



JT Mackley and Co
**Littlehampton East Bank Tidal Walls Reach 4 set-back flood
defence**
Design Basis Report

September 2017

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1. General

1.1 Purpose of the report

The purpose of this report is to document the information that forms the basis of the design of the proposed infrastructure. It serves to provide all parties involved in the design, construction and operation of the facility with a clear and common understanding of the design criteria used.

1.2 Project Background

Previously, in 2013 The Environment Agency (EA) undertook the installation of flood protection works along the River Arun. During this phase, a small section of wall was not installed, located outside of 47 River Road (riverside autos). The scope of works is to design and construct this segment of the wall.

The works comprise of an approximate 26.7m length segment of sheet pile wall with a concrete capping beam, and fill behind.

1.3 Scope and limitations

This Specification covers the information required for the design of the marine infrastructure for the Littlehampton East Bank Tidal Walls, Reach 4.

The works shall be designed in accordance with the functional requirements, design loads and procedures as stipulated within this document, the project references and design standards.

The works are limited to design and construct of the following elements:

- Steel Sheet pile Wall;
- Concrete capping beam;
- Upstream and downstream concrete return walls; and
- Temporary works to support capping beam formwork and pile guides.

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1.4 Assumptions

The existing topographical survey does not indicate the location of the newly installed upstream and downstream flood protection works, nor does it indicate the pontoons which are located in front of these walls.

The location of these elements have been estimated based on onsite measurements.

A detailed topographical survey is planned, after which the design may be modified slightly to reflect the surveyed location of the existing structures.

1.5 Definitions

Table 1 - Definitions

Acronym	Definition
EA	Environment Agency
CD	Chart Datum
OD	Ordnance Datum
MHWS	Mean High Water Springs
MHWN	Mean High Water Neaps
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Spring
MMO	Marine Management Organisation

2. Site Information

2.1 Survey Control

The vertical datum shall be set to Ordnance Datum. The relationship between OD and Chart Datum (CD) datum shall be referenced on the drawings. Bathymetric survey for navigation and dredging works shall be undertaken to CD.

The horizontal co-ordinate system shall be to OS National Grid (OSGB1936). Transformation from WGS84 to OSGB to be completed by using OSTN02 transformation parameters.

2.2 Topographic Data

The following topographic survey data has been provided for the project:

- Littlehampton topographic survey, points in OD at approximately 10 to 15m centres. File name "[oslittlehampton.dwg](#)". Note: this survey does not include as built location of the recent downstream and upstream works.
- Topographic survey via drone (engaged by Mackley) to be provided after completion of Survey

2.3 Bathymetric Data

The following bathymetry survey data has been provided for the project:

- River Arun, Littlehampton Marine Geophysical Survey, Footbridge Bathymetric Chart L3211-12/02 Rev 0. Points in OD at approximately 5m centres. File name "[bathy.pdf](#)".

2.4 Geotechnical Data

The design is based on the following geotechnical investigative and interpretative reports

- Interpretative report specific to Lot 47 – Investigation Limited, 47 River Road, Littlehampton, West Sussex. Note: report based on establishing conditions for shallow pad / pile foundations for recent building development works. File name "[brief geotechnical report lw23030](#)".
 - BH1 – located within the yard of lot 47 to 20m below ground level
 - WS1 to 4 – Shallow boreholes located beneath the existing Riverside Auto buildings to 3m below ground level
- Factual report for Littlehampton Arun Tidal Defences from the mouth of River Arun to approximately 500m north of the A259 road crossing in the north (approximately 2.6km). The report provides two boreholes within proximity to site. File on GHD drive located "[Ground Investigation Littlehampton Arun G120043U.pdf](#)".
 - CPRCB10 and CPRCB11 to 20m below ground level

2.5 Climate Data

2.5.1 Temperature, Rainfall and Wind

Refer to Met Office website for climate station Littlehampton.
<http://www.metoffice.gov.uk/public/weather/climate/gcp95cbbs>

2.6 Meteorological Data

2.6.1 Tidal Planes

Table 2 - Tidal Plane Elevations (relative to Ordnance Datum (mOD))

Tidal Plane	(mCD)	(mOD)
MHWS	+5.6	+2.86
MHWN	+4.5	+1.76
MLWN	+1.5	-1.24
MLWS	+0.7	-2.04

0m OD = -2.74m CD

2.6.2 Sea Level Rise

Maritime and coastal structures shall adopt a Sea Level Rise (SLR) provision as nominated within UKCP09 and provided in the table below.

Table 3 - Design Sea Level Rise

Year of end of planning period	Sea Level Rise (m)
Year 2050	0.3
Year 2060	0.4
Year 2070	0.5

2.6.3 Extreme Water Levels

Flood protection level for the downstream properties has been identified as +4.80m OD.

Flood protection level for the upstream property has been identified as +4.90m OD.

To provide consistency between the two properties and the already provided flood immunity, the new structure shall be designed to have a flood protection level of +4.9m OD.

2.6.4 Waves

Maximum waves at the project site are understood to be generated from vessel wake, the magnitude of which is assumed to be: Hsig = 0.3m and Tpeak = 60 sec.

2.6.5 Currents

Current values are assumed to 2m/s at ± 20 degrees to the alignment of the structure for both flood and ebb flows.

2.7 Site Services

Two buried cables / pipelines are understood to be located beneath the ferry wharf, just downstream of the pedestrian footbridge. It is understood that no cross river cables or pipes are buried beneath the project site.

3. Project Information

3.1 Design Reliability

The facility falls under the legislative requirements of Environment Agency and Arun County Council. As such the minimum design reliability requirements are defined by the recurrence intervals and partial load and resistance factors of BS 6349 and referenced Eurocodes.

The design life and event recurrence intervals are listed in the relevant section of this report. The maintenance regime associated with this is also described in the same sections.

The works shall provide a standard of protection of 1 in 300 (0.33 annual exceeded probability) to year 75, design horizon 2050.

Components susceptible to wear and tear or degradation, such as fender panel pads, chains, handrails and grating shall have a design life of 10 years. These parts shall be designed to allow easy replacement.

3.2 Existing Infrastructure

3.2.1 Existing Flood Defence Works

Flood defence works have been completed both downstream and upstream of the project site, to which the works are to tie into.

The downstream works were part of the recent Environmental Agency Flood Protection Scheme, and included a sheet pile wall and reinforced concrete, with a glass flood balustrade to a height of +4.8m OD.

The upstream works were part of the recent redevelopment of Lot 49 River Road, and included a brick retaining wall with a concrete capping beam to a height of +4.9m OD.

3.2.2 47 River Road, Existing Sea Defence Condition

The existing sea defence along the face of 47 River Road consists of a timber retaining wall, as well as some concrete, brickwork and blockwork. The existing timber elements have been in position at the site for some time and have been subjected to coastal conditions, including salt water, marine borer attacks, and continuous changes in tidal levels leading to degradation of the timber elements and erosion of the soil retained behind.

A condition investigation of the site was conducted on the 21st October 2014 by a structural engineer from RSK and found that:

The timber wall is in extremely poor condition with damaged / lost horizontal boards, damaged tie rods, rotting timber piles and the formation of large voided areas beneath the yard area where the river has washed out the subgrade material.

The concrete capping beam has moved in position and temporary works comprising steel beams laid across the yard and resin fixed to the capping beam are in place to restrain further movement¹.

¹ 47 & 49 River Road Littlehampton, Structural Assessment of Buildings Prior to Sheet Piling Works, 287160-01 (00) – RSK, October 2014

3.2.3 47 River Road, Existing Building

The same condition conducted in October 2014 by RSK extending to the Riverside Autos building located within the yard. This investigation found:

This building dates back to the late 19th century (approx 1880). The original parts of the building are formed with stone cob walls, a solid concrete ground floor and timber suspended floors above.

No information is available to determine the foundation construction.

The rear elevation of the building is set back from the river wall and rather haphazardly clad in corrugated sheet steel. It was reported to RSK that the original rear section of No. 47 collapsed at some stage in the past. Although both the circumstances of this event and any improvements/strengthening that may have been made to the building as a result are unknown it does bring into question the stability of the building. The main wall to the left hand side (when viewing from River Road) has numerous open existing or previously repaired cracks.

The windows and possibly some of the metal cladding to the rear wall appear poorly fixed and may become damaged and fall if vibration is experienced by the building during piling operations. This also applies to loose roof slates and loose bricks/mortar to the front elevation on River Road.

The building is located approximately 5m from the last pile to be installed and could be affected by vibrations during installation of the piles.

3.3 Ground Level

The finish ground level behind the flood defences shall match the existing ground level (approximately +3.50m OD).

3.4 Sheet pile Alignment

The alignment of the sheet piles shall match that of the existing works for the downstream property (TBC – alignment may be amended slightly to allow extension of the upstream pontoon, topographical survey to confirm)

The alignment of the works shall be in accordance with drawing 66-000009-K-003².

3.5 Environment Requirements

3.5.1 Phase 1 Ecological Survey (Keystone Ecology)

An ecological survey is required of the site. In undertaking this, a combination of two Phase I survey techniques will be utilised, namely an Ecological Appraisal and River Corridor Survey. These survey's will aim to address potential ecological constraints arising from both terrestrial and aquatic environments.

An assessment of the building immediately adjacent to the site will also be undertaken simultaneously with the above survey's.

The river corridor survey will be undertaken covering approximately 200m of the River Arun including habitat upstream and downstream, where access permits. The survey methodology shall be based on the River Corridor Survey guidelines produced by the National Rivers Authority in 1992 (River Corridor Surveys Methods and Procedures: 1992. Bristol).

² Easting and Northings for the alignment of the sheet pile wall shall be provided on drawing 66-000009-K-003 following receipt of the drone site survey to be completed.

The bat roost inspection survey shall be in accordance with current bat guidelines (Collins, 2016) and shall involve an internal and external examination of the buildings, including any roof spaces or cellars.

The works will conclude with the preparation of a preliminary ecological appraisal report that from an appendix to the overall EIA screening report. The PEA will be undertaken in compliance with BS42020:2013 and CIEEM Guidelines for Ecological Report Writing (2016). It will comprise:

- A field survey to map habitats on site according to standard Phase I Habitat Survey
- A basic search of habitats present for evidence of use by and / or potential for protected species
- A basic search of the local biological records centre and any relevant web-based sites for details of important sites/habitats, species/habitats of principal importance and local biodiversity action plan species

3.5.2 Planning (Paris Smith LLP)

Works associated with the planning submission shall include:

- A site visit.
- Attendance at meetings with Council officers/consultees.
- Agreeing with the Council everything required to be submitted as part of the application.
- Completion of the applicable application form.
- Production of Planning Statement by the end of August.
- Reviewing other technical documents and plans to ensure consistency.
- Submission of planning application.
- Answering any post submission queries.
- Liaising with the client and other consultants throughout, whenever appropriate.
- Ongoing monitoring of the planning application once it has been submitted (up until a delegated decision has been issued.)

In addition to support the application, the following activities will be required:

- Preparation of EIA screening report in accordance with Part 1 and Part 2 of the 2011 regulations.

3.5.3 Marine Licencing

It is understood that the existing MMO licence will be extended by 12 months. An EA representative has made initial discussion with MMO and confirmed applicability.

A document, outlining the requirements of the extension, including timeframe and construction process will be required to confirm the applicability of the previous licence for these works.

The works will also need to be presented to the Littlehampton Harbour Master to confirm the acceptance of the proposed alignment of the flood protection, and positioning of the construction equipment (jack up barge).

4. Structural Design

4.1 Design Actions

4.1.1 General

The marine structures shall be designed to resist the design loads defined in this section and the environmental events associated with the following return periods.

Design actions shall be in accordance with BS 6349 and BS EN1991-1-1:2002 for a design life of 75 years.

4.1.2 Permanent Loads

Mean values of density shall be used for self weight calculation. Density values presented in BS EN1991-1-1:2002 shall be utilised.

4.1.3 Live/Imposed Loads

The minimum uniformly distributed loads and point loads shall be in accordance with Table 4.

Table 4 - Live Loads

	Uniformly Distributed Load	Point Load (area/ centres)
Hardstand Areas for Sheet Pile wall design		
Short Term	10 kPa	100 kN (300mm x 300mm)
Long Term	5 kPa	

4.1.4 Wave Loads

Wave loads are considered negligible at the site and for the design actions and therefore are not considered within the design.

4.1.5 Current Loads

Elements that extend into the river and impede or alter the flow of the river shall be designed considering effects from current loads. Current loads shall be determined in accordance with BS 6349 Part 1-2.

4.1.6 Wind Loads

Wind loads are considered negligible for the design actions and therefore are not considered within the design.

4.1.7 Seismic Loads

Seismic loads are considered negligible at the site and therefore are not considered within the design.

4.1.8 Thermal Loads

Structures shall be designed to accommodate movements due to thermal expansion and contraction.

The temperature ranges used to calculate contraction or expansion movements shall be in accordance with NA to BS EN 1991-1-5:2003 and the temperatures listed in Section 2.5.1.

The effects of vertical differential temperature gradients shall be considered with the temperature gradient sourced from NA to BS EN 1991-1-5:2003.

4.1.9 Soil Loads

The design of the sheet pile shall consider the additional imposed actions of granular fill to a height of +3.57m OD behind the wall.

4.1.10 Transportation and construction loads

All transport and construction loads shall be accommodated in the design. Loads that shall be included within the assessment shall include, however are not limited to, the following:

- Crane Loads
- Construction Vehicles
- Temporary stresses from incomplete structures
- Increased mass due to form work and temporary structures
- Effects of modularised or prefabricated elements
- Additional stresses generated during sea transport

The assessment of construction loads shall identify the minimum required time for curing of concrete to allow continuation of the works where applicable.

4.1.11 Combination of actions

Actions should be combined using the formulae given in BS EN 1990:2002+A1 and in Table 2 of BS 6349 Part 1-2 to verify ultimate and serviceability limit states for a full range of design situation appropriate to the works.

4.2 Crack Control

Crack control in reinforced concrete structures shall be achieved by limiting steel stresses in accordance with the recommendations of AS4997.

4.3 Deflection Limitations

The structure and its component members should be designed for serviceability by controlling or limiting settlement, deflections, and cracking.

Deformations should be calculated in accordance with BS EN 1992 to BS EN 1999 by using appropriate combinations of actions according to BS EN 1990:2002+A1, expressions 6.14a to 6.16b.

Deflection under serviceability loads and load factors shall not exceed the recommended deflection limits stated within EN 1993-5:2007 and EN 1997-1:2004.

The maximum acceptable relative rotation of the sheet piles under in service loads shall be limited to 1/300.

4.4 Fill design

Backfill behind the newly installed sheet pile wall shall consist of self compacting gravel material.

4.5 Sheet pile Wall Design

4.5.1 Stability

Sheet pile walls shall be designed using limit equilibrium methods based on traditional factor of safety ("FoS"). The following minimum factors of safety will be adopted based on the recommendations contained in "Soil Strength and Slope Stability" textbook by Duncan & Wright (2005):

- Short term stability FoS = 1.3
- Long term stability FoS = 1.5
- Stability under seismic conditions FoS = 1.0

4.5.2 Modelling

Modelling of the wall shall be completed utilising Wallap.

4.5.3 Pile Design

The pile design shall be undertaken in accordance with BS EN1993-5:2007.

4.5.4 Pile Testing and Verification

Sheet piles are to be installed to a minimum toe level to achieve lateral stability. The minimum toe level shall be identified on the project drawings. During driving, an experience geotechnical engineer shall be onsite to confirm the parameters utilised for design from the provided geotechnical investigation match those at the location of the pile.

4.5.5 Pile Driveability

A pile driveability analysis using proprietary software 'GRLWEAP' shall be undertaken to provide input on the ability to drive to the piles to their proposed toe levels with the nominated hammer. The driveability assessment will also confirm if driving stresses are within allowable limits for the pile material.

4.5.6 Tidal Lag

The sheet pile wall shall be designed with a tidal lag of not less than one third of the spring tidal range unless drainage holes are provided within the sheets.

If a drainage system is provided, the design shall consider the difference between two layers of holes as the tidal lag.

4.5.7 Drainage

The sheet pile wall drainage system shall incorporate granular material and weep holes to allow the free drainage of water, in order to prevent the buildup of water behind the wall, including the water differential from tidal lag. Weep holes shall be protected with geotextile to prevent the loss of soil through the wall.

4.6 Geotechnical Design Parameters

The following parameters have been interpreted from the two geotechnical investigations identified within Section 2.4.

Borehole CPRCB11

Easting: 502,324. Northing: 102,178. Ground Level: +3.29m OD

Table 5 - Borehole CPRCB11 Interpretation

Layer Type	Nominated Type	Depth			SPT	γ (kN/m ³)		Effective Cohesion	Undrained Cohesion	Angle of Shearing Resistance
		Top of Layer	Bottom of Layer	Total		Dry	Saturated			
Made Ground	Pavement	3.29	3.24	0.05						
Made Ground	Pavement	3.24	3.14	0.1						
Made Ground	Pavement	3.14	3.09	0.05						
Made Ground	Soft Clay	3.09	2.93	0.16	-	16	18	0	20	20
Made Ground	Loose Sand	2.93	2.83	0.1	-	16	20	0		30
Made Ground	Loose Gravel	2.83	2.45	0.38	-	16	20	0		30
Made Ground	Loose Gravel	2.45	2.09	0.36	-	16	20	0		30
VS Clay	Soft Clay	2.09	1.29	0.8	47	16	20	0	20	20
S Clay	Soft Clay	1.29	0.59	0.7	8	16	18	0	20	20
D Sand	Dense Sand	0.59	0.29	0.3		18	21			30
Chalk	Chalk Grade Dm	0.29	-1.21	1.5	14 to 19	16	20	0		30
Chalk	Chalk Grade Dm	-1.21	-3.11	1.9	11	14	19	0		30
Chalk	Chalk Grade Dm	-3.11	-6.11	3	13	14	19	0		30
Chalk	Chalk Grade C	-6.11	-9.11	3	24	18	22	20		34
Chalk	Chalk Grade B	-9.11	-11.61	2.5	47	18	22	20		34
Chalk	Chalk Grade A	-11.61	-16.81	5.2	50 to 75	19	23	20		34

Borehole CPRCB10

Easting: 502,361. Northing: 102,140. Ground Level: +3.27m OD

Table 6 - Borehole CPRCB10 Interpretation

Layer Type	Nominated Type	Depth			SPT	γ (kN/m3)		Effective Cohesion	Undrained Cohesion	Angle of Shearing Resistance
		Top of Layer	Bottom of Layer	Total		Dry	Saturated			
Made Ground	Pavement	3.27	3.2	0.07		Excluded from Analysis				
Made Ground	Loose Sand	3.2	2.93	0.27	-	16	20	0		30
Made Ground	Loose Gravel	2.93	2.87	0.06	-	16	20	0		30
Made Ground	Loose Sand	2.87	2.62	0.25	-	16	20	0		30
Made Ground	Loose Gravel	2.62	2.32	0.3	-	16	20	0		30
Made Ground	Loose Gravel	2.32	2.14	0.18	-	16	20	0		30
Made Ground	Loose Gravel	2.14	1.27	0.87	40	16	20	0		30
Chalk	Chalk Grade Dm	1.27	-0.73	2	12 to 17	16	20	0		30
Chalk	Chalk Grade Dm	-0.73	-1.23	0.5	15	16	20	0		30
Chalk	Chalk Grade C	-1.23	-2.33	1.1		18	22	20		34
Chalk	Chalk Grade C	-2.33	-5.33	3	33	18	22	20		34
Chalk	Chalk Grade A	-5.33	-13.73	8.4	50 to 100	19	23	20		34
Chalk	Chalk Grade A	-13.73	-16.73	3	50 to 75	19	23	20		34

*Design Values***Table 7 - Ground Profile Design Values**

Layer Type	Nominated Type	Depth			SPT	γ (kN/m ³)		Effective Cohesion	Angle of Shearing Resistance	Wall Friction Angle ³	Youngs Modulus (MPa)	Poisson's Ratio
		Top of Layer	Bottom of Layer	Total		Dry	Saturated					
Granular Fill		4.9	-1	5.9		16	20		30	22	100	0.3
D Sand	Dense Sand	-1	-1.3	0.3		18	21		30	11	70	0.3
Chalk	Chalk Grade Dm	-1.3	-2.8	1.5	14 to 19	16	20	0	30	14	95	0.3
Chalk	Chalk Grade Dm	-2.8	-7.7	4.9	11	14	19	0	30	14	95	0.3
Chalk	Chalk Grade C	-7.7	-10.7	3	24	18	22	20	34	17	120	0.2
Chalk	Chalk Grade B	-10.7	-13.2	2.5	47	18	22	20	34	22	150	0.2
Chalk	Chalk Grade A	-13.2	-18.4	5.2	50 to 75	19	23	20	34	22	150	0.2

³ Wall friction effects will not be considered for the design of the anchor wall (if applicable).

4.7 Materials

4.7.1 Concrete

BS 6349 Concrete Mix

Concrete properties and mix design shall be in accordance with BS 6349 Part 1-4:2013.

Minimum cover to reinforcement shall be 65mm (60mm + 5mm) – assumes controlled placement of reinforcement.

Concrete mix shall be C40/50, maximum water cement ratio of 0.35, minimum cement content of 380 kg/m³. Cement combination shall be IIB-V + SR (25% to 35% fly ash).

Alternative Mix

Alternatively, the following mix design shall be utilised for a minimum cover to reinforcement of 55mm (50mm + 5mm):

- | | |
|---|-----------------|
| • Concrete 28 day cylinder strength (MPa): | 50 |
| • Max. W/B ratio by mass: | 0.40 |
| • Max. coarse aggregate size (mm): | 20 |
| • Cement type: | LH ⁴ |
| • Min. cement content (kg/m ³): | 400 |
| • Max. cement content (kg/m ³): | 450 |

4.7.2 Sheet piles

Steel sheet piles shall be in accordance with BS 6349 Part 1-4.

4.8 Functional Requirements

4.8.1 Structural Elevations

The crest of the capping shall match the existing height of the works completed in 2013

4.8.2 Handrailing

Handrails, including guardrails, shall be provided at stairways, landings, platforms, walkways and deck edges in accordance with BS 6349.

Where road traffic barriers act as separation between vehicles and personnel access, or where combined vehicles and personnel access is required, handrails shall be provided in addition to the road traffic barriers.

4.8.3 Stairs, platforms and Walkways

No stairs, platforms or walkways are to be provided along the length of the wall.

4.8.4 Ladders

No ladders to be provided along the length of the wall.

⁴ Type LH cement contains 25% Fly Ash, 5% Silica Fume, 70% General Portland Cement, 25 l/m³ DCI (calcium nitrite corrosion inhibitor)

4.8.5 Security and Fencing

Security and fencing shall be the landowners responsibility. Temporary fencing shall be erected during construction to prevent unauthorised access to the site.

4.9 Safety

4.9.1 Minimum Clearances for Access (if required for temporary works)

The design shall be in accordance with the following minimum clearances:

- Height over walkways, passageways and platforms 2,500 mm
- Width for passageways and elevated walkways 750 mm
- Width of catwalks 1,000 mm
- Width where maintenance access only is required 600 mm
- Vehicle clearance width (single lane – inside width) 4,000 mm

Safe access shall be provided for all maintainable equipment.

4.9.2 Safety Signage

Safety signage shall be provided by the landowner after completion of the works.

4.9.3 Safety Equipment on Marine Structures

Not provided.

4.10 Durability

4.10.1 Exposure Environments

Exposure categories shall be determined in accordance with the more stringent requirements of BS 6349 or BS EN1993-5:2007.

Buried environments shall be assessed in accordance with BS EN1993-5:2007 Part 4, including an assessment of acid sulphate soils determined from the relevant site investigations.

4.10.2 Coatings

Steel elements are to be designed without protective coatings. Steel thickness shall consider the effects of corrosion.

4.10.3 Corrosion Allowance

Corrosion allowance requirements for steel piles are provided below for a 75 year design life.

Table 8 - Corrosion Rates

Zone	Corrosion Allowance	Protection Requirements
Atmospheric zone (all steel above splash zone)	2.0 mm	Not painted. Shall be protected by additional steel thickness.
Splash zone	5.6 mm	Not painted. Shall be protected by additional steel thickness.
Submerged zone (below -1m LAT to 3 metre below seabed)	2.4 mm	Not painted. Shall be protected by additional steel thickness.
Buried zone (below 3 metre below seabed)	1.25 mm	Not painted. Shall be protected by additional steel thickness.

- The splash zone is defined as LAT to 300mm above HAT
- Components susceptible to wear and tear or degradation, such as guardrails, handrails, fender panel pads, chains, etc, shall have a durability design life of 10 years and may be designed without a corrosion allowance. These parts shall be designed to allow easy replacement.

4.10.4 Maintenance Requirements

The adoption of a design life represents the duration the asset will be expected to possess the structural integrity and capacity to resist the specified design loads and continue to be serviceable. A maintenance inspection schedule to monitor the condition of the structures is expected to be implemented as per the following:

- inspection of marine structures every 3 years
- inspection of marine furniture every 3 years

4.10.5 Dissimilar Metals

All contact faces of dissimilar metals shall be electrically separated with non-ferrous material to prevent dissimilar metal corrosion.

5. Buildability Statement

5.1 Introduction

The works include the provision of flood protection along the River Arun, located near the water edge of 47 River Road.

Recently, the Environment Agency (EA) has completed flood protection works along the River Arun as part of the Littlehampton East Bank Tidal Walls Flood Defence Scheme. During this phase of works, a segment of the flood protection was not constructed at 47 River Road as these works were to be completed by the landowner. Due to a change in circumstances for the landowner, they are no longer able to complete the flood protection works at the site and as such the EA has elected to continue a similar solution to the downstream configuration. Previous works by the EA and landowner, and the site are identified in Figure 1.

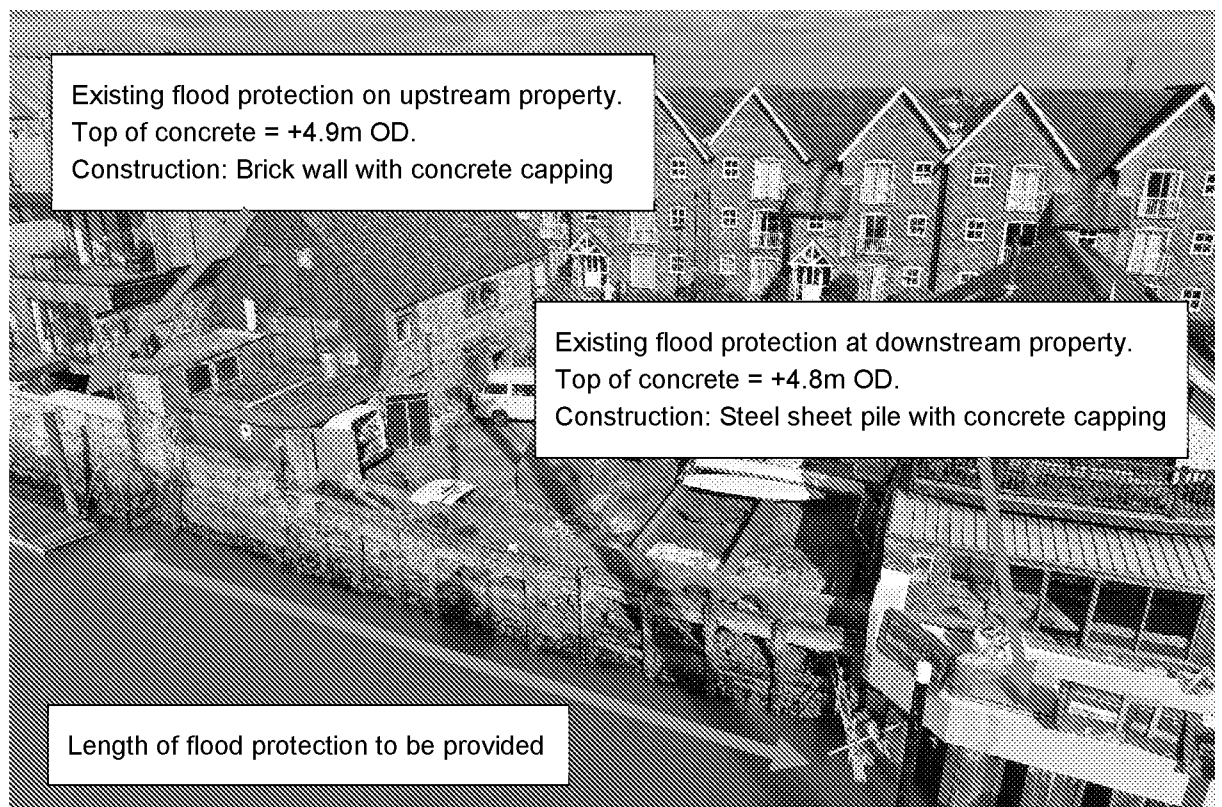


Figure 1 - Area of Works

The current concept considers the use of steel sheet piles, embedded into the sub strata, with a concrete capping beam. Fill will then be placed behind the wall to infill the gap between the existing timber retaining structure and the new sheet pile wall.

The capping beam will also be connected to the existing downstream capping beam, and form a closed connection (i.e. the new structure will butt up against the existing structure, some bricks may be required to be removed) with the upstream brick wall and concrete capping beam

The existing timber wall may be removed to improve the integrity of the fill placed between the existing ground and sheet piles.

5.2 Construction Method

5.2.1 Process

Works are envisaged to occur with the following process:

1. Sheet piles will be driven to required toe level utilising a vibratory hammer from a jack up barge, or soft start percussive piling
2. Drainage layer installed within pans of sheet piles;
3. Initial stage of fill provided between the existing reclamation slope and sheet pile walls;
4. Capping Beam constructed utilising framing off the initial fill, or scaffolding;
5. Fill to ground level (+3.5m OD) and compaction.

5.2.2 Driving of Sheetpiles

The sheet piles are proposed to be driven from floating or jack up barge, utilising a crane attached vibratory hammer and temporary frames. Driving of the sheetpiles is anticipated to start at the downstream end, and progressively work upstream utilising the panel driving technique.

A temporary guide frame will be constructed to control the straightness of the wall. The guide will consist of two I beams laid along the length of the wall, one on the seaward face of the sheet piles, the other on the landward face. This will be constructed by temporary connection to the existing downstream structure (nominally the capping beam) and the use of temporary spuds at intervals to vertically support the frame.

The panel driving technique shall follow the nominal process identified by ArcelorMittal and described within Figure 2.

Prior to driving the piles the follow preparation works are required to be undertaken:

- Water pressure relief holes will be included in the design of the piles. A series of drainage holes will be cut into the sheet pile in the area of the drainage column (see Section 5.2.3);
- Clutches will be cut at the base and head of each connecting sheet pile to aid in the ease of clutching the sheet piles together. Clutch grease will also be applied to minimise friction during the driving process;
- A corner will need to be developed at the upstream end. A corner section (or connector) will be utilised to allow the change in direction of the piles.

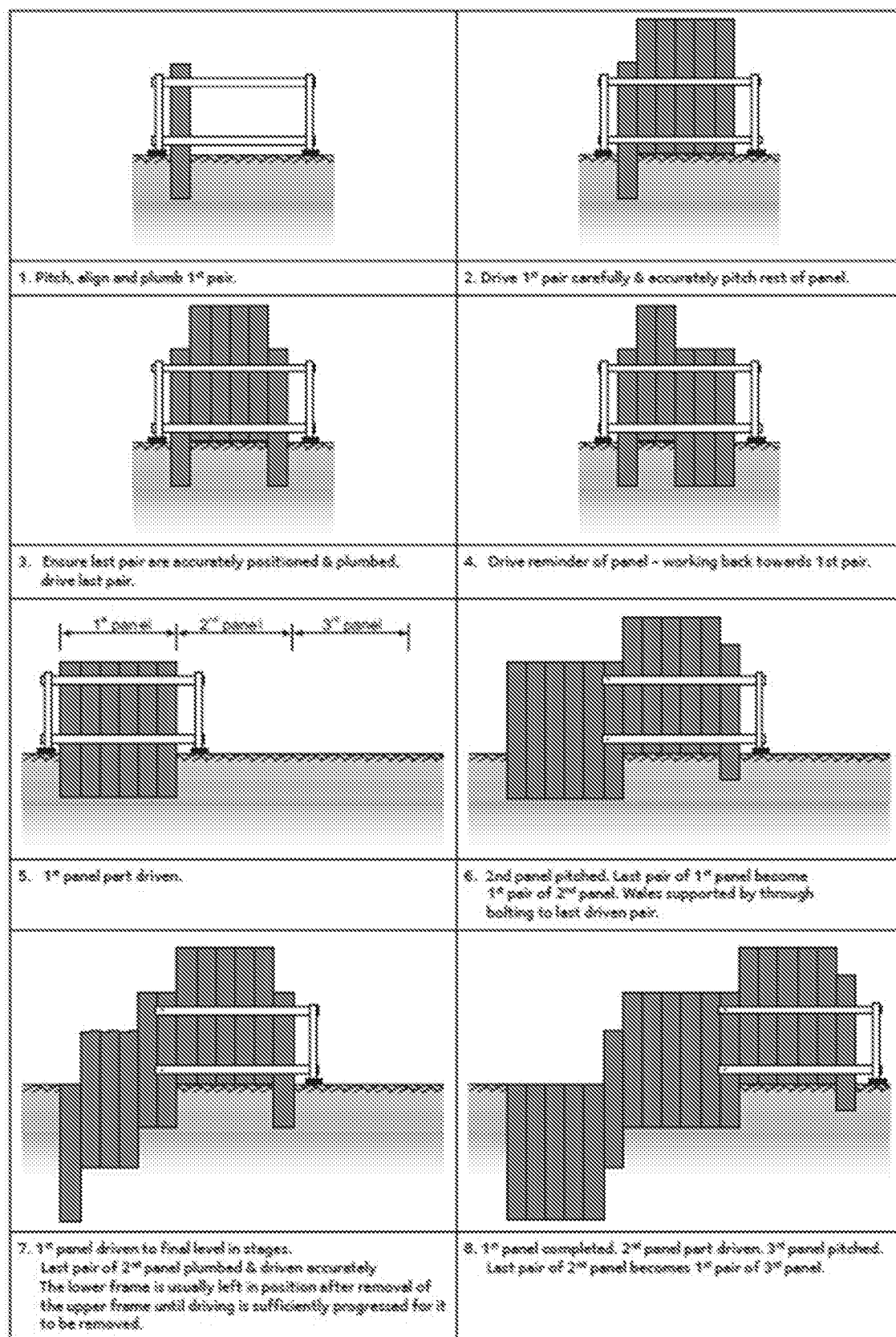


Figure 2 - Panel Driving (Source ArcelorMittal)

Note: Figure 2 shows the traditional pile guide configuration. The intended configuration for the installation of the piles Jack Up barge will only utilise the top gate.

5.2.3 Drainage Layer

The design considers that drainage system will be provided to prevent the build-up of groundwater behind the piles.

To facilitate this, each of the sheet piles shall have a series of drainage holes drilled into the pans. These holes will approximately align as per the below figure, as the piles are laterally loaded and the toe of the pile is defined during design, the location of these holes is readily known, therefore enabling prefabrication. This is beneficial as the steel does not need to be cut in or above water.

The sheet pile pans will then be filled with gravel material and sealed with geotextile. The gravel will allow the flow of water, and the geotextile will prevent the loss of fines. A geotextile bag will be prefabricated and filled with gravel. Once the piles are installed, the bags will be lowered into the appropriate pans to form the drainage layer. Fill will then be added behind to support the bags. Volume of gravel will be slightly greater than the pan to allow the material to fill the void.

In some locations, more than one bag may be required per each pan depending on the height and weight of the bags. In this instance, another layer of geotextile shall be provided over the full height of the pile between the geobags and fill material so that fines do not migrate through the point where the bags meet.

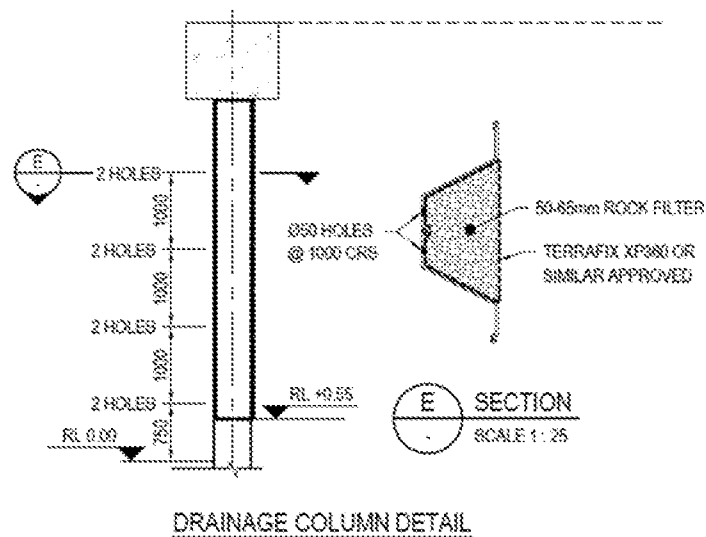


Figure 3 - Example Drainage Column Detail

5.2.4 Capping Beam

Once the piles have been driven and trimmed to their final level, a reinforced cast insitu-concrete capping beam will need to be installed. Casting of the capping beam will occur in two stages:

1. Capping beam; and
2. Flood protection upstand.

It is intended that the formwork for the capping beam will be constructed over temporary scaffolding or structure to reduce the fill volume, and therefore lateral load, on the unsupported sheet piles. The formwork will be constructed out of ply wood and supported via the temporary formwork constructed utilising the Redeb system, or from a small scaffolding structure constructed over a portion of the fill material.

Reinforcement cages will be prefabricated on ground and lifted into the formwork, with continuity bars located as required. Once placement of the reinforcement bars has completed, the concrete will be poured from land utilising a tub lifted by a small crane.

The design locates the soffit of the capping beam above MHWS, and therefore the formwork should not be inundated by water; however it may be exposed to wave actions. In the event water seeps through the formwork at high tide prior to the concrete pour, the water shall be drained and the reinforcement bars cleaned with potable water to remove any chlorides.

5.2.5 Fill

The capping beam shall be formed, poured and cured (7 days) prior to undertaking placement of fill behind. This is to prevent deformation of the sheet piles as the capping beam will provide some lateral restraint once tied into the existing downstream and upstream walls.

Fill material will be placed in layers of no more than 1m. The first layer of material shall be placed at low tide to allow sufficient compaction of the material to be achieved. The remaining layers shall be placed in line with the rising tide, with each layer being compacted as required by the specification.

Special attention will need to be paid to compaction of the fill under the capping beam (Figure 4). In this area, access to the fill will be constrained by the overhang of the capping beam. As such, the depth of layers may need to be reduced to allow sufficient compaction to be achieved.

Fill will be placed upto +3.5m OD.

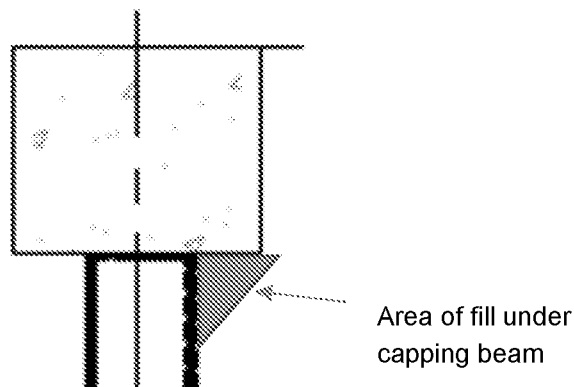


Figure 4 - Area of Fill Beneath Capping Area

5.3 Site Working Hours

Normal working hours for the works are 07.00 to 18.00 – Mon to Fri, and Sat 08.00 to 13.00

No construction activities are undertaken outside of these hours, without prior written agreement of the Project Manager

5.4 Contingency in Event of Flood or Extreme Weather

In the event of extreme weather or tide, the following procedure will be implemented.

During installation of the sheet piles, works will be completed from a jack up barge, similar to the Haven Seariser 1 shown in Figure 5. During this phase of works, equipment to install the piles (crane and hammer) will be stored on the jack up barge or at the Tarmac Wharf.

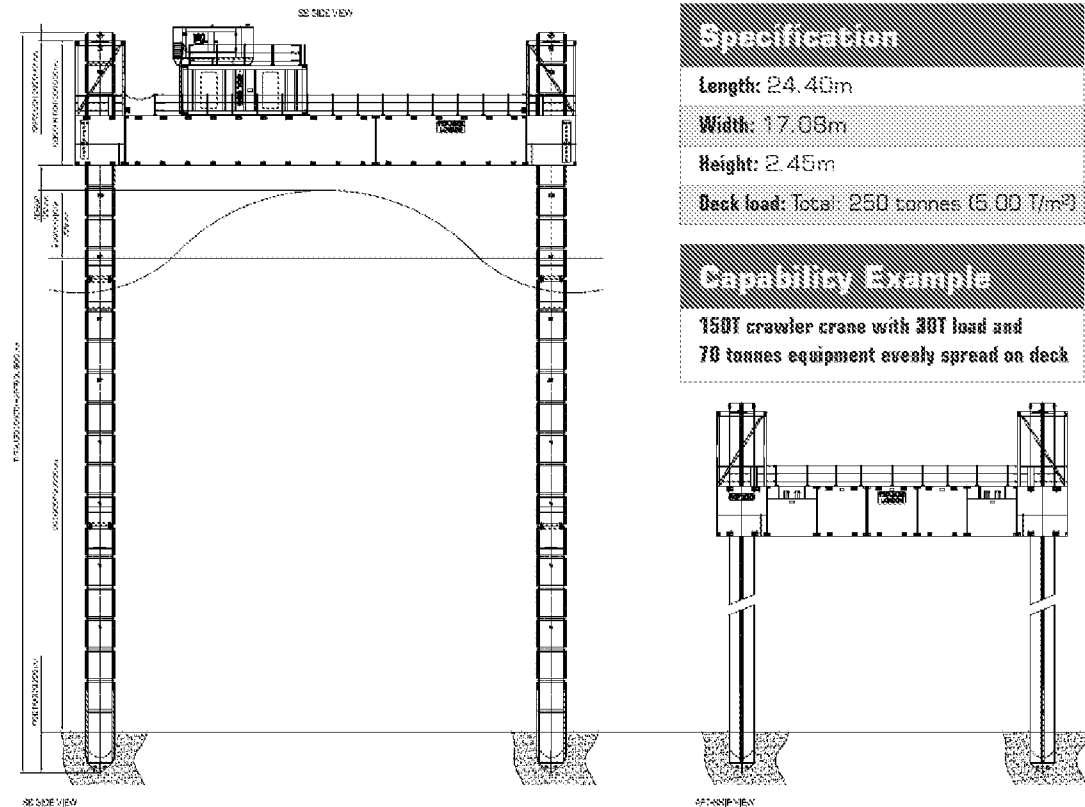


Figure 5 - Jack Up in Raised Position (Source: Topbond Jackup)

In the event of a flood, it is anticipated that sufficient warning can be provided owing to the weather conditions required to develop such an event. The barge will remain in location and will be raised to a suitable level such that it is above the anticipated flood level. Equipment aboard the barge at the time will be securely tied down and personnel will be transferred to site prior to the flood event occurring. This process is represented within Figure 6. See detail sent

In the event of a storm where high winds are anticipated which may exceed the capacity of the barge spuds, the barge shall be floated to the Tarmac Wharf and securely moored alongside. Any loose equipment will be removed from the deck and stored on land or in containers on the Tarmac wharf. The works will stop and the barge jacked up, no adverse effect on Jack up

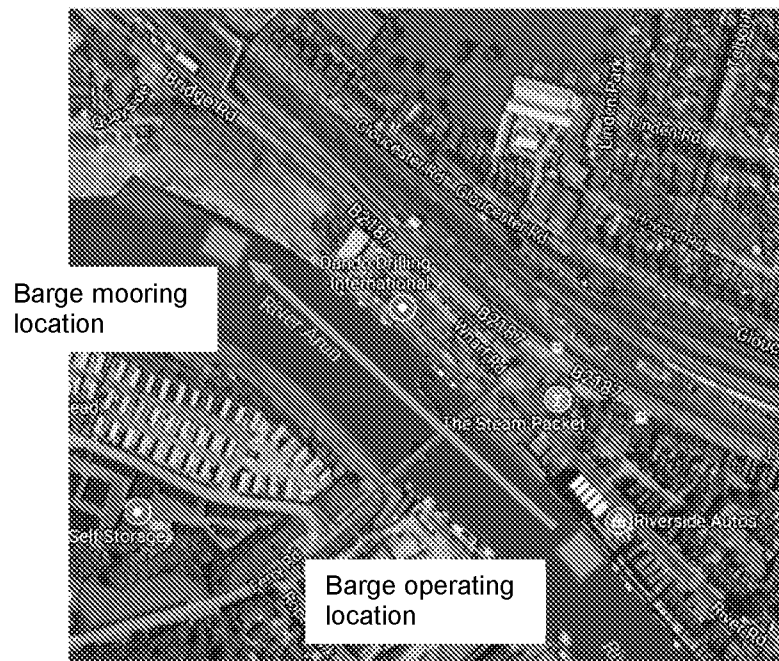


Figure 6 - Barge Course to Extreme Weather Mooring

During the piling phase, only minimum equipment will be stored on land at Riverside Autos. The driving of the sheet piles is intended to not inhibit or damage the existing flood protection and therefore the river wall will continue to provide tidal and flood protection for the site.

During backfilling works will occur behind the newly driven sheet pile wall. The top of the sheet piles will be around the same height as the existing ground level of the site, therefore the sheet piles will act as flood protection for the site during minor flooding events. In extreme flooding events, the existing material bags located on site will be aligned along the face of the site to act as additional flood protection.

Works will only be completed during suitable wind periods. During periods of high wind, all equipment will be securely stored or tied down on site behind the sheet piles or temporary defences depending on the anticipated water level during the event.

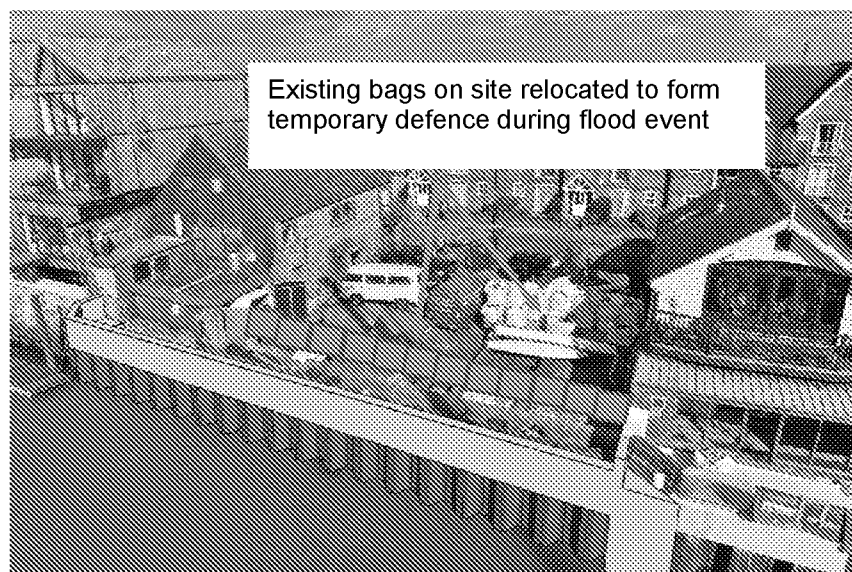


Figure 7 - Temporary Flood Defence Configuration

All COSHH fluids will be securely sealed and locked away. In the event of anticipated extreme weather these will be removed from site.

5.5 Vehicle Movements

5.5.1 Estimate Vehicle Movements

The estimated number of vehicles which are expected to require access to the site are presented in Table 9. As the sheet piles will be driven by the equipment located on the floating barge, it is expected that the piles will be delivered to the nearby Tarmac Wharf and floated to the barge.

Table 9 - Vehicle Numbers for Access to 47 River Road

Type	Description	Est. Volume	Unit	Required Number of Trucks
Establishment	Welfare delivery	1	No.	1
Establishment	Welfare removal	1	No.	1
Establishment	Site container	1	No.	1
Establishment	Site container	1	No.	1
Fill Material	20 tonne lorry, 450 tonne of soil in bulk condition	450	t	23
Construction Equipment	Sheet piles	3	No.	3
Reinforcement	Delivery of reinforcement	4	No.	4
Concrete	6 m ³ tonne concrete mixer, 100 tonne of concrete	100	t	8
Personnel Access	Personnel Access (6 weeks @ 6 days, 2 weeks @ 7 days, crew of 6) - Cars	180	No.	180
Total (Trucks Only) + 20% contingency				50

5.5.2 Access Route

Access to site during delivery's is intended to follow the path shown in Figure 8.



Figure 8 - Access Route to Site for Construction Vehicles (Source: Google)

5.5.3 Sheetpiles

Sheet piles are intended to be installed via the jack up barge. The sheet piles will be delivered to the Tarmac wharf located upstream of the construction site and either floated to the barge, or placed on the barge prior to the barge being mobilised to site. The access route for the sheet piles is shown in Figure 9

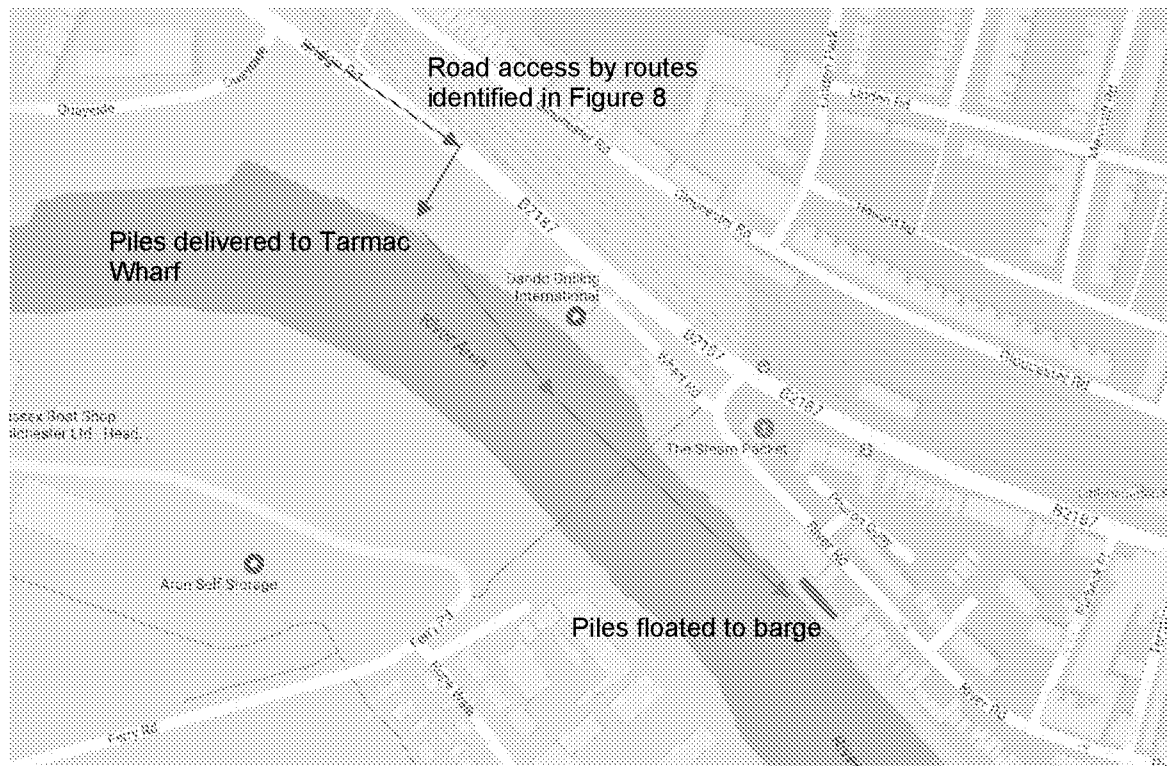


Figure 9 - Sheet pile Access Route

5.6 Site Waste Management Plan

Site waste for the works is envisaged to be a small quantity. Site waste shall be managed based on the following processes and elements. Note, site waste management shall be further developed after the completion of the detailed design phase and recorded within the construction management plan.

Site waste should only be:

- Cut-off from piles: any steel removed from the head of the pile after the designated toe level has been met shall be removed and sent to a local scrap metal yard for recycling;
- Any additional volume of concrete left over from the pour of the capping beam shall be either returned to batching plant, or disposed of correctly at the nearest landfill – the concrete capping beam shall be constructed from land;
- Any additional fill material left over for fill between the existing timber wall and new sheet piles shall be spread over the site to assist levelling, and making good of the yard after works are completed; and
- General site waste, such as building products, packaging, additional tie wire, etc shall be sorted for recycling or disposal and sent to a local land fill or recycling yard.

No construction material shall remain on site after completion of the works.

Once the works are completed, the ground level of the existing yard shall be restored with imported granular fill. This will provide a level surface, but does not include any betterment to the existing yard condition.

During the driving of the sheet piles, it is expected that sediments will be stirred up by the vibratory action of the piling hammer. In addition to this, a crane and hammer with associated hydraulic hoses will be hanging over the water. Therefore, to prevent the release of potential foreign contaminants to the river water, a temporary floating bund will be provided around the site which will encompass the jack up barge. In addition, the hydraulic fluid for the works will utilise biodegradable hydraulic fluids.

6. Project Risk Assessment

A project risk assessment shall be completed for the works, including a design risk assessment and H&S workshop. The purpose of the risk assessment is to attempt to identify risks or hazards associated with the design, construction, importation, commissioning, operation, maintenance, demolition and disposal of the works.

For each risk item raised, a risk rating based on the probability of the event occurring and the consequence of the event will be determined. Where possible, any items identified as high or medium risks shall consider potential mitigation methods, or the possibility of designing the risk out.

The procedure for the risk assessment will follow the guidelines set out by the EA and GHD's safety in design guidelines (HSE40). The risk assessment shall utilise the EA NCPMS Risk Management System proforma.

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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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