat that climate change and sea level rise represents to the SSSI. It states that *'Over the next twenty years coastal squeeze is likely to result in the loss of a significant amount of intertidal flats and saltmarsh. This is an issue for Adur due to its coastal location, the Adur Estuary SSSI and the compact nature of the district. New development that could result in further coastal squeeze will need to demonstrate how it is addressing this issue.'*

'Coastal squeeze' is defined as intertidal habitat loss which arises due to the high water mark being fixed by a defence and the low water mark migrating landwards in response to sea level rise (ScienceDirect, 2014).

2.1.2 Local designated sites

Shoreham Beach and Basin Road South are designated as Sites of Nature Conservation Importance (SNCI) and Local Nature Reserves (LNR). SNCIs are non-statutory areas of local importance for nature conservation that complement national and internationally designative geological and wildlife sites, as selected by the local authority. LNRs are designated statutorily under Section 21 of the National Parks and Access to the Countryside Act 1949, and amended by Schedule 11 of the Natural Environment and Rural Communities Act 2006, by principal local authorities.

Basin Road South SNCI/LNR is located at the eastern end of Shoreham Harbour, approximately 3km east of the WHA. Shoreham Beach lies approximately 600m south of the WHA. Both areas contain vegetated shingle habitat, which is a nationally rare habitat type listed on Annex 1 of the EC Habitats Directive as a habitat of international conservation importance (Halcrow, 2014). These sites are considered to be of high ecological value at district level and are an important habitat for a diverse range of rare plants. Shoreham Beach represents an important high tide roosting area for wading birds that have fed on the mudflats within the Adur Estuary SSSI (Morgan, 2006). Both areas are also known to contain several reptile species, including the protected slow-worm *Anguis fragilis* and viviparous lizards *Lacerta vivipara*.

Both sites have been identified as particularly vulnerable to damage due to trampling (Shoreham Harbour Regeneration, 2014) and are likely to be sensitive to changes in coastal processes.

The Adur Estuary RSPB reserve is located on the opposite side of the estuary to the WHA area, to the east of Norfolk Bridge. The reserve comprises saltmarsh and mudflat habitat and provides feeding and roosting areas for waders and wildfowl.

2.1.3 Biodiversity Action Plan habitats and species

A search of the MAGIC online database identified a number of Biodiversity Action Plan (BAP) habitats in the study area. These are habitats identified as being the most threatened and requiring priority conservation action under the UK Biodiversity Action Plan (UK BAP).

Mudflat habitat is present along both sides of the Adur Estuary through the study area. This includes the section of foreshore adjacent to the Shoreham Harbour Footbridge to Riverside Centre section of the WHA. Made ground is also present within several sections of the river channel.

Sand and gravel beds are present at the mouth of the river, bordering the Kingston Beach section of the WHA. This BAP habitat also runs in both directions along the coastline.

A significant area of coastal and floodplain grazing marsh is present adjacent to the southern side of the estuary, to the west of the WHA. The WHA is also bordered by grassland BAP habitat, which covers the entire Shoreham spit, Shoreham Beach and the estuary up to the northern river shoreline. In addition, Shoreham Beach is covered by a coastal vegetated shingle habitat.

BAP species identified in the study area include Corn Bunting *Emberiza calandra*, Grey Partridge *Perdix perdix*, Lapwing *Vanellus vanellus*, Redshank *Tringa totanus* and Turtle Dove *Streptopelia turtur*.

All public bodies have a duty to protect and promote BAP habitats and species and their conservation is a material planning consideration. Local Planning Authorities should aim to conserve and enhance biodiversity, as stated by the National Planning Policy Framework (NPPF) (Adur District Council, 2013). In accordance with the Revised Draft Adur Local Plan (Adur District Council, 2013), all new developments are required to take account of and incorporate biodiversity features at the design stage.

In addition, the Local Plan lists the Adur Estuary and Shoreham Beach as Biodiversity Opportunity Areas (BOA). BOAs are regional priority areas of opportunity for restoration and creation of BAP habitats and are a spatial representation of the BAP targets and area. BOAs also represent the targeted landscape-scale approach to conserving biodiversity in Sussex and the basis for an ecological network, with BAPs targeting BOAs (Sussex Biodiversity Partnership, 2009).

The Adur Local Plan (Adur District Council, 2013) also states that *'New development that could result in further coastal squeeze will need to demonstrate how it is addressing this issue.'* Revised Draft Policy 31: Biodiversity states that:

'All development should ensure the protection, conservation, and where possible, enhancement of biodiversity.' and

'If significant harm cannot be avoided (by locating on an alternative site with less harmful impacts), adequately mitigated, or compensated for, then planning permission should be refused.'

2.1.4 Protected and notable species

A reptile survey conducted on the northern edge of Shoreham Harbour's Eastern Arm in 2009 indicated the presence of an exceptional population of viviparous lizards and a significant population of slow-worm south of the A259 (Shoreham Harbour Regeneration, 2014).

A Great Crested Newt *Triturus cristatus* Habitat Suitability Index (HSI) survey undertaken in 2009 concluded that due to a general lack of ponds and standing water bodies within the Shoreham Harbour area, there is a negligible risk of an impact on this protected species (Shoreham Harbour Regeneration, 2014).

A range of notable bird species are known to frequent the inter-tidal habitats in the Adur estuary. These include over-wintering and wading bird species including Ringed Plover, Dunlin *Calidris alpina,* Redshank, Oystercatcher *Haematopus ostralegus* and Lapwing. The Adur Estuary SSSI citation states that *'The number of ringed plover regularly exceed 1% of the total British population, making the estuary of national importance for this species.'*

Dunlin and Lapwing has been classified as having 'red' status by the Royal Society for the Protection of Birds (RSPB) (RSPB, 2014), meaning that they are globally threatened and have experienced a historic population decline in the UK. Red species are the highest conservation priority, requiring urgent action. Ringed Plover, Oystercatcher and Redshank are categorised as 'amber' species, meaning they have an unfavourable conservation status and have experienced historic population decline in the UK, although the population is now recovering (RSPB, 2013).

The Adur estuary is also notable for its shellfish populations, with both Mussels *Mytilus edulis* and Cockles *Cerastoderma edule* collected from Adur and Worthing beaches, although there are no designated shellfisheries in the area. In addition, the river supports a wide range of fish species including Flounders, Eels, Grey Mullet, Sand Smelt and Bass, present in the estuary

during summer and autumn, and Tench, Bream, Carp, Chub, Roach and Rudd present upstream in the freshwater river. Sea Trout are also known to migrate through the estuary to spawning grounds in the catchment headwaters (Ouse and Adur River Trust, 2014).

2.2 Historic environment

Historic features within close proximity to the project have the potential to be impacted by the project either due to direct impacts on the fabric of the structure or due to changes to its setting. A search was undertaken to identify these sites, including for designated sites such as Scheduled Monuments and listed buildings and for local historic sites and features.

Information for this study was obtained from English Heritage, West Sussex Council and other online databases (see Section 1.4).

The settlement of Old Shoreham dates back to pre-Roman times, with the name Shoreham being of Saxon origin. The town and port (referred to as New Shoreham) was established by the Normans towards the end of the 11th Century. Shoreham High Street is likely to be the surviving part of a road that followed the coast line east in the Middle Ages. Shoreham High Street runs to the Brighton Road Bridge roundabout from Old Shoreham Road. After the roundabout, the High Street in an east south east direction for approximately 300m following the estuary shoreline until the Shoreham Harbour footbridge, which borders the western boundary of the WHA. From this footbridge, the High Street becomes Brighton Road, forming the northern border of the WHA. Damage from waves from the south west eroded much of the east end of the town south of the High street (Adur District Council, 2008).

2.2.1 Scheduled monuments

There are two scheduled monuments within 500m of the WHA (see Figure 2-2). The closest is The Marlipins, which is also designated a Grade II* listed building. The site is located approximately 115m to the west of the WHA area and comprises a 12th century building constructed mainly of stone and flint with a distinctive chequered pattern (Adur District Council, 2008). Intervening urban development prevents a view of the monument from the WHA area.

Figure 2-2: Scheduled monuments and listed buildings and within 500m of the WHA

Shoreham Fort is located approximately 300m south of the WHA. The fort was built in 1857 and is an important example of experimental fortification using a Carnot Wall, which is an unusual type of loop-holed wall. Views of the monument are possible from the eastern end of the WHA.

The next closest scheduled monument is a Romano-British villa located 1.2km to the northeast of the WHA in Southwick. Again, this monument is screened from the WHA area by significant intervening urban development.

2.2.2 Listed buildings

There are no listed buildings within the WHA area but there are 38 listed buildings within 500m of this area (see Figure 2-2). Kingston Lighthouse is located approximately 100m to the east of the WHA area and is classified as Grade II listed, whilst to the west, a Grade II listed mid-18th century residential property (23-25 High Street) is located approximately 75m from the WHA. Both of these listed buildings can be seen from the WHA area.

The majority of listed buildings are clustered within Shoreham town centre; approximately 100m to the north west of the WHA (see Figure 2-2). Intervening urban development is likely to restrict views of these buildings from the WHA area. Other listed buildings within close proximity to the WHA area, and which can be viewed from this area include Shoreham Town Hall (Grade II) and The Marlipins (Grade II*) to the west.

There are two Grade I listed buildings within 500m of the WHA. These comprise medieval churches located approximately 150m to the north west (Church of St Mary de Haura) and 300m to the west (Church of St Julian) of the WHA.

The Heritage Gateway website also identifies a number of other important heritage sites within and in close proximity to the WHA area. These include an early 19th century warehouse (Warehouse Brighton Road), located in close proximity to the existing flood defences within the centre of the WHA area; the wreck of the Lord Beaconsfield, an early 20th century Lugger that sank near the mouth of the River Adur, to the west of Shoreham lifeboat station; and the remains of Shoreham Whitefriars, a 14th century Carmelite monastery located within the river, approximately 200m to the west of the WHA.

2.2.3 Conservation areas

The western section of the WHA is located within Shoreham-by-Sea Conservation Area, which encompasses a section of the River Adur and adjacent river frontage development, as well as the shopping areas of High Street, East Street and Brunswick Road, and the areas surrounding St Mary's Church. In 1993 this area was extended to infill the remaining areas south of the railway line and to encompass two further streets north of the railway line: Southdown Road and Queens Place.

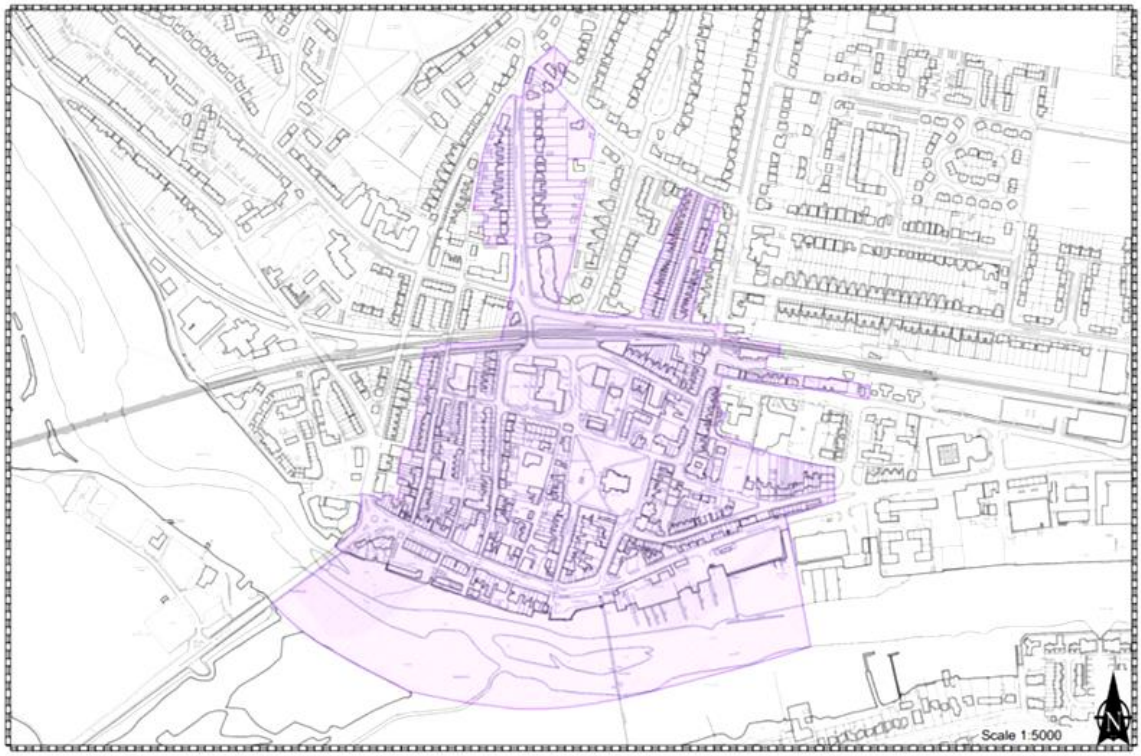

Figure 2-3: Shoreham Conservation Area (Adur & Worthing Councils, 2014)

The Conservation Area Appraisal (Adur District Council, 2008) describes the existing condition of the conservation area and highlights key objectives to preserve and enhance its value. It identifies that the entrance to the conservation area to the south, via Shoreham Harbour footbridge is aesthetically of good quality and is an important gateway into the designated area. Key issues to be addressed include improving publically accessible linkages between the river and conservation area. The appraisal also states that *'The Shoreham-by-Sea Conservation Area encompasses the historic core of Shoreham and as such the potential for medieval deposits and features is high, and could extend into the project area.'*

There is also a conservation area to the north east of the WHA, on the northern border of the railway line that runs from east to west to the north of the A259. Development at the WHA is unlikely to affect this area due to the barrier created by the railway line.

2.3 Water environment

2.3.1 Surface water quality

The Adur Estuary is classified within the South East River Basin Management Plan (RBMP) (Environment Agency, 2009a) as a heavily modified waterbody. Its current Water Framework Directive (WFD) status is 'moderate' and it has a target of achieving Good Ecological Potential (GEP) by 2027. The waterbody extends upstream as far as Henfield. Eight mitigation measures have been identified for the waterbody, which are necessary in order for the waterbody to achieve GEP and each of which is currently in place. Any development proposals that could affect the Adur Estuary will need to demonstrate no deterioration in the status of the waterbody and should work towards helping it achieve its status objective.

The Environment Agency takes periodic water samples along the River Adur to establish its chemical and biological quality. The closest sampling site to the WHA is at the confluence with the River Black Sewer, approximately 6km upstream of this area. The most recent sampling (2009) identified the chemical quality as 'fair', biological quality as 'fairly good', and nitrate and

phosphate levels as 'very high' and 'excessively high' respectively (Environment Agency, 2009c).

2.3.2 Groundwater quality

The South East RBMP identifies that the Shoreham area, including the WHA, forms part of the Brighton Chalk Block groundwater body. Its current quantitative status is 'poor' and its current chemical status is 'good' (Environment Agency, 2009a). Pressures in the waterbody identified in the RBMP that are affecting its status include the impacts of hazardous substances and other pollutants, nutrients, abstractions and other artificial flow pressures.

The Shoreham area, including the WHA, has been identified as a Groundwater Vulnerable Zone (GVZ) – 'major aquifer (high)' – and a Nitrate Vulnerable Zone (NVZ). The WHA area is not underlain by a groundwater Source Protection Zone (SPZ). The nearest SPZ is located approximately 500m to the north. This area is designated as a Total Catchment (Zone 3), with an Inner Zone (Zone 1) located approximately 1.5km to the north.

2.3.3 Water resources

Southern Water provides potable water supplies and sewerage services to Shoreham. Much of the Adur District overlies the Brighton Chalk Aquifer which is an important and heavily exploited groundwater resource (Shoreham Harbour Regeneration, 2013).

Household per capita consumption of water in the Sussex Coast Water Resource Zone is 160 litres per person per day (Shoreham Harbour Regeneration, 2013). This is above the average for England (150 litres per person per day) (HM Government, 2008). The Environment Agency (2007) has classified the area as having serious water stress, where demand for water is high and resource availability low.

2.4 Landscape and visual amenity

Shoreham-by-Sea is located immediately to the south of the South Downs National Park. The boundary of the National Park is approximately 800m to the north of the WHA area. The primary landmark within the town is the Church of St Mary de Haura, which is located within the town centre and rises to a height of 25m. The church features prominently in views of the town from the National Park (Adur District Council, 2008).

The view of the town from the south side of the River Adur opposite the WHA has been identified as an important view. The Adur Conservation Area Appraisal (Adur District Council, 2008) states that *'The view of the town from the south side of the river and the perception of its mass, scale and landscape setting against the backdrop of the downland and with the wide sweep of the River Adur in the foreground is critical in protecting the character of the town in the future.'* Other important views of the town include from Shoreham Beach and from Norfolk Bridge, to the west of the WHA. The WHA is visible from each of these viewpoints.

The Conservation Area Appraisal identifies that the riverside setting is a key component of the special character of Shoreham-by-Sea conservation area, but states that the relationship between the river and the south side of the High Street is poor. The Management Strategy for the conservation area provides the following recommendations to strengthen this relationship:

- *'Provision of a riverside walk along the north bank of the river including the provision of street furniture, landscaping and lighting as appropriate to enhance the environment.'*
- *'Strengthen visual and access links between the High Street and river front by enhancing existing links and creating new links where practical.'*
- *'Use of planning application and Local Development Framework processes to ensure access to river and provision for riverside recreation is incorporated into new developments.'*

2.4.1 National Character Areas

National Character Areas (NCAs) divide England into 150 distinct natural areas, defined by a unique combination of landscape, biodiversity, geodiversity and cultural and economic activity.

Shoreham-by-Sea falls with the South Coast Plain NCA (126) (Natural England, 2014). The profile states that *'Future management of this NCA requires balancing the needs of often competing interests. Protection against flooding remains a priority to encourage growth and allow internationally important habitats and species to flourish, while also maintaining the productive landscape and historic and geological features of the area.'*

The profile also states that *'Large lengths of the stretch of coastline encompassed in the South Coastal Plain NCA are in an unnatural form, and as such there is a significant risk of 'coastal squeeze' occurring.'*

The NCA profile includes a Statement of Environmental Opportunities (SEO) of which SEO1 requires partners to work together to limit the adverse impacts flood defences have on biodiversity, public access and historic interest.

2.4.2 Landscape Character Areas

West Sussex County Council (2007) has defined Shoreham-by-Sea as having Landscape Character Areas (LCA) being in Worthing & Adur Fringes, South Coast Shoreline and Built Up Areas. The key characteristics, as defined in the landscape character assessment (Wessex County Council, 2014a) in the Worthing & Adur Fringes include:

- Low lying flat landscape.
- Dominant urban fringe with major conurbations, including Shoreham.
- River estuary at Shoreham with numerous houseboats moored along its reaches.
- Busy minor and major roads.

Notable historic features within this LCA include the Roman-British Villa and Shoreham Airport. The key issues, as identified in the Adur & Worthing Fringes assessment (Wessex County Council, 2014a) are:

- '*Extension of coastal conurbation.*
- *Recreational pressures from urban population.*
- *Loss of mature elm trees in the 1970s and 1980s due to Dutch elm disease.*
- *Loss of tree and hedgerow cover from agricultural intensification since World War II.*
- *Conversion of agricultural buildings to light industrial uses.*
- *Farm diversification and garden centres leading to introduction of signs and fencing.*
- *Introduction of large scale glasshouses with distributions sheds.'*

The landscape and visual sensitivities are urban development pressures, with the closing of open views between settlements (West Sussex County Council, 2014a).

The South Coast Shoreline LCA extends between West Wittering and Shoreham and comprises the majority of the West Sussex coastline (West Sussex County Council, 2014b). A key characteristic of this LCA includes the influence of extensive linear urban coastal resort development that includes Shoreham. Shingle and sand dune habitats of national importance are also present at Shoreham. Key issues for this LCA include fragmented coastal habitats, coastal geomorphology and recreational pressure (West Sussex County Council, 2014b). Although fragmented coastal habitat is a key issue, Shoreham is noted for having good survival of some characteristic coastal habitats.

The landscape and visual sensitivities for the South Coast Shoreline LCA are include erosion of coastal habitats, rise in sea level, loss of open views and unsympathetic urban development (West Sussex County Council, 2014b).

As a result of these LCA assessments, land management guidelines have been developed (West Sussex County Council, 2014a and 2014b). Those relevant to the WHA include:

- Maintain and enhance landscape and biodiversity of existing wetland habitats.

- Ensure any new development does not result in adverse impact on open character and characteristic views.
- Maintain the historic character of the shoreline.
- Conserve and enhance the natural landscape of the coast.
- *'Assess options for coastal management in a comprehensive way, reflecting the dynamic and interdependent processes of erosion and deposition. Where practical, favour "softer" coastal management solutions such as coastal re-alignment, or ensure sympathetic design of any engineered defences.'* (West Sussex County Council 2014b).

2.5 Contaminated land

A Phase I Geo-Environmental Assessment was completed for Shoreham Harbour in March 2009 by WSP Environmental Ltd (2009). The report highlighted that the soils within the area contain hydrocarbons, metals and inorganic contamination with evidence to suggest migration of contaminants between sites via groundwater. The groundwater also appears to be contaminated and there is limited evidence of remedial action of these issues. The report states that it is the opinion of Adur District Council that *'the majority of the area has significant pollutant linkages.'*

Shoreham Harbour contains industrial activity and there are a wide range of former and current land uses that have the potential to contaminate the underlying land and groundwater. Former land uses have included a power station, aggregate sorting and storage sites, garages, oil and petrol storage areas, a waste water treatment facility and other waste uses. Consequently, significant risks of pollutant linkages have been found on the Shoreham Harbour area and in general the area is at a very high risk of being contaminated (Shoreham Harbour Regeneration, 2013).

A search of the Environment Agency's *What's in your backyard* website revealed two historic landfill sites (Ropetackle Road and Adur Recreation) on either side of the river, upstream of Norfolk Bridge. Ropetackle Road last received waste on 31 December 1949 and Adur Recreation on 31 December 1970. Both sites are likely to contain a mix of inert, commercial, industrial and household waste (Environment Agency, 2014b).

2.6 Air quality

Shoreham Air Quality Management Area (AQMA) covers the western part of the WHA, running along Shoreham High Street from Norfolk Bridge (approximately 400m upstream of the study area) to Surry Street (just to the north of the WHA) (Adur District Council, 2007).

Road vehicles are the greatest contributing factor to poor air quality in the area, emitting a variety of pollutants including carbon monoxide, nitrogen oxides, volatile organic compounds and particulate matters (Shoreham Harbour Regeneration, 2013). Another concern for air quality is the open storage of aggregates and woodchip in the port causing dust and air pollution (Shoreham Harbour Regeneration, 2013).

2.7 Noise

The main generator of background noise at Shoreham Harbour is road traffic. There are parts of the Shoreham Harbour regeneration area where traffic noise exceeds World Health Organisation (WHO) guidelines. Rail related noise is also an issue around the WHA (Shoreham Harbour Regeneration, 2013).

2.8 Population and local community

The Adur District, of which Shoreham is a big component, has a population of 61,200 and is the least populous local authority in South East England (Shoreham Harbour Regeneration, 2013). Adur District's population is mostly concentrated in the towns of Shoreham-by-Sea and Southwick. Around 10% of Adur District's population is aged 20-29, with 29% of residents over the age of 60, compared with 18% in Brighton & Hove. The median age in Adur District in 2011

is 44, which is five years above the national average (Shoreham Harbour Regeneration, 2013). Life expectancy is 79.4 years for men and 83.1 years for women, which are both lower than the South East average, but higher than the national average (Adur District Council, 2012).

In 2010, 61% of the population of Adur District were of working age. In 2011, 78.1% of Adur District's working age population were economically active, compared with 73.7% in neighbouring Brighton & Hove (Shoreham Harbour Regeneration, 2013). 2.7% of the working age population in Adur claim Job Seeker's Allowance, which is just higher than the South East England's rate of 2.5%. 21.5% of these claims last over 12 months.

The Indices of Multiple Deprivation show that Adur District was ranked 135th out of 354 local authorities in the country in 2010, with rank 1 being the most deprived (Shoreham Harbour Regeneration, 2013). Deprivation in the district has been worsening, as in 2004 Adur District was ranked 179 (Adur District Council, 2012).

Adur District has 87% of dwelling stock owner occupied or privately rented. There is a high demand for affordable housing in the Adur District which significantly exceeds supply (Shoreham Harbour Regeneration, 2013).

2.9 Local economy

Shoreham Port is the largest commercial port between Southampton and Dover and provides around 1,400 jobs. The port receives 700 to 900 ship arrivals per year, which results in a trading throughput of approximately 1.8 million tonnes per year. The main commodities at the port are aggregates, timber, scrap metal, cereals, oil and steel. The port is in the eastern section of Shoreham Harbour; however the entrance of the port is just south of the eastern end of the WHA.

There is not a strong tourism market in Shoreham-by-Sea, despite being located close to the seaside resorts of Brighton and Worthing. Only 6.2% of jobs in Adur District are tourism related, compared with 11.9% in Brighton & Hove. There is currently very little serviced accommodation within Shoreham-by-Sea, with only 62 rooms on offer (Shoreham Harbour Regeneration, 2013). In 2011, Adur had approximately 86,800 trips by staying visitors, yet only 2.7% of all overnight trips use the district's serviced accommodation, instead staying with friends and family (Adur District Council, 2013).

Key natural features of Shoreham to provide opportunities for recreation, such as sailing. This is exampled by the presence of the yacht club on the WHA. It is an aim of the Adur Local Plan to improve recreation and leisure facilities (Adur District Council, 2013).

3 Project options

Three overall flood risk management options have been identified for each frontage of the WHA. These are described in

Table 3-1. The project options are currently at an initial concept stage, and therefore a high-level- appraisal of the potential environmental risks and opportunities has been undertake to inform the development. **Error! Reference source not found.** defines whether the concept esign option would involve development seaward of the existing flood defences i.e., with the Adur Estuary channel. The assessment is based on these proposed defences, as defined in JBA Consulting's drawings 2014s0848-001, 2014s0848-002, 2014s0848-003.

Table 3-1: WHA flood defence options

WHA frontage	Defence category	Defence type	Proposed defence alignment	Encroach into River Adur (Y/N)	Option No.
Adur Ferry Bridge to Riverside Centre	Revetments	Concrete blockwork (modular)	Concrete revetment set forward of existing defence line.	Y	1.1
	Flood wall	Reinforced concrete	Flood wall set back from existing defence line	N	1.2
			Flood wall on top of existing defence line	N	1.3
	Piling	Steel sheet piles	Piled wall in front of existing defence line.	Y	1.4
Riverside Centre to Kingston Beach	Piling	Steel sheet piles	Raise existing sheet pile capping.	N	2.1
			New pile capping set forward from existing defence line.	Y	2.2
	Flood wall	Reinforced concrete	Flood wall on top of existing defence line.	N	2.3
			Flood wall set back from existing defence line.	N	2.4
	Land raising	Self supported	Land raising behind existing defence line.	N	2.5
Kingston Beach	Revetment and flood wall	Rock armour	Raised concrete revetment, new flood wall and rock armour	Y	3.1
	Revetment and flood wall	Concrete blockwork	Replacement concrete revetment and new flood wall	Y	3.2
	Piling	Steel sheet piles	Piled wall and removal of rock armour	Y	3.3

4 Impact appraisal

This section describes the outcomes of the environmental appraisal. It summarises the key potential environmental impacts, both positive and negative, associated with each of the project options. It uses information gathered during the desk study exercise and assesses whether each option has the potential to cause a significant environmental impact on the sensitive environmental features of the study area.

The results of the appraisal are set out using an appraisal matrix for each of the three frontages of the WHA. The appraisal itself was carried out using the scoring mechanism as set out in Table 4-1 and assesses the potential impact of each option against the environmental baseline. The rationale behind each score was described except where a neutral impact was identified.

Table 4-1: Impact scoring categories

Impact key	Potential impact
++	Potential for a significant positive impact
+	Potential for a positive impact
0	Likely to be a neutral impact
-	Potential for a negative impact
--	Potential for a significant negative impact
?	Impact not known/unclear

4.1 Adur Ferry Bridge to Riverside Business Centre concept options

Table 4-2 shows the outcomes of the appraisal for each of the flood defence options identified for the Adur Ferry Brigde to Riverside Business Centre frontage of the WHA. For each option number, refer to **Error! Reference source not found.** for the design concept. Table 4-3 describes the impacts each option could have on the environmental aspects.

Table 4-2: Potential impacts associated with concept options for Adur Ferry Bridge to Riverside Business Centre

Topic	Environmental aspect	Potential impact			
		Option 1.1	Option 1.2	Option 1.3	Option 1.4
Biodiversity and nature conservation	Designated sites	--	0	-	--
	BAP habitat	--	0	-	-
	Notable species	--	-	-	--
Historic environment	Scheduled monuments	0	0	0	0
	Listed buildings	+	+	+	+
	Conservation areas	-	-	-	-
Water environment	Surface water	--	-	-	--
	Groundwater	0	0	0	-
	Water resources	0	0	0	0
Landscape and visual amenity	Landscape character	--	-	-	-
Climate change		+	+	+	+
Contaminated land		?	?	?	?
Air quality		-	-	-	-
Noise		0	0	0	-
Population and local community		+	+	+	+
Local economy		++	++	++	++

Table 4-3: Potential key environmental issues associated with Adur Ferry Bridge to Riverside Business Centre concept options

Environmental aspect	Notable feature	Assessment summary			
		Option 1.1	Option 1.2	Option 1.3	Option 1.4
Biodiversity and nature conservation	Designated sites	This option requires the proposed concrete block revetment to be set forward (seaward) of the existing revetment defences. The new defence line will therefore encroach onto the river bed. Mudflat habitat is present in this area, which is a BAP habitat and a feature of the Adur Estuary SSSI, which is located immediately adjacent to this section of the WHA. Construction of the concrete block revetments would result in the permanent loss of an area of mudflat and could cause damage and disturbance to a wider area of habitat outside the footprint of the proposed flood defence. This loss of mudflat habitat would conflict with strategic objectives for biodiversity set out in the Adur Local Plan. The loss of mudflats should be kept to an absolute minimum, with the line of the proposed defences as close as possible to the existing flood defence line. Construction best practice and seasonal constraints would need to be applied during construction to avoid a significant impact on the features of the SSSI. This option is also likely to worsen the effects of climate change on inter-tidal habitats by exacerbating the risk and extent of coastal squeeze in this location. Without provision of adequate mitigation to ensure coastal squeeze impacts are addressed through the development process, this option would conflict with a range of biodiversity policy.	Set back of the defence line would reduce the potential risks to sensitive sites and habitats. If this option includes removal of the existing defences there is potential for a long-term benefit.	Appropriate construction best practice would need to be implemented to avoid the risk of adverse impacts on features of the SSSI during construction. Such impacts could include damage and disturbance, including the risk of pollution, and appropriate controls may need to be put in place including seasonal restrictions on construction works.	The impacts associated with this option are likely to be similar to those identified for Option 1.1. The option includes encroachment onto the riverbed; therefore there would be a permanent loss of BAP habitat. This option is likely to result in future impacts on inter-tidal habitats due to coastal squeeze caused by climate change. This is due to the hard defence line migrating seaward and accelerating the process by which the low water mark is raised and leaving the inter-tidal areas permanently submerged.
	BAP habitat		Set back of the defence line would reduce the potential risks to sensitive sites and habitats. If this option includes removal of the existing defences there is potential for a long-term benefit.	These concept options do not encroach into the river channel and therefore would not result in the permanent loss of inter-tidal BAP habitat in the short term. However, with the influence of climate change, future impacts on BAP habitat and SSSI features could occur due to coastal squeeze. Therefore, these flood defence options would need to demonstrate how the impacts of coastal squeeze are being addressed, in accordance with the requirements of the Adur Local Plan. It is possible that Option 1.2 could have a limited positive impact as the reinforced concrete wall would be set landward of the existing defences. If these existing defences are removed as part of the development then additional space may be provided for the development/creation of new inter-tidal habitat	
	Notable species	Construction of this option could lead to temporary disturbance of notable bird, fish	Construction of these options could lead to temporary disturbance of notable bird, fish and shellfish species present in the Adur Estuary.		As stated for Option 1.1, this option could cause temporary and permanent disturbance

Environmental aspect	Notable feature	Assessment summary			
		Option 1.1	Option 1.2	Option 1.3	Option 1.4
		and shellfish species present in the Adur Estuary, whilst the permanent loss of inter-tidal habitat as a direct result of the construction of the option and future loss due to coastal squeeze could have a permanent adverse affect bird and fish feeding and foraging in the vicinity of the WHA.	Future adverse impacts due to inter-tidal habitat loss could also occur due to the retention of the existing defence line.		to important bird, fish and shellfish species known to frequent the inter-tidal areas adjacent to the WHA. These impacts would affect a smaller area than would occur through Option 1.1, but the impacts could still be significant, particularly due to future sea level rise that would exacerbate the effects of coastal squeeze.
Historic environment	Scheduled monuments	There is a low risk of temporary adverse effects on the setting of The Marlipins should the construction area extend westwards along the A259 or if it effects traffic movements along this highway increasing traffic congestion around the monument. Intervening urban development prevents views of the flood defences from the monument although views of both the defences and the monument are possible from the southern bank of the Adur Estuary. However, impacts on the setting of the monument affecting visual amenity are not likely to be significant. The potential for positive or negative impacts, and their significance, would depend upon whether the flood defences provide an increase in protection to The Marlipins. As such, because The Marlipins is upstream, they are unlikely to assist in reducing flood risk.			
	Listed buildings	Temporary adverse effects on the setting of listed buildings in the vicinity of this section of the WHA (most notably 23-25 High Street) are possible during the construction phase due to a range of construction activities. There is also a low risk of permanent impacts on the setting as the flood defence structure would be visible within views of the listed building from the south. All of these options will increase protection for the listed buildings, with climate change impacts having been considered during the design of the options.			
	Conservation areas	New flood defence structures on land could have both temporary and permanent visual impacts on the south eastern entrance of the Shoreham Conservation Area, affecting several important views of the site. These impacts may be negative as the flood defences could affect the existing historic urban character of the riverside frontage. There could be some impact during construction for pedestrians entering/exiting the conservation area, particularly in the western portion of this section.			
Water environment	Surface water	Construction of new revetments within the river channel could affect the ecology and hydromorphology of the river. These impacts could conflict with the WFD objectives for the waterbody. Any development proposals that could affect the Adur Estuary will need to demonstrate no deterioration in the status of the waterbody and should work towards helping it achieve its status objective. In addition, construction of the flood defence structure could have temporary and permanent impacts on water quality due to the release of construction materials or the mobilisation of ground contamination.	Construction of the flood defence could conflict with the objectives of the WFD. However, this option could offer an opportunity to contribute to the WFD if it incorporated the removal of the existing defence structures so that the hard defence line is moved landward. Impacts during the construction phase are also possible due to the release of contaminating materials.	Construction of the flood defence could conflict with the objectives of the WFD. Construction of the flood defence structure could have temporary and permanent impacts on water quality due to the release of contaminating construction materials or the mobilisation of ground contamination.	Construction of new sheet piles within the river channel could affect the ecology and hydromorphology of the river. These impacts could conflict with the WFD objectives for the waterbody. Any development proposals that could affect the Adur Estuary will need to demonstrate no deterioration in the status of the waterbody and should work towards helping it achieve its status objective. In addition, construction of the flood defence structure could have temporary and permanent impacts on water quality due to the release of contaminating construction materials or the mobilisation of ground contamination.
	Groundwater	No impacts on groundwater are anticipated.			This option involves ground penetration works; therefore there is the potential for release of contaminants into groundwater

Environmental aspect	Notable feature	Assessment summary			
		Option 1.1	Option 1.2	Option 1.3	Option 1.4
					during construction. This is a particular risk for should long piles be used.
	Water resources	There is a low risk that construction of the flood defences could affect any surface water or private discharges into the estuary. However, the works also offer an opportunity to consolidate and better regulate any such discharges; inclusion of pollution control measures could have a positive impact on water quality in the estuary.			
Landscape and visual amenity	Landscape character	Construction of a concrete revetment and associated ground raising may have a significant adverse impact on the landscape character of this section of the river frontage.	These options would result in an increase in the height of the flood defences, which may have a permanent adverse impact on the character of the area.		
Climate change		All flood defence options will increase the level of protection for Shoreham against the increased risk of flooding due to climate change. This is likely to benefit people and property. However, with sea level rise there is an increased risk of coastal squeeze affecting inter-tidal habitats and their ability to adapt to this impact. Overall, the impact in relation to climate change is likely to be positive.			
Contaminated land		There is a risk that construction activities (particularly the use of long piles for Option 1.4) could lead to the mobilisation of contaminated materials in the ground, which could affect surface water and groundwater quality. However, construction of the flood defence would offer an opportunity to remediate any ground contamination present in the scheme area.			
Air quality		There is a risk that construction activities could have a temporary adverse impact on local air quality, especially that of the AQMA.			
Noise		There is a small risk that construction activities could have a temporary adverse impact on noise levels in the area. However, since the WHA is an area of high noise levels due to the proximity of highways, the railway and various water based activities, negative impacts from construction activities are likely to be negligible.			Installation of the sheet piles could have a significant negative impact on the local noise environment.
Population and local community		There will be a permanent positive impact for the yacht club once constructed due to providing increased flood protection. However, construction activities could disrupt the yacht club and any visitors to the area, thus providing a temporary negative impact. The flood defences will provide increased protection from flooding and will have a significant positive impact on people and property in Shoreham.	Subject to alignment this option does not protect the yacht club; therefore the yacht club will have the same risk of flooding as at present. Construction activities could disrupt the yacht club and any visitors to the area, thus providing a temporary negative impact. Although the yacht club is not protected by this option, the moorings will remain suitable for the yacht club. The flood wall will provide increased protection from flooding for the community.	The flood wall will provide increased protection from flooding for the community. Construction activities would temporarily negatively impact the yacht club and any visitors to the area. By integrating new moorings in this area, there will be a permanent positive impact on the yacht club.	
Local economy		The flood defences will provide permanent increased protection from flooding for the town centre, which includes a commercial area, therefore has been assessed as likely to have a significant positive impact.			

4.2 Riverside Business Centre to Kingston Beach concept options

Table 4-4 shows appraisal for the potential impacts of each flood defence option for Riverside Business Centre to Kingston Beach. For the option numbers, refer to **Error! Reference source ot found.** for the design concept. Table 4-5 describes the impacts each option could have on the environmental aspects.

Table 4-4: Potential impacts associated with concept options for Riverside Business Centre to Kingston Beach

Environmental aspect	Notable feature	Potential impact				
		Option 2.1	Option 2.2	Option 2.3	Option 2.4	Option 2.5
Biodiversity and nature conservation	Designated sites	-	--	-	0	-
	BAP Habitat	-	--	-	0	-
	Notable species	-	--	-	-	-
Historic environment	Scheduled monuments	0	0	0	0	0
	Listed buildings	+	+	+	+	+
	Conservation areas	+	+	+	+	+
Water environment	Surface water	-	--	-	0	-
	Groundwater	0	-	0	0	0
	Water resources	0	0	0	0	0
Landscape and visual amenity	Landscape Character	0	-	-	-	--
Climate		+	+	+	+	+
Contaminated land		?	?	?	?	?
Air quality		-	-	-	-	-
Noise		0	-	0	0	0
Population and local community		+	+	+	+	+
Local economy		++	++	++	++	++

Table 4-5: Potential key environmental issues associated with Riverside Centre to Kingston Beach concept options

Environmental Aspect	Notable feature	Summary				
		Option 2.1	Option 2.2	Option 2.3	Option 2.4	Option 2.5
Biodiversity and nature conservation	Designated Sites BAP Habitat	Appropriate construction best practice would need to be implemented to avoid the risk of adverse impacts on features of the SSSI during construction. Such impacts could include damage and disturbance, including the risk of pollution, and appropriate controls may need to be put in place including seasonal restrictions on construction works. With the influence of climate change, future impacts on the habitat features could occur due to coastal squeeze. Therefore, these flood defence options would need to demonstrate how the impacts of coastal squeeze are being addressed, in accordance with the requirements of the Adur Local Plan.	This option requires the proposed sheet pile to be set forward (seaward) of the existing defences. The new defence line will therefore encroach onto the river channel. Although there is encroachment, the proposed structure does not deviate significantly from the existing structure, and therefore is unlikely to worsen the effects of coastal squeeze. This section of the WHA borders BAP mudflat habitat, therefore appropriate construction best practice would need to be implemented to avoid the risk of adverse impacts on features of the BAP habitat.	Appropriate construction best practice would need to be implemented to avoid the risk of adverse impacts on features of the SSSI during construction. Such impacts could include damage and disturbance, including the risk of pollution, and appropriate controls may need to be put in place including seasonal restrictions on construction works. With the influence of climate change, future impacts on the habitat features could occur due to coastal squeeze. Therefore, these flood defence options would need to demonstrate how the impacts of coastal squeeze are being addressed, in accordance with the requirements of the Adur Local Plan.	Set back of the defence line would reduce the potential risks to sensitive sites and habitats. If this option includes removal of the existing defences there is potential for a long-term benefit.	Appropriate construction best practice would need to be implemented to avoid the risk of adverse impacts on features of the SSSI during construction. Such impacts could include damage and disturbance, including the risk of pollution, and appropriate controls may need to be put in place including seasonal restrictions on construction works. With the influence of climate change, future impacts on the habitat features could occur due to coastal squeeze. Therefore, these flood defence options would need to demonstrate how the impacts of coastal squeeze are being addressed, in accordance with the requirements of the Adur Local Plan.
	Notable species	Construction of these options could lead to temporary disturbance of notable bird, fish and shellfish species present in the Adur Estuary. Future adverse impacts due to inter-tidal habitat loss could also occur due to the retention of the existing defence line.	Construction of this option could lead to temporary disturbance of notable bird, fish and shellfish species present in the Adur Estuary, whilst the permanent loss of inter-tidal habitat as a direct result of the construction of the option and future loss due to coastal squeeze could have a permanent adverse affect bird and fish feeding and foraging in the vicinity of the WHA.	Construction of these options could lead to temporary disturbance of notable bird, fish and shellfish species present in the Adur Estuary. Future adverse impacts due to inter-tidal habitat loss could also occur due to the retention of the existing defence line. As stated for Option 2.1, important reptile populations would not be affected.		

Environmental Aspect	Notable feature	Summary				
		Option 2.1	Option 2.2	Option 2.3	Option 2.4	Option 2.5
Historic environment	Scheduled monuments	There is a low risk of temporary adverse effects on the setting of The Marlipins should the traffic movements along A259 increasing traffic congestion around the monument. Temporary adverse effect on the setting of the Marlipins museum scheduled monument is possible during the construction phase due to a range of construction activities, especially towards the Riverside Centre. Permanent adverse effects are not likely due to the distance this section from the WHA is from The Marlipins.				
	Listed buildings	Temporary adverse effects on the setting of listed buildings in the vicinity of this section of the WHA (most notably 55-57 New Road) are possible during the construction phase due to a range of construction activities. However, it is unlikely that there would be a permanent adverse impact on the setting as the flood defence structure is unlikely to be visible from the listed buildings due to the current buildings on the harbour area. All of these options will increase flood protection for the listed buildings, with climate change impacts having been considered during the design of the options, thus having a permanent positive impact.				
	Conservation areas	New flood defence structures are not likely to impact on the south eastern entrance to Shoreham Conservation Area, due to the distance between this section of the WHA and the designated area. The flood defences are likely to provide increased flood protection to the Conservation Area, thus providing a permanent positive impact.				
Water environment	Surface water	Construction of the flood defence structure could have temporary impacts on water quality due to the release of contaminating construction materials or the mobilisation of ground contamination.	Construction of new sheet piles within the river channel could affect the ecology and hydromorphology of the river. These impacts could conflict with the WFD objectives for the waterbody. Any development proposals that could affect the Adur Estuary will need to demonstrate no deterioration in the status of the waterbody and should work towards helping it achieve its status objective. In addition, construction of the flood defence structure could have temporary and permanent impacts on water quality due to the release of contaminating construction materials or the mobilisation of ground contamination.	Construction of the flood defence structure could have temporary impacts on water quality due to the release of contaminating construction materials or the mobilisation of ground contamination. However, this option could offer an opportunity to contribute to the WFD if it incorporated the removal of the existing defence structures so that the hard defence line is moved landward. Impacts during the construction phase are also possible due to the release of contaminating materials.	Construction of the flood defence structure could have temporary impacts on water quality due to the release of contaminating construction materials or the mobilisation of ground contamination.	Construction of the flood defence structure could have temporary impacts on water quality due to the release of contaminating construction materials or the mobilisation of ground contamination.
	Groundwater	No impacts on groundwater are anticipated.	This option involves ground penetration works; therefore there is the potential for release of contaminants into groundwater during construction. This is a particular risk for should long piles be used.	No impacts on groundwater are anticipated.		

Environmental Aspect	Notable feature	Summary				
		Option 2.1	Option 2.2	Option 2.3	Option 2.4	Option 2.5
	Water resources	There is a low risk that construction of the flood defences could affect any surface water or private discharges into the estuary. However, the works also offer an opportunity to consolidate and better regulate any such discharges; inclusion of pollution control measures could have a positive impact on water quality in the estuary.				
Landscape and visual amenity	Landscape character	No impacts on landscape character identified, as this option does not change significantly from the character of the current flood defences.	These options would result in an increase in the height of the flood defences, which may have a permanent adverse impact on the character of the area.			The land raising may have a significant adverse impact on the landscape character of this section of the river frontage.
Climate		All flood defence options will increase the level of protection for Shoreham against the increased risk of flooding due to climate change. This is likely to benefit people and property. However, with sea level rise there is an increased risk of coastal squeeze affecting inter-tidal habitats and their ability to adapt to this impact. Overall, the impact in relation to climate change is likely to be positive.				
Contaminated land		There is a risk that construction activities (particularly the use of sheet piles for Option 2.1) could lead to the mobilisation of contaminated materials in the ground, which could affect surface water and groundwater quality. However, construction of the flood defence would offer an opportunity to remediate any ground contamination present in the scheme area.				
Air quality		There is a risk that construction activities could have a temporary adverse impact on local air quality, especially that of the AQMA.				
Noise		There is a small risk that construction activities could have a temporary adverse impact on noise levels in the area. However, since the WHA is an area of high noise levels due to the proximity of highways, the railway and various water based activities, negative impacts from construction activities are likely to be negligible.	Installation of the sheet piles could have a significant adverse impact on the local noise environment.	There is a small risk that construction activities could have a temporary adverse impact on noise levels in the area. However, since the WHA is an area of high noise levels due to the proximity of highways, the railway and various water based activities, negative impacts from construction activities are likely to be negligible.		
Population and local community		Construction activities could have a negative impact on any visitors to the area, and at the western end of this section there could be negative impacts to the yacht club. However, these impacts would be temporary. The flood defences will provide increased protection from flooding for the community, thus having a permanent positive impact.				
Local economy		The flood defences will provide increased protection from flooding for the commercial areas of Shoreham in the town centre and surrounds, thus having a permanent positive impact.				

4.3 Kingston Beach concept options

Table 4-6 shows appraisal for the potential impacts of each flood defence option at Kingston Beach. For the option numbers, refer to **Error! Reference source not found.** for the design concept. Table 4-7 describes the impacts each option could have on the environmental aspects.

Table 4-6: Potential impacts associated with concept options at Kingston Beach

Environmental Aspect	Notable features	Potential Impact		
		Option 3.1	Option 3.2	Option 3.3
Biodiversity and nature conservation	Designated Sites	0	0	0
	BAP Habitat	-	-	-
	Notable Species	-	-	-
Historic environment	Scheduled monuments	-	0	-
	Listed buildings	-	0	-
	Conservation areas	0	0	0
Water environment	Surface water	-	-	-
	Groundwater	0	0	-
	Water resources	0	0	0
Landscape and visual amenity	Landscape character	-	-	-
Climate		+	+	+
Contaminated land		?	?	?
Air quality		-	-	-
Noise		0	0	-
Population and local community		+	+	+
Local economy		++	++	++

Table 4-7: Potential key environmental issues associated with Kingston Beach concept options

Environmental Aspect	Notable feature	Summary		
		Option 3.1	Option 3.2	Option 3.3
Biodiversity and nature conservation	Designated Sites	It is unlikely that construction works undertaken to the Kingston Beach section of the WHA would adversely affect the Adur Estuary SSSI. However, care should be taken during construction to not disturb the SSSI and species associated with it. Therefore, appropriate construction best practice would need to be implemented to avoid the risk of adverse impacts on features of the SSSI during construction. Such impacts could include damage and disturbance, including the risk of pollution, and appropriate controls may need to be put in place including seasonal restrictions on construction works,		
	BAP Habitat	This option requires the proposed rock armour revetment to be set forward (seaward) of the existing revetment defences. The new defence line will therefore encroach onto the river channel. Inter-tidal sand and gravel habitat is present in this area, which is a BAP habitat. Construction of the rock armour revetments would result in the permanent loss of an area of intertidal habitat and could cause damage and disturbance to a wider area of habitat outside the footprint of the proposed flood defence. This loss of habitat would conflict with strategic objectives for biodiversity set out in the Adur Local Plan. The loss of the habitat should be kept to an absolute minimum, with the line of the proposed defences as close as possible to the existing flood defence line. Construction best practice would need to be applied during construction to avoid a significant impact on the surrounding features of the BAP habitat. This option is also likely to worsen the effects of climate change on inter-tidal habitats by exacerbating the risk and extent of coastal squeeze in this location. Without provision of adequate mitigation to ensure coastal squeeze impacts are addressed through the development process, this option would conflict with a range of biodiversity policy.	This option requires the removal of the existing flood defences to enable the proposed concrete revetment being placed on top. The impacts associated with this option are likely to be similar to those identified for Option 3.1. The option includes encroachment onto the riverbed; therefore there could be a permanent loss of BAP habitat.	This option requires the removal of the existing concrete revetment to be replaced by piling and rock armour. The impacts associated with this option are likely to be similar to those identified for Option 3.1. The impacts associated with this option are likely to be similar to those identified for Option 3.1. The option includes encroachment onto the riverbed; therefore there would be a permanent loss of BAP habitat. This option could result in future impacts on inter-tidal habitats due to coastal squeeze caused by climate change. This is due to the hard defence line changing the coastline features and therefore potentially accelerating the process by which the low water mark is raised and leaving the inter-tidal areas permanently submerged.
	Notable species	Construction of these options could lead to temporary disturbance of notable bird, fish and shellfish species present in the Adur Estuary, whilst the permanent loss of inter-tidal habitat as a direct result of the construction of the option and future loss due to coastal squeeze could have a permanent adverse affect bird and fish feeding and foraging in the vicinity of the WHA... However, the important reptile populations located both upstream and downstream of the WHA are unlikely to be affected by the construction works.		
Historic environment	Scheduled monuments	Kingston Beach is within sight of Shoreham Old Fort scheduled monument, therefore the	The flood defences will have a similar appearance to existing defences, and	Kingston Beach is within sight of Shoreham Old Fort scheduled monument, therefore the

		significant change from the existing flood defences could have a permanent negative impact on the setting of the fort. There is a risk that construction could have a negative impact on the view from Shoreham Old Fort.	therefore are unlikely to have any impact on Shoreham Old Fort.	significant change from the existing flood defences could have a permanent negative impact on the setting of the fort.
	Listed buildings	Temporary adverse effects on the setting of listed buildings in the vicinity of this section of the WHA (most notably Kingston Lighthouse) are possible during the construction phase due to a range of construction activities. There is also a low risk of permanent impacts on the setting as the flood defence structure would be visible from the lighthouse.	The flood defences will have a similar appearance to existing defences, and therefore are unlikely to have any impact on Kingston Lighthouse.	Temporary adverse effects on the setting of listed buildings in the vicinity of this section of the WHA (most notably Kingston Lighthouse) are possible during the construction phase due to a range of construction activities. There is also a low risk of permanent impacts on the setting as the flood defence structure would be visible from the lighthouse.
	Conservation areas	The Kingston Beach section of the WHA is of a sufficient distance from the Shoreham Conservation Area, therefore no impacts are anticipated.		
Water environment	Surface water	Construction of flood defences within the river channel could affect the ecology and hydromorphology of the river. These impacts could conflict with the WFD objectives for the waterbody. Any development proposals that could affect the Adur Estuary will need to demonstrate no deterioration in the status of the waterbody and should work towards helping it achieve its status objective. In addition, construction of the flood defence structure could have temporary and permanent impacts on water quality due to the release of contaminating construction materials or the mobilisation of ground contamination.		
	Groundwater	No impacts on groundwater are anticipated.		These options involve ground penetration works; therefore there is the potential for release of contaminants into groundwater during construction. No permanent impacts on groundwater quality have been identified.
	Water resources	There is a low risk that construction of the flood defences could affect any surface water or private discharges into the estuary. However, the works also offer an opportunity to consolidate and better regulate any such discharges; inclusion of pollution control measures could have a positive impact on water quality in the estuary.		
Landscape and visual amenity	Landscape character	Construction of rock armour may have a significant adverse impact on the landscape character of this section of the river frontage due to the significant difference to the current flood defences.	Although the concrete revetment is of a similar nature to the current flood defence, the proposed flood wall results in an increase in the height of the flood defences, which may have a permanent adverse impact on the character of the area.	Construction of rock armour may have a significant adverse impact on the landscape character of this section of the river frontage due to the significant difference to the current flood defences.
Climate		All flood defence options will increase the level of protection for Shoreham against the increased risk of flooding due to climate change. This is likely to benefit people and property. However, with sea level rise there is an increased risk of coastal squeeze affecting inter-tidal habitats and their ability to adapt to this impact. Overall, the impact in relation to climate change is likely to be positive.		
Contaminated land		There is a risk that construction activities (particularly the use of sheet piles for Option 3.3) could lead to the mobilisation of contaminated materials in the ground, which could affect surface water and groundwater quality. However, construction of the flood defence would offer an opportunity to remediate any ground contamination present in the scheme area.		

Air quality	There is a small risk that construction activities could temporarily negatively impact the local air quality of the area, however Kingston Beach is a sufficient distance from the AQMA to have no affect on the area.	
Noise	There is a small risk that construction activities could have a temporary adverse impact on noise levels in the area. However, since the WHA is an area of high noise levels due to the proximity of highways, the railway and various water based activities, negative impacts from construction activities are likely to be negligible.	Installation of the sheet piles could have a significant impact on the local noise environment.
Population and local community	Construction is unlikely to disrupt the Royal National Lifeboat Institution lifeboat station. The flood defences must consider the lifeboat station to avoid increasing the risk of flooding to the station. The flood defences will provide increased protection from flooding for the community, providing a permanent positive impact.	
Local economy	The flood defences will provide increased protection from flooding for the commercial areas in the harbour, thus having a permanent positive impact.	

4.4 Discussion

This appraisal provides a high-level assessment of the associated potential environmental risks and benefits for each of the concept flood defence options.

4.4.1 Adur Ferry Bridge to Riverside Business Centre

Within the Adur Ferry Bridge to Riverside Business Centre frontage of the WHA, Option 1.1 and Option 1.4 would involve extending the flood defence line seaward into the river channel. For Option 1.1, the proposed concrete revetments extend the line further forward than for Option 1.4, which involves creating new sheet piled flood defences immediately in front of the existing defence line. Both options would cause the permanent loss of inter-tidal BAP habitats and would be likely to have the greatest long term impact on these areas due to the risk of sea level rise causing coastal squeeze. Such impacts would in turn have the potential to adversely affect the special interest of the Adur Estuary SSSI and would conflict with a wide range of legislation and strategic objectives focused on the protection and enhancement of such sites.

Coastal squeeze may still occur as a result of options 1.2 and 1.3, but impacts are likely to be less extensive. In addition, Option 1.2 would involve setting back the flood defence line landward of the exiting defences. If these existing defences could be removed as part of this option, then it would offer an opportunity to create new inter-tidal habitats, which would be afforded some space to migrate to particularly in the event of coastal squeeze. These potential impacts are closely linked to the WFD objectives for the waterbody and as such, it is possible that all of the options could conflict with achieving these objectives.

Each of these options could also cause a range of landscape and visual impacts affecting local landscape character, historic features and important views in Shoreham. Option 1.1 in particular, which involves large revetment structure extending into the estuary and associated ground raising behind could have a significant adverse impact on landscape character and could affect the setting of Shoreham Conservation Area.

In addition, construction of each option would present a number of significant environmental risks that would require robust mitigation. This would include significant disruption to water-based recreational activities and to Shoreham Yacht Club in particular, which moor boats along this section of the WHA. This could result in knock-on impacts on the local economy and any sailing-based tourism. Appropriate controls would need to be put in place to limit the size of the construction footprint during this phase so as to minimise the level of disturbance or damage caused to habitats within the river channel. Further controls would be required to avoid the risk of contamination of surface waters due to the release of contaminating construction materials or the mobilisation of contaminants that may be present in made ground. In relation to Option 1.4, installation of the sheet piles could have a significant impact on the local noise environment.

Each of these options is also likely to lead to a range of environmental benefits. The new defences would increase protection for people and property in Shoreham and could reduce flood risk to sensitive historic sites such as listed buildings in the town centre. The defences would reduce the impacts of sea level rise caused by climate change on these aspects and would also make a positive contribution to the local economy by reducing the risk of flooding to the town. Also, whilst construction of the flood defences could present a risk to surface waters and groundwaters due to the potential mobilisation of contaminants in made ground, there would also offer an opportunity to undertake land remediation should ground contamination be identified, which would provide a permanent benefit to the local environment.

4.4.2 Riverside Business Centre to Kingston Beach

Options 2.1 to 2.5 would be implemented along the Riverside Business Centre to Kingston Bridge frontage of the WHA. Extensive sheet piled walls currently form the defences throughout this section. Options 2.1 to 2.3 would involve the construction of a new defence line adjacent to the existing defences. Each option would be likely to have a range of environmental affects. Most notably, raising of the defence level would have the potential to cause coastal squeeze affecting inter-tidal areas upstream and downstream. This impact may be most significant in

relation to Option 2.2, which would extend the defence line seaward. In addition, these options would be unlikely to have a significant impact on local landscape character as they would largely resemble the existing riverside frontage; however, there is the possibility of providing a benefit to landscape character if sensitive materials and finishes are applied to the defences and also to the existing flood defence structures that would remain in-situ.

Option 2.4 would involve setting the flood defence line landward and this could have a range of benefits; most notably in terms of reducing the future impacts of coastal squeeze and potentially through a positive contribution to local landscape character. In addition, as the construction works would be undertaken outside the river channel, the risks of an adverse impact on river ecology or water quality would be reduced, whilst construction of the defences may be easier and quicker, reducing the impact on people and property.

Option 2.5 would involve ground raising behind the existing flood defences. This option would have a range of impacts, the type, scale and significance of which would depend upon the extent of ground raising and the form that it takes. The use of soft engineering techniques or the application of green landscape features could provide a range of landscape, biodiversity and amenity benefits. However, ground raising could negatively impact on landscape character if materials and treatments are not sensitively applied.

Each of these defence options would again provide benefits to people and property through a reduction in flood risk, which would also make a positive contribution to the local economy.

4.4.3 Kingston Beach

Options 3.1 to 3.3 would be applied to the Kingston Beach frontage of the WHA at its eastern end. This area is relatively small and currently contains an existing concrete revetment with rock armour providing flood defence, which would be removed and replaced under each of these options. Options 3.1 and 3.2 involve removal of the revetment and its replacement with a new revetment, whilst Option 3.3 would see the construction of a new sheet pile wall. Option 3.1 would extend the footprint of the flood defence seaward into the estuary and would involve raising of the revetment height along its length and installation of rock armour. There could be a number of environmental issues associated with this, including damage or loss of any inter-tidal or sub-tidal habitat present within the development footprint, as well as accelerating the risk of coastal squeeze, and potential impacts on landscape character, which could affect the setting of Shoreham Fort scheduled monument, located to the south, and Kingston Lighthouse a short distance to the east. There would also be a number of environmental risks during the construction phase that would require careful management including controls placed on the manner of construction so as to minimise impacts on water quality or disturbance.

Options 3.2 and 3.3 also present several environmental risks but these are potentially less significant than those associated with Option 3.1. This is largely due to the more limited development area required, which would be largely contained within the footprint of the existing concrete revetment. Option 3.2 would see a like-for-like replacement of the revetment together with the construction of a new flood wall at its landward extent. There could be potential issues associated with the landscape impact of this new structure and its effect on the setting of Shoreham Fort and Kingston Lighthouse would need careful consideration. Option 3.3 would effectively see a continuation of the sheet piled wall currently found along the Riverside Centre to Kingston Bridge section of the WHA. As mentioned previously, installation of the sheet piles could have a significant impact on the local noise environment, with potential knock-on effects on recreation and amenity within the estuary. However, this option may result in a smaller flood defence footprint that the other options and the existing concrete revetment structure, effectively setting the defence line a short distance landward, which could help mitigate the impact of coastal squeeze in the short term. In the longer term, impacts associated with coastal squeeze could be an issue for each of these options.

Overall, there are environmental risks and benefits associated with each of the flood defence concept options. These risks are likely to be most significant where the option extends the defence line seaward into the estuary as this could have direct impacts on sensitive habitats and species, as well as future impacts due to the risk of accelerating the effects of coastal squeeze. These options could conflict with wider environmental policies including achievement

of WFD objectives and protecting and enhancing protected habitats. Impacts on landscape character and the setting of historic features may also be more significant with these options. Where options propose setting back the defence line, there are opportunities to provide significant benefits should the existing flood defences be removed. This could help mitigate the risk and impacts of coastal squeeze, and could make a positive contribution to WFD objectives. Each option would improve the level of flood defence and reduce flood risk to people and property in Shoreham-by-Sea. This could deliver a range of social and economic benefits, as well as contributing to the better protection of environmental features such as Shoreham Conservation Area.

5 Recommendations

5.1 Scope of future environmental work

The environmental impacts of any flood defence scheme would need to be assessed further during the development of the preferred concept option so as to inform its detailed design and the requirement for appropriate mitigation measures.

A number of surveys and assessments would be required to gain a more detailed understanding of the environmental baseline and the potential environmental issues associated with the scheme. These surveys would need to be agreed in advance through consultation with Adur District Council and other relevant stakeholders, including the Environment Agency, English Heritage and Natural England.

The preferred concept option would require formal screening by Adur District Council under the Town and Country Planning (Environmental Impact Assessment) Regulations 2011 to determine the requirement for a statutory EIA.

A Preliminary Ecological Appraisal (PEA), following the Institute of Ecology and Environmental Management guidelines (IEEM, 2013), would be required to provide detailed baseline ecological data and to identify potential ecological constraints, opportunities and associated mitigation measures. The PEA would include an Extended Phase I Habitat Survey following JNCC methodology. The PEA would inform the requirement for further Ecological Impact Assessment (EcIA) and protected species surveys. Careful consideration of the potential effects on the Adur Estuary SSSI would be required and it is recommended that early consultation with Natural England is undertaken.

A detailed historic environment assessment may be required to determine the potential impacts of the preferred concept option on heritage features within the surrounding area. This assessment would be prepared in line with the Institute for Archaeologists *Standard and Guidance for historic environment desk-based assessment* (2012) and would be carried out with reference to the relevant legislative and planning frameworks. A field reconnaissance survey would also be required to assess the condition of the known sites, to identify further sites of heritage significance or archaeological potential and to identify potential effects (both direct and indirect) of the project.

A Landscape and Visual Impact Assessment (LVIA) would need to be undertaken to assess the potential significant landscape impacts associated with the preferred concept option. This should be undertaken in accordance with the Guidelines for Landscape and Visual Impact Assessment 3rd edition (Landscape Institute and the Institute of Environmental Management and Assessment, 2013). This would include the identification of landscape and visual receptors within the study area, and would include a description of the magnitude of impacts arising from the development on the landscape environment and visual amenity.

Interventions to the form and functioning of the riverine and coastal environment require assessment to ensure that WFD objectives are not compromised. Therefore, a hydromorphological audit would be required to assess the impacts of the scheme on the combined hydrological and geomorphological processes in the area. Information gathered from the assessment would allow a conceptual model of local system function to be developed, which would provide important information concerning the river and coastal system and would enable the project to be assessed against sustainability objectives.

The potential impacts associated with the construction phase of the project would need to be considered due to the potential risks to water quality and ecology in the River Adur, and impacts on local air quality and noise affecting local residents, businesses and recreational activities. Appropriate construction working methods and pollution prevention measures would need to be identified to ensure the risks to the water and groundwater environment are effectively managed.

Planning permission for the preferred concept option may be required as may several other consents including Flood Risk Management consent from the Environment Agency and a Marine Licence from the Marine Management Organisation (MMO) for the construction of the

scheme. Early consultation with Adur District Council would be recommended to determine the likely consenting requirements and supporting information necessary to inform the consenting process.

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