Uber Boat
by thames clippers

HAMMERSMITH TEMPORARY FERRY

FLOOD RISK ASSESSMENT

BECKETT RANKINE
Marine Consulting Engineers

AUGUST 2021
2048-BRL-02-XX-RP-C-1200

CONTROLLED DOCUMENT STATUS

CLIENT	Uber Boat by Thames Clippers
PROJECT TITLE	Hammersmith Temporary Ferry
SUBJECT	Planning & Consents
DOCUMENT TITLE	Flood Risk Assessment
DOCUMENT REF	2048-BRL-02-XX-RP-C-1200

REVISION RECORD

REV	STATUS	DATE	SUMMARY OF CHANGES	PREP	CHK	APP
P01	S2 – Suitable for Information	10/05/2021	-	RS	NS	GG
P02	S2 – Suitable for Information	02/06/2021	Updated to include EA comments	GG	HP	TKHB
P03	S2 – Suitable for Information	13/06/2021	Update to include EA query responses	GG	OM	TKHB
P04	S2 – Suitable for Information	18/08/2021	Update to include LBHF query responses	GG	HP	HP

CONTENTS

1 INTRODUCTION

1.1 General

1.1.1 Two piers are to be constructed as part of the Hammersmith Temporary Ferry development for use by the Transport for London service run by Uber Boat by Thames Clippers. These piers shall act as a temporary replacement for the closed Hammersmith Bridge to transfer pedestrians and cyclists across the River Thames. Planning permission is being sought for a temporary period of up to 3 years. They will then be removed and the site restored to its present condition.

1.1.2 Beckett Rankine (BR) has prepared this Flood Risk Assessment to determine the level of flood risk associated with the works. This will also enable the identification of mitigation measures needed to make the proposed development safe for its lifetime and ensure it does not increase flood risk for 3rd parties.

1.1.3 This report uses information and guidance as set out by the following documents:

- The National Planning Policy Framework (NPPF), February 2019
- The Environment Agency's Flood Risk Assessment: Climate Change Allowance Guidance, February 2016
- Thames Estuary Design Water Levels and Future Defence Crest Levels, May 2015
- Thames Estuary 2100 Plan, November 2012
- London Borough of Richmond upon Thames Strategic Flood Risk Assessment – Level 1, March 2021
- London Borough of Hammersmith and Fulham Strategic Flood Risk Assessment Final, December 2016

2 THE PROPOSED PLAN

2.1 Site Location

2.1.1 The site is located just east of Hammersmith Bridge on the River Thames, see Figure 2.1. Hammersmith Pier (off the North bank) is located within the London Borough of Hammersmith and Fulham (LBHF). Barnes Pier (off the South bank) is located within the London Borough of Richmond upon Thames (LBRuT).

Figure 2.1: Site location

2.2 The Proposed Development

2.2.1 In April 2019, the Hammersmith Suspension Bridge was closed indefinitely to all motor traffic after cracks were discovered in the bridge's pedestal. In August 2020, this closure was extended to pedestrians and cyclists. As an alternative crossing, a temporary ferry service is planned to transport pedestrians and cyclists across the river, with temporary piers to be installed on either bank to serve the ferry vessels.

2.2.2 Hammersmith Pier will utilise a second-hand barge restrained using spud legs. Minor bed levelling in front of the barge will be required to create a suitable berthing pocket for the vessels. Access to the pier from the land will be via a steel frame ramp over the existing flood defence boards across the slipway at the end of Queen Caroline Street, leading onto a modular pontoon walkway. The walkway will be restrained by tubular piles and will partially rest on the foreshore during nearly all states of tide.

2.2.3 Barnes Pier on the South bank will re-use the existing Savoy pier; again, this will be restrained by spud legs. Access to the pier will be via an aluminium canting brow. The area landside is below the flood defence level and regularly floods – therefore a steel framed walkway will be installed to raise the level of the landing with only minimal reduction in flood storage volume.

2.2.4 Figure 2.2 below illustrates the proposed development.

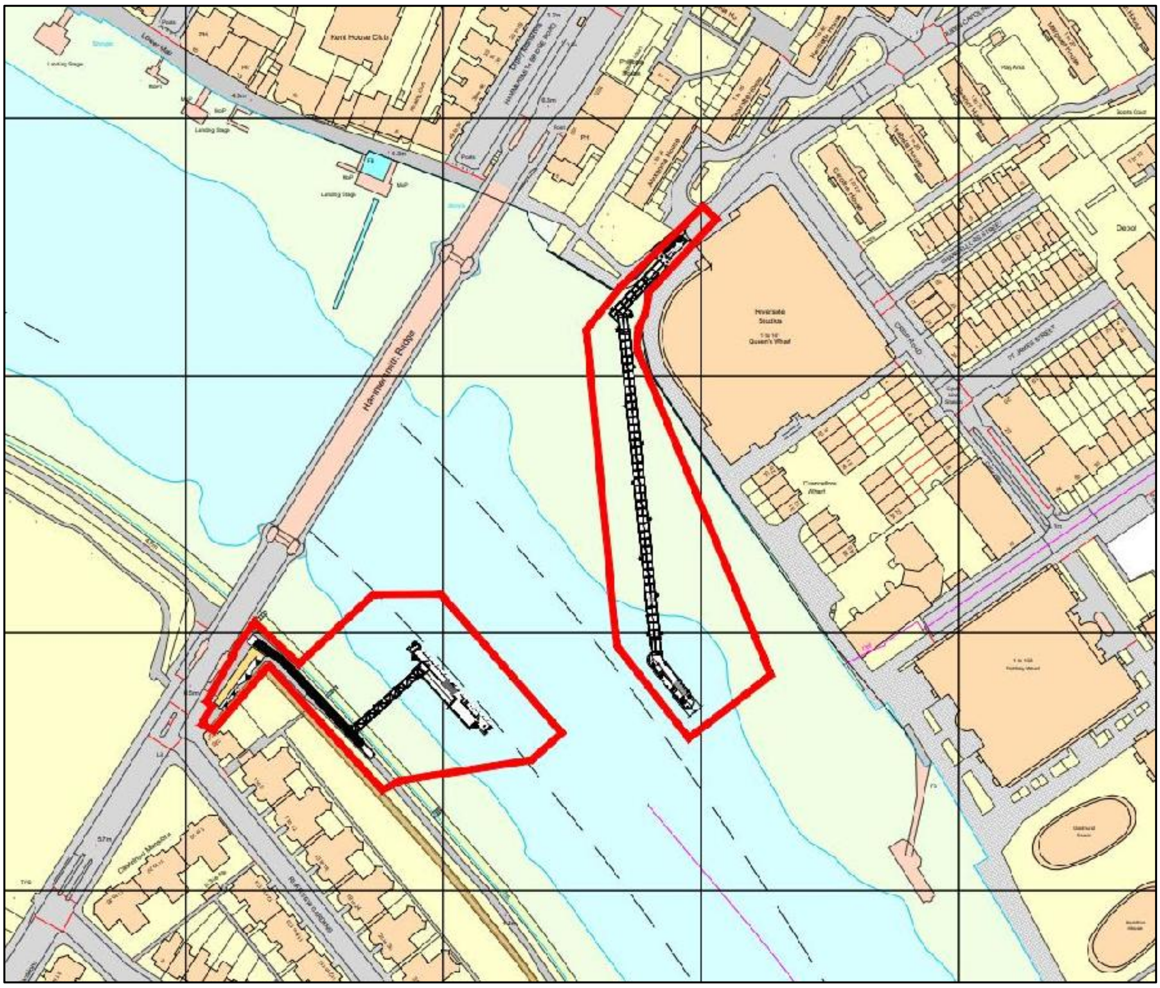


Figure 2.2: Proposed development plan

2.3 Flood Defences

2.3.1 The site is protected by the Thames Tidal Defences (TTD), which provides protection through a combination of raised defences, flood proofing and the Thames Barrier. The TTD are designed to defend against events of a 1 in 1000-year flood event (up to and including the 0.1% AEP tide level) however there will always be a residual risk from the barriers being overtopped during a flooding event.

2.3.2 The Thames Estuary plan 2100 states that Hammersmith could witness flood depth of up to 2m if the Thames Barrier fails.

2.4 Operational Requirements

2.4.1 The piers are to be designed for an operational life of 3 years with a maximum possible life of 5 years.

3 NATIONAL PLANNING POLICY FRAMEWORK

3.1 National Planning Policy Framework (NPPF)

3.1.1 The NPPF (February 2019) sets out the Government's planning policies for England and how these are expected to be applied. With respect to floods, local planning authorities should adopt proactive strategies to mitigate and adapt to climate change, considering flood risk, coastal change and water supply.

3.1.2 Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. Local Plans should be supported by Strategic Flood Risk Assessment and develop policies to manage flood risk from all sources, taking account of advice from the Environment Agency and other relevant flood risk management bodies, such as lead local flood authorities and internal drainage boards. Local Plans should apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change, by:

- If required, applying the Sequential Test.
- If necessary, applying the Exception Test.
- Safeguarding land from development that is required for current and future flood management.
- Using opportunities offered by new development to reduce the causes and impacts of flooding.
- Where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to facilitate the relocation of development, including housing, to more sustainable locations.

3.2 Flood Zone

3.2.1 Flood Zones refer to the probability of river or sea flooding, ignoring the presence of defences. Flood zones do not consider the possible impacts of climate change and consequent changes in the future probability of flooding. There are 3 types of Flood Zones which are defined for planning purposes as defined in Table 3-1.

Table 3-1: Flood zone definitions **Source: https://www.gov.uk/guidance/flood-risk-and-coastal-change#Table-1-Flood-Zones**

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding (shown as 'clear' on the flood map – all land outside Zones 2 or 3).
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1,000 annual probability of sea flooding (shown in light blue on the flood map).
Zone 3a High Probability	Land having between a 1 in 100 or greater annual probability of river flooding; or land having between a 1 in 200 or greater annual probability of sea flooding (shown in dark blue on the flood map).
Zone 3b Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments area of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency (not separately distinguished from Zone 3a on the flood map).

3.2.2 According to the Environment Agency's flood map, the proposed site lies within Flood Zone 3, see Figure 3.1. More specifically, everything riverward of the flood defence is in Flood Zone 3b and everything landward of the flood defence is in Flood Zone 3a as shown in Figure 3-2. As the piers will float atop of the river, they are in Flood Zone 3b (see Figure 3.2).

3.2.3 The area where the walkway leading to the Barnes Pier will be, regularly floods since it is located riverward of the flood defences, and thus is considered in zone 3b. The map in Figure 3.2 does not include this area, but Figure 3.3 highlights the extra area to be considered.

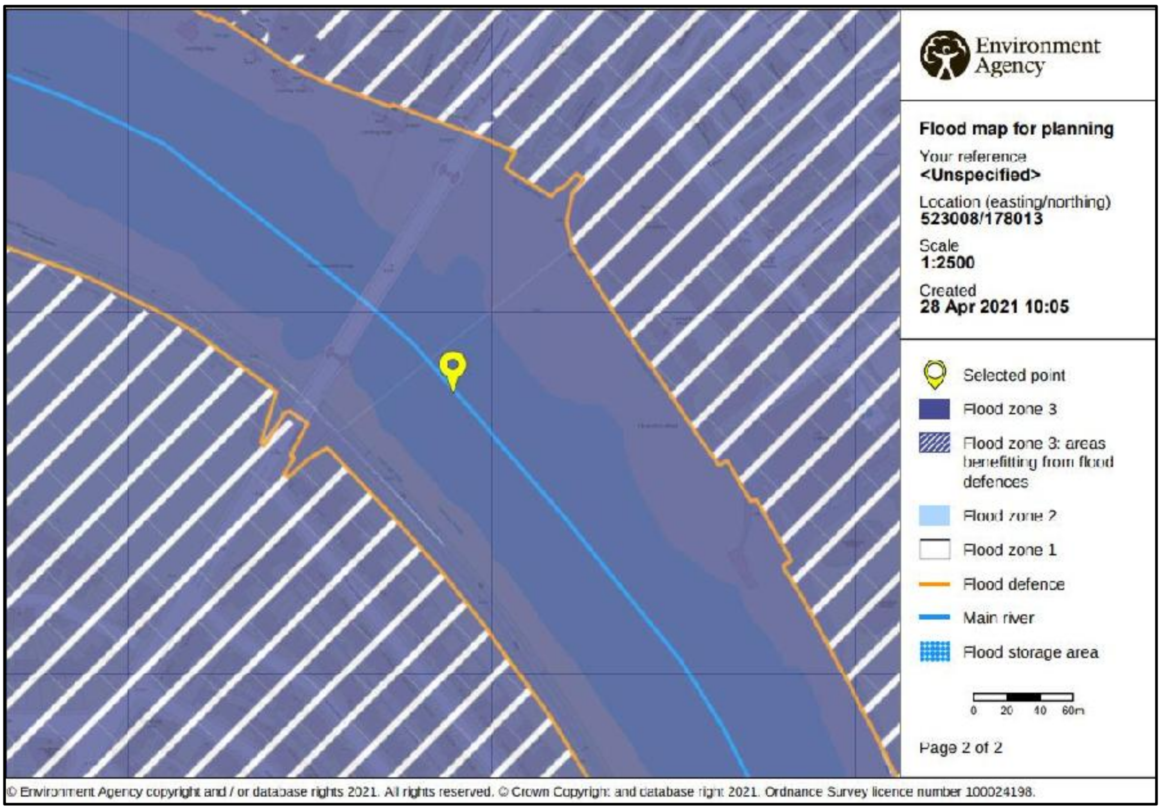


Figure 3.1: Site flood zone **Source: https://flood-map-for-planning.service.gov.uk/**

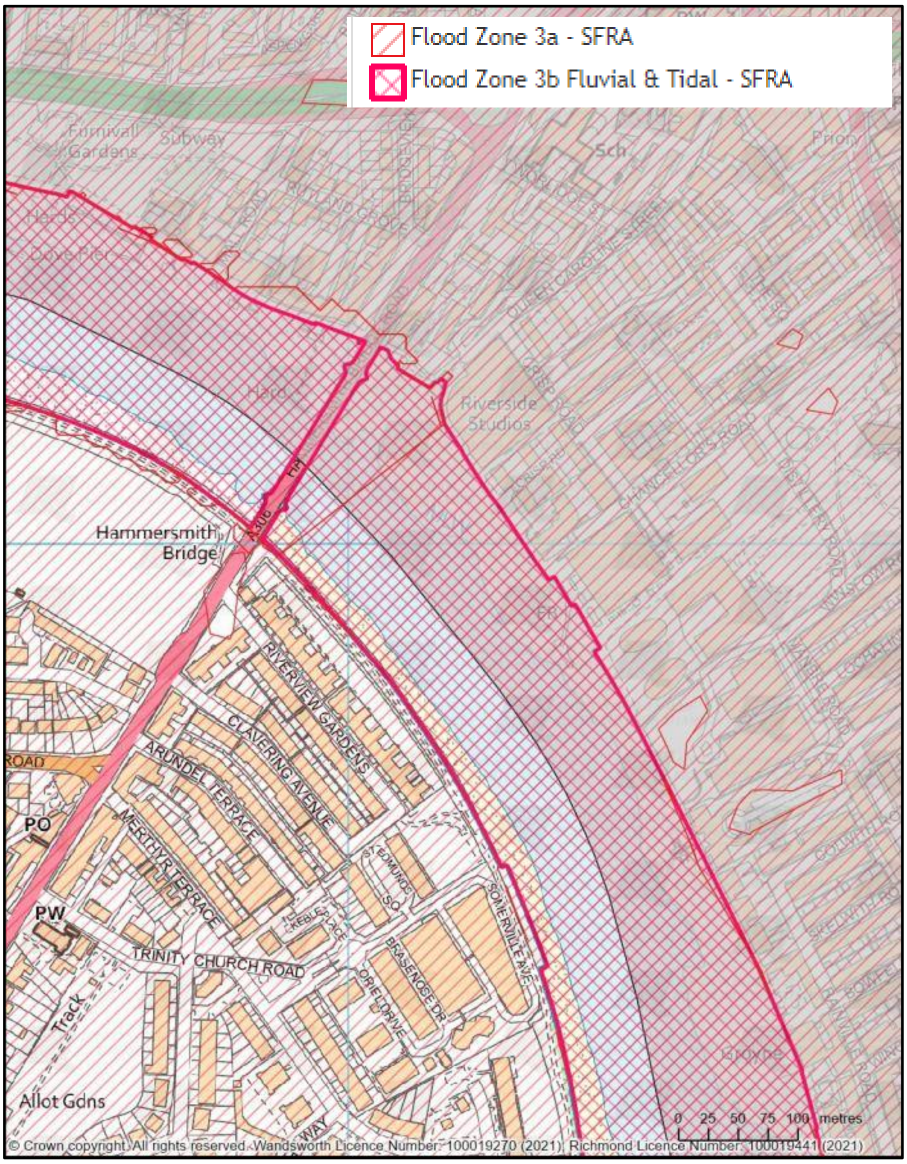


Figure 3.2: Site flood zones 3a and 3b

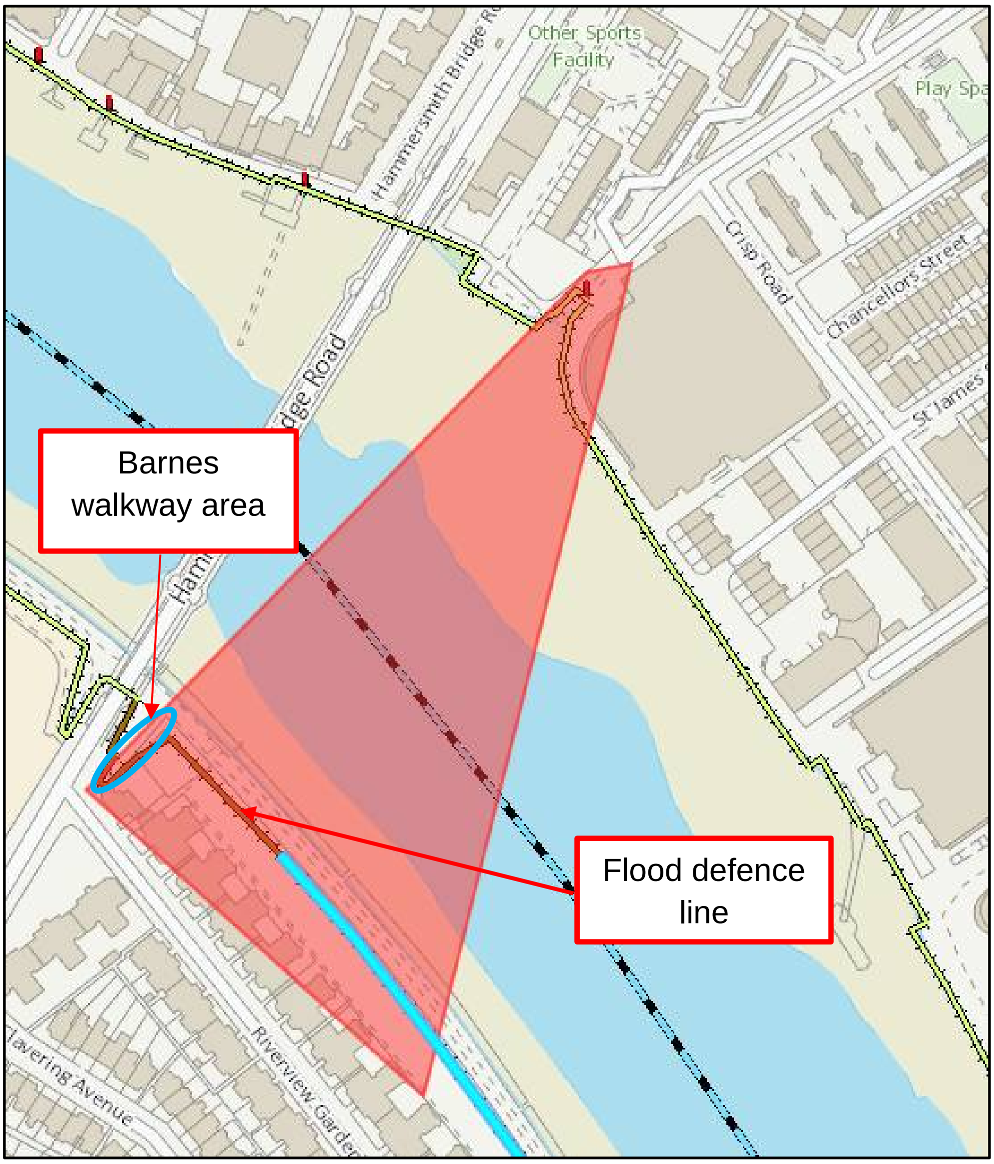


Figure 3.3: Barnes walkway area that should be considered zone 3b

3.3 Sequential Test

3.3.1 The aim of the Sequential Test is to ensure that a sequential approach is followed to steer new development to areas with the lowest probability of flooding i.e., to steer new development to Flood Zone 1.

3.3.2 Where there are no reasonably available sites in Flood Zone 1, local planning authorities in their decision making should consider the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required.

3.3.3 When no reasonably available sites in Flood Zones 1 or 2 are available, only then should the suitability of sites in Flood Zone 3 be considered, considering the flood risk vulnerability of land uses and applying the Exception Test.

3.3.4 As the proposed development must be on the river, there is no possibility of moving the project to another area less likely to flood.

3.4 Flood Risk Vulnerability Classification

3.4.1 Table 3-2 outlines the different classifications of flood risk vulnerability.

Table 3-2: Flood risk vulnerability classification
Source: Table 2, https://www.gov.uk/guidance/flood-risk-and-coastal-change#Table-3-Flood-risk-vulnerability)

Vulnerability classification	Land uses
Essential infrastructure	Essential transport infrastructure (including mass evacuation routes) which must cross the area at risk. Essential utility infrastructure which must be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. Wind turbines.
Highly vulnerable	Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding. Emergency dispersal points. Basement dwellings. Caravans, mobile homes and park homes intended for permanent residential use. Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as ‘Essential Infrastructure’).

More vulnerable	Hospitals Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. Non–residential uses for health services, nurseries and educational establishments. Landfill* and sites used for waste management facilities for hazardous waste. Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.
Less vulnerable	Police, ambulance and fire stations which are not required to be operational during flooding. Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure. Land and buildings used for agriculture and forestry. Waste treatment (except landfill* and hazardous waste facilities). Minerals working and processing (except for sand and gravel working). Water treatment works which do not need to remain operational during times of flood. Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.
Water-compatible development	Flood control infrastructure. Water transmission infrastructure and pumping stations. Sewage transmission infrastructure and pumping stations. Sand and gravel working. Docks, marinas and wharves. Navigation facilities. Ministry of Defence installations. Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. Water-based recreation (excluding sleeping accommodation). Lifeguard and coastguard stations. Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

3.4.2 The proposed development is classified as water compatible as its function is to act as a berthing facility for passenger vessels; this means it falls within the category of 'docks, marinas and wharves'.

Table 3-3: Flood zone compatibility
Source: Table 3, https://www.gov.uk/guidance/flood-risk-and-coastal-change#Table-2-Flood-Risk-Vulnerability-Classification

Flood Zones	Flood Risk Vulnerability Classification				
	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Zone 1	✔	✔	✔	✔	✔
Zone 2	✔	Exception Test required	✔	✔	✔
Zone 3a	Exception Test required	✕	Exception Test required	✔	✔
Zone 3b	Exception Test required	✕	✕	✕	✔
Key: ✔ Development is appropriate ✕ Development should not be permitted					

3.4.3 As shown in Table 3-3, because the proposal is water-compatible and in Zone 3b, the development is deemed appropriate, and no Exception Test is required provided that the infrastructure is designed and constructed to:

- Remain operational and safe for users in times of flood.
- Result in no net loss of floodplain storage.
- Not impede water flows and not increase flood risk elsewhere.

3.4.4 Mitigation measures for the above are discussed in Section 0.

4 STRATEGIC FLOOD RISK ASSESSMENT

4.1 General

4.1.1 A Strategic Flood Risk Assessment (SFRA) is a study carried out by one or more local authorities to assess the risk to an area from flooding from all sources, now and in the future, considering the impacts of climate change, and to assess the impact that changes or development in the area will have on flood risk.

4.1.2 The SFRA is to consider flooding from all sources such as river, sea, tides, estuary, surface water, sewer, groundwater, artificial infrastructures (reservoirs, etc).

4.1.3 The London Borough of Hammersmith and Fulham (LBHF) SFRA was last updated by Capita and Aecom in December 2016. The London Borough of Richmond upon Thames (LBRuT) SFRA was last updated by Metis Consultants in March 2021.

4.2 Development Control Recommendations

4.2.1 The SFRAs have been used to assist in developing this site-specific flood risk assessment. Table 4-1 sets out the flowing recommendations for proposed developments in Flood Zone 3b. According to LBRuT SFRA this development is classified as a minor development as the site area is less than 1 hectare.

Table 4-1: Recommendations for developments in Flood Zone 3b **Source: Table 6-1, LBRuT SFRA**

Policy Response	Recommendation	Action
Site-specific FRA	Required for all developments	This current document forms the site-specific FRA for the proposed development.
Environment Agency Consultation	Required for all developments	See Section 6.
Statement on SuDS	Minor developments that have a bearing on a site's existing drainage regime need to provide a Statement on SuDS	See Section 7.

Flood Compensation Storage	For fluvial flooding only, compensation for any loss of Zone 3b (functional floodplain) should be provided on a level-for-level and volume-for-volume basis	See Section 8.7.
Site-Specific Flood Emergency Plan	Required for all developments	See Section 8.4.
Buffer Zone	Developments should be set back from the riverbanks and existing flood defences infrastructure where possible - 16m for the tidal Thames. Developments within this distance may require a flood risk activity permit in addition to planning permissions.	A Flood Risk Activity Permit has been obtained for the work (ref: EPR/ZB3355LH)

4.2.2 As mentioned in Section 3.4, since the development is water-compatible, the Exception Test is not required.

5 FLOOD RISK OVERVIEW

5.1 Tidal Levels

5.1.1 Tidal levels have been taken from the Port of London Authority Chart 311 and are as shown in Table 5-1.

Table 5-1: Tidal details, referred to levels at Hammersmith Bridge.

Tidal level	Ordnance Datum (m)	Chart Datum (m)
Highest recorded (1978)	+5.45	+7.13
HAT	+4.67	+6.35
Mean High Water Springs	+3.95	+5.63
Mean High Water	+3.23	+4.91
Mean High Water Neaps	+2.50	+4.18
Ordnance Datum (Newlyn)	--------	+1.68
Mean Low Water Neaps	-0.98	+0.70
Mean Low Water Springs	-1.19	+0.49
Chart Datum	-1.68	--------

5.2 Climate Change Impact

5.2.1 Due to the temporary nature of the works (operational life of up to 3 years) the impact of climate change on the development is negligible, and thus will not be further considered in this document.

5.3 River and Coastal Flood Risk (Fluvial)

Figure 5.1: Flood risk from rivers or seas **Source: Environment Agency**

5.3.1 Figure 5.1 shows that the pontoon and pier locations have a 'High' risk of flooding for both piers. Alongside this, the landside access for the Barnes pier is at a 'High' risk. However, the landside access of the Hammersmith (North) pier presents a 'Very low' risk of flooding.

5.4 Surface Flood Risk

5.4.1 Surface flooding is due to the impact of heavy rainfall. As per Figure 5.2, there is a 'Very low' risk on all parts of the site, except for the landside access of the Hammersmith pier on Queen Caroline Street where there is a 'High' risk.

5.4.2 On further inspection Queen Caroline Street has sufficient drainage to ensure that surface water does not accumulate where the landside access will be. The area is not known to flood or experience water ponding currently. The area is sloped towards the park land immediately to the west to aid infiltration. The adjacent Queen Caroline Street provides further drainage. The access ramp has been designed with drainage in mind such that there will be no deck ponding. Therefore, the surface flood risk is minimal in this area and is not a major risk to the site.

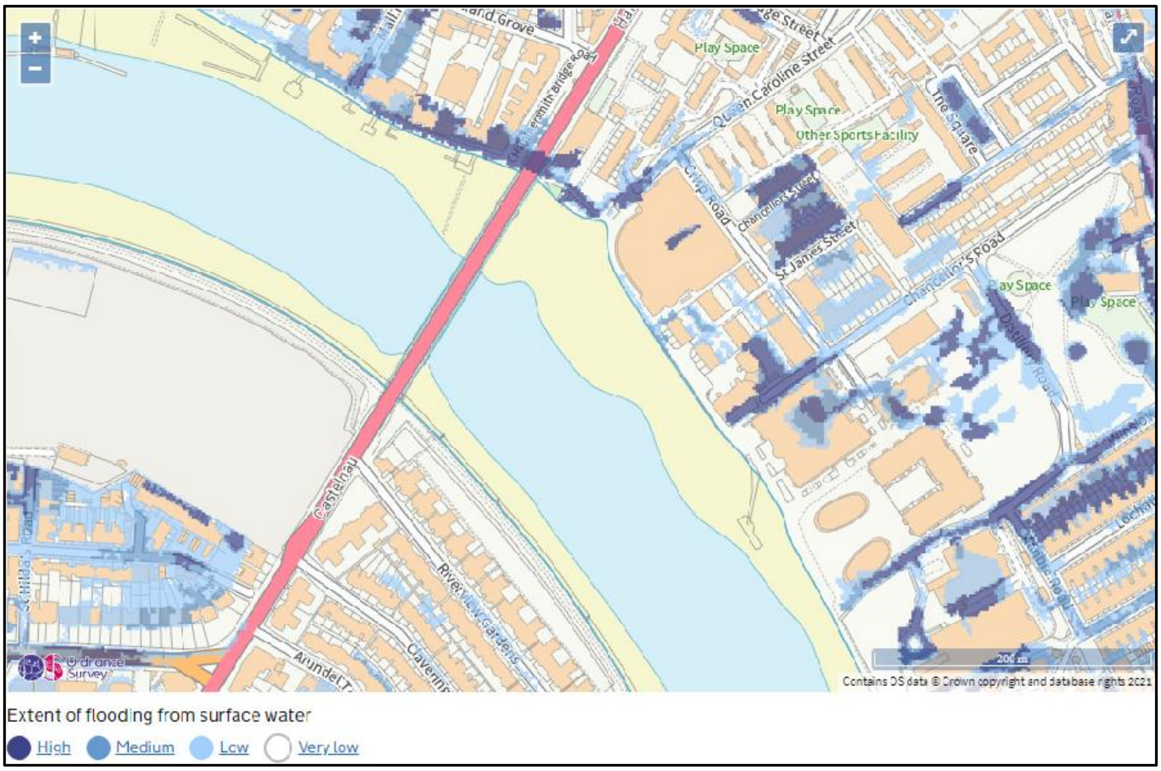


Figure 5.2: Flood risk from surface water **Source: Environment Agency**

5.5 Reservoir Flood Risk

5.5.1 There is some risk from reservoirs flooding in the area, as shown in Figure 5.3.

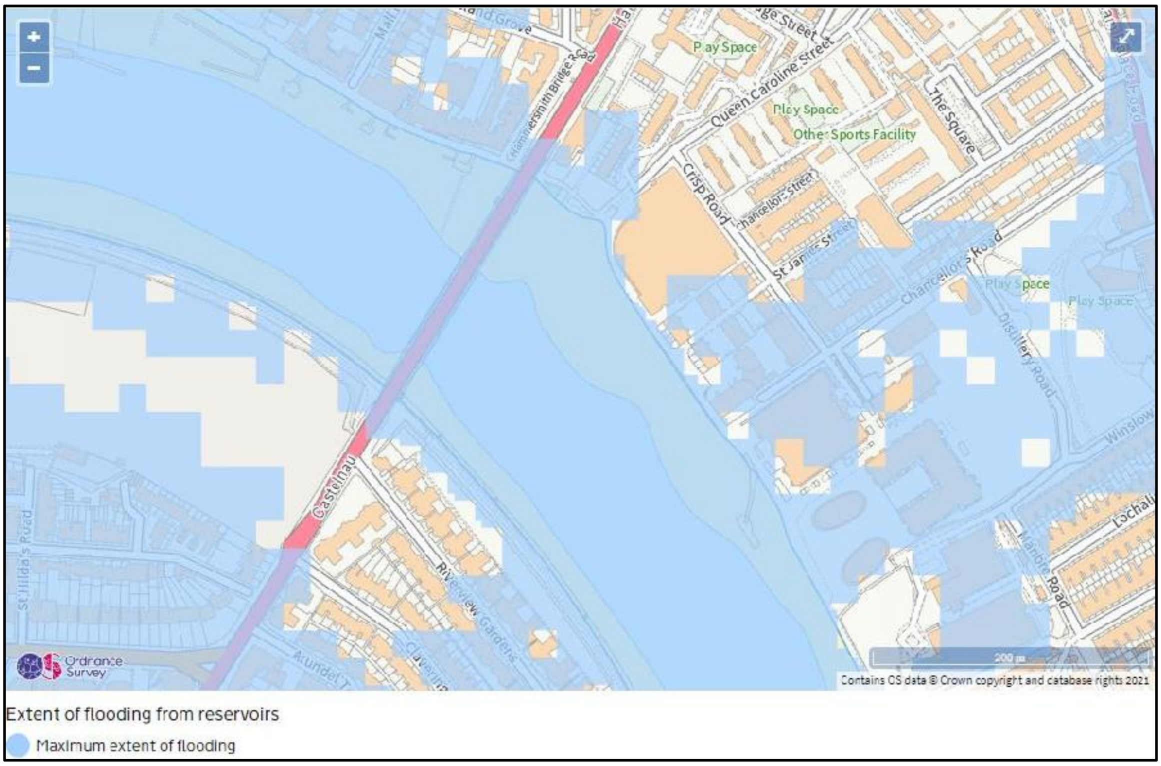


Figure 5.3: Flood risk from reservoirs

5.5.2 On further inspection, the likelihood of this happening is minimal. This is because under the Reservoirs Act 1975 every reservoir in the UK has regular inspections and is supervised by reservoir panel engineers. Additionally, the LBRuT SFRA states that there have been no reports of flooding from reservoirs within the Richmond upon Thames borough and the LBHF SFRA makes no mention of any reservoir floods in the Hammersmith and Fulham borough. Therefore, reservoirs present a minimal risk and the EA map shown is for the worst-case scenario, only if they were to flood.

5.6 Groundwater Flood Risk

5.6.1 There is no groundwater flood risk at the proposed location. The water table is at +2.16mOD for the Barnes pier and at 0.02mOD for the Hammersmith pier. The proposed works will not penetrate to these levels behind the flood defences, so there is no risk of groundwater flooding.

5.7 Services Flood Risk

5.7.1 A small pipe (approximately 12mm diameter) carrying potable water will be run from landside to the piers. If it were to rupture on the riverward side, it will drain naturally into the river. If it were to rupture on the landward side, due to the limited pipe size and pressure, it can be assumed that the existing drainage system will be able to withstand the excess water, thus meaning there is no additional risk of flooding.

6 ENVIRONMENT AGENCY CONSULTATION

6.1.1 Ongoing discussion has been had with the Environment Agency with reference to the Flood Risk Activity Permit and the associated information. These meetings took place on 8th April and 22nd April, respectively.

6.1.2 The outcome of these meetings has been used to inform this Flood Risk Assessment and the wider permit.

6.1.3 The Flood Risk Activity Permit has now been granted on 12^{th} July 2021

7 STATEMENT ON SUSTAINABLE URBAN DRAINAGE SYSTEMS (SUDS)

7.1 General

7.1.1 SUDS provide an alternative to directly channelling surface water through a network of pipes and sewers to nearby watercourses. These are environmentally beneficial, causing minimal or no long-term detrimental damage.

7.1.2 It is deemed that SUDS are not necessary for the development as the structure does not impact the rainfall volume entering the river across the area; surface water landing on the riverward structures (i.e. the walkways, brows, pontoons and piles) will be allowed to naturally drain directly to the river. The landside elements of each pier are considered in more detail below.

7.2 Hammersmith Pier - Landside

7.2.1 The section of landside access situated behind the flood defences is paved and drains naturally into the existing surface water drainage network. This will be done by using a slip-resistant drainable surface for the decking material (e.g. GRP mesh or similar). Given this, no additional pressure will be placed on the existing surface water drainage system from retainment, and therefore this will remain sufficient post-installation of the pier.

7.3 Barnes Pier - Landside

As the landside access is in front of the flood defence, this can be deemed as ‘riverward’ meaning that no additional drainage system is necessary. Furthermore, the implementation of drainable decking material again will allow water to percolate through the walkway such that no water will be retained. Hence there will be no different than in its current state.

FLOOD DEFENCE CONSIDERATION

7.4 Flood Defence Level Continuation

7.4.1 Hammersmith Temporary Pier lands at the Queen Caroline Street Slipway. One of the timber planks which blocks off the slipway will be removed to facilitate this. The plank will be replaced following removal of the pier. The removal of this plank will not reduce the wall level beneath flood defence level (5.54m OD), and it will remain higher (or equal in level to) the adjacent flood defence wall at Queen's Wharf which is compliant with the statutory flood defence level, shown at the left of Fig 8.1.

Figure 0.1: Hammersmith Temporary Pier - Landing Location

7.4.2 As part of the ongoing operation and maintenance plan for the Hammersmith Ferry, the operator will ensure that the Timber flood boards which make up the flood defence at the slipway are maintained while the pier structure is in place. This may include complete replacement of the timber flood boards should their condition require it. It is envisaged that their condition will be established as part of the initial inspection prior to the works starting. Further inspections of the flood defence will be carried out prior to commissioning, and then periodic inspections will be carried out during operation. An initial inspection interval of 6-months is anticipated but this is to be varied depending on the results of the inspections.

7.4.3 Additionally, the landside ramp on the top of the Queen Caroline Street Slipway is designed such that it can be removed and access to the flood defence granted in the case of an emergency.

7.4.4 The landside interface of Barnes Pier is located on the Barnes towpath. The towpath is below flood defence level. A lightweight steel walkway will be installed to allow pier users dry transit from the pier in high water conditions. The flood defence crest is an upstand brick wall located at the back of the Riverview Garden's properties. The wall is setback such that it is not affected by the works.

7.4.5 Hence the installation, operation and decommissioning of the temporary piers will have no impact on the maintained height of the current flood defence.

7.5 Stability and Loading Consideration

7.5.1 Hammersmith Temporary Pier access will not load adversely load the flood defence. The access structure will ramp over the timber boarding such that there is no load transfer into the flood defence wall. Any loading applied by the lightweight steel frame access structure will be distributed across the landside and slipway surface such that there is no additional load placed on the flood defence.

7.5.2 The landside access at Barnes Temporary Pier has the potential to impact the stability of the revetment located in front of the flood defence (see Appendix A). We have carried out detailed analysis of the slope stability of the revetment and have developed the design such that the integrity of the revetment is not compromised. The revetment is currently stable. The analysis considers the stability of the revetment during construction and post construction. The crest of the flood defence is not affected by the works and its stability has therefore not be considered.

8 MITIGATION MEASURES

8.1 Introduction

8.1.1 As stated in Section 3.4, the proposed development, being a ferry operation, is water-compatible and therefore no Exception Test is required provided that that the infrastructure is designed and constructed to:

- Remain operational and safe for users in times of flood.
- Result in no net loss of floodplain storage.
- Not impede water flows and not increase flood risk elsewhere.

8.1.2 The following mitigations shall be implemented to ensure the statements in 8.1.1 are met.

8.2 Raised Landing

8.2.1 The landside access to the Barnes pier will have a lightweight steel framed walkway installed with a deck level just above the highest astronomical tide (HAT) level. This will ensure access remains possible at all states of tide.

8.3 Flood Warning

8.3.1 The flood warnings summary has been replaced by the Flood Information Service which also includes a 5-days flood risk forecast.

8.3.2 During flooding conditions, the Environment Agency constantly updates news in its social media (Facebook and Twitter). However, for home or business activities at risk of flooding it is possible to sign up by calling Floodline (tel. 0345 988 1188, 24 hours) to get flood warning by telephone, email or text message.

8.4 Site Specific Emergency Evacuation Procedures and Response Plan

8.4.1 The operational management plan for each pier will include a site-specific emergency evacuation procedure to ensure that the risk to life is minimised should a flood event occur. This will specifically cover the risk of ferry users becoming trapped on Barnes Pier should the access be submerged during flood conditions (at water levels about HAT). The ferry service will not be operational during flood events thereby reducing the risk of anyone being on the walkway.

8.5 Service Protection

8.5.1 Services running down to the piers (water, data and power etc) shall be enclosed in suitable weather and puncture resistant sheathing. The interface where they are connected landside shall be located above flood defence level and enclosed to prevent possible tampering and vandalism.

8.6 Pier Restraint

8.6.1 The piles and spud legs are to be designed for extreme water levels so the pontoons will always remain safely attached to its mooring during all flood events.

8.7 Flood Plain Storage

8.7.1 As they are floating structures, the pontoons result in no loss of floodplain storage.

8.7.2 The piles and spud legs used to restrain the structures use an insignificant amount of floodplain volume (<8m3 in total) and shall be removed once the Hammersmith Bridge is repaired and the need for the temporary ferry has ended. As such the impact will be negligible.

8.8 Water Flows

8.8.1 The only objects below the still water level which could impede water flow are the pile and spud legs. As the dimensions of these are small in comparison to the river (16No. ~ø0.5m), the general water flow will not be impeded and thus the risk of increased flooding on adjacent land remains unaffected. The impact of the Hammersmith Pier access walkway on flow rates has been assessed as part of the Hydrodynamic Assessment and been determined to be minimal. Although the walkway grounds at low water levels, it is a lightweight floating structure with very small draught and will not affect the risk of flooding at the site.

8.9 Flood Defence Monitoring

8.9.1 The slipway, river wall and revetment will be monitored carefully during construction. This monitoring will be carried out through a combination of manual and electronic measurements. If movement is observed the works will be halted and the works methodology reviewed.

8.9.2 If movement does occur, a condition assessment and additional analysis of the structure will be carried out to assess the long-term stability of the structure.

8.9.3 For the duration of the ferry operation the two piers will be subject to regular inspection and maintenance. It is expected that the Hammersmith Pier may accumulate flotsam, especially on its downstream side. The pier's maintenance programme will include for regular collection and removal of any trapped flotsam.

9 CONCLUSION

9.1.1 The Temporary Hammersmith and Barnes Piers are a water-compatible development located in flood zone 3b, the functional flood zone which is at a high risk of tidal flooding according to the EA and both SFRAs. The landside access to both piers are considered to be in flood zone 3a.

9.1.2 As the development is water-compatible the Exception Test is not required.

9.1.3 As the development is only a temporary replacement to the Hammersmith Bridge, climate change will have negligible impact during the ferry's operational life.

9.1.4 The landside access to the Barnes pier is at a high risk from fluvial flooding but a raised steel frame walkway shall be implemented to increase the level above HAT. This shall reduce the chance of entrapment on the Barnes pier is as far as reasonably possible. The operation management plan for the ferry service will define a water-level which, if exceeded, will lead to ferry closure. Should tide levels exceed this with insufficient warning, the operational emergency evacuation plan should be implemented.

9.1.5 The landside access to the Hammersmith pier is at a high risk of flooding from surface water according to the EA maps, however the existing drainage is sufficient to ensure that surface water will not accumulate, reducing the risk. Additionally, the implementation of the pier is not deemed to worsen this existing risk.

9.1.6 The flood defence level is provided by the river wall and timber flood boards on the north bank, and by the set-back upstand wall on the south bank. The flood defence stability and structural integrity will not be impacted by the works.

9.1.7 An inspection and maintenance programme will ensure that the temporary piers and their shore interfaces remain in good condition during the time they are present at the site.

APPENDIX A BARNES TEMPORARY PIER – REVETMENT STABILITY

APPENDIX A BARNES TEMPORARY PIER – REVETMENT STABILITY

BECKETT RANKINE
Marine Consulting Engineers

Project:	Hammersmith Ferry			Page	1
Subject:	Bankseat Design	Job No:	2048	Of	2
Date: 30/04/21	Made by: NS	Checked by: HP	Approved by: JFP	REV	P01

SCOPE
The purpose of these calculations is to generate a RIBA stage 3 design for the in-situ concrete bankseat supporting the Barnes aluminium canting brow.

DESIGN SCENARIOS

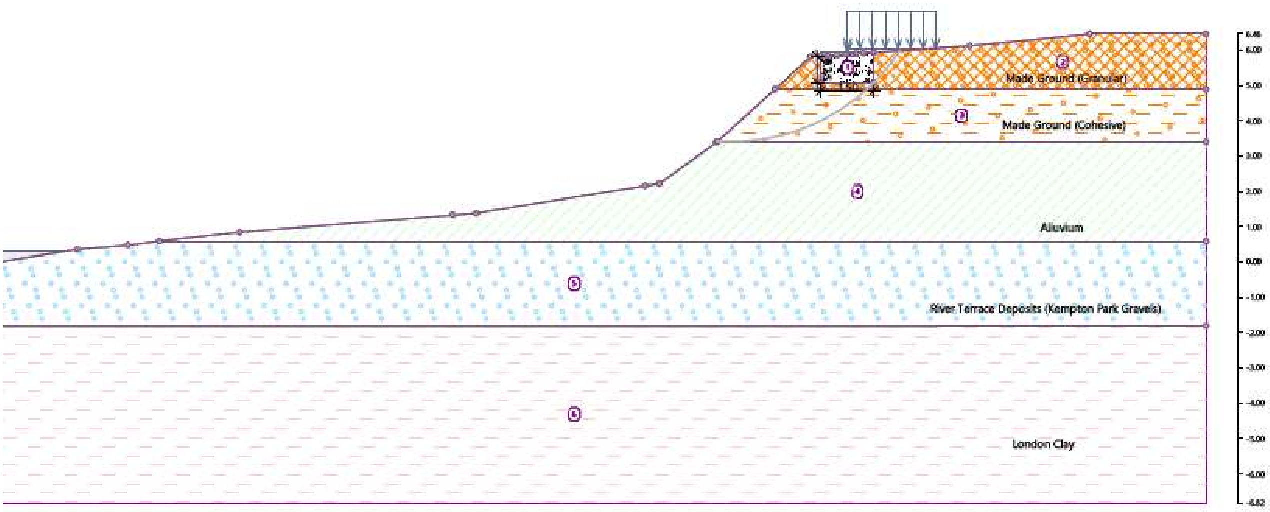
Scenario 1 (for structural design)

1. 5kPa crowd loading is present across the brow alongside wind, dead weight and bearing friction.

Scenario 2 (for slope stability only)

1. No stone pitching is present (i.e. there is no benefit provided).
2. 2.5kPa crowd loading is present across the brow (equivalent of in excess of 3 boat loads – deemed to be appropriate if assuming only 1 half of the brow has queuing people on at any one time).

ASSUMPTIONS



1. A 2.5m wide walkway at the top of the slope imposing a 5kPa strip surcharge
2. Allowance for 300mm wide coping stone on top of wall (actual width is tbc).
3. Vertical Loading from bearing is spread across full width of beam, and lateral frictional load across half the length of the beam.
4. Friction loads are based on dynamic coefficient for a clean steel on steel bearing with partial safety factor applied (this was found to be greater than the accidental static case, i.e. a bearing seizing)
5. Bearing and brow information is based on that provided by Tyne Gangway during meetings to date and GA drawing TG-00020197 Rev A alongside other similar structures.
6. Ground model based on BH101 from report no. 102963-PEF-BAS-ZZZ-REP-GE-00002.
7. It is assumed that the TOB will be ~50mm bgl to remove the need for decommissioning at later stages. As such, a 50mm upstand will be required for the bearing area – it is assumed that this will not impact the detailing for the section.
8. Loads have been applied conservatively without combination factors.
9. By inspection, settlement analysis is deemed unnecessary due to the length of the footing.

Allowance in the calculations has been made for a generic 10kPa construction surcharge load as the detailed loading is unknown.

CALCULATIONS

The following are applied to scenario 1 and 2 as detailed above:

2048-BRL-02-XX-CA-C-2201-A – Calculates the loading imposed on the bankseat

2048-BRL-02-XX-CA-C-2201-B – Provides a summary of the ground model

2048-BRL-02-XX-CA-C-2201-C – Slope Stability Assessment

2048-BRL-02-XX-CA-C-2201-D – Vertical Section Design

2048-BRL-02-XX-CA-C-2201-E – Biaxial Section Design (incl. bending, shear and crack width)
2048-BRL-02-XX-CA-C-2201-F – Torsion Check

DRAWINGS

2048-BRL-01-XX-DR-C-2000-T01 (Site Plan)
2048-BRL-01-XX-DR-C-2001-T01 (Key Plan)
2048-BRL-01-XX-DR-C-2010-T01 (Barnes Pier GA)
2048-BRL-01-XX-DR-C-2012-T01 (Barnes Pier Sections)

OUTPUTS

General Dimensions	Length (along footpath) = 4.5m Width (across footpath) = 1.5m Depth = 0.75m
Minimum Reinforcement Requirements	Longitudinal – Top/Bottom/Sides = 3140mm^2/m – Sides = 1890mm^2/m Shear Links – 2356mm^2/m

NB: Assumed that C40/50 concrete is used with 20mm aggregate and a nominal cover of 50mm.

For the design, it is assumed that scenario 2 shall be progressed due to its more conservative approach.

CHANGE LOG

Date	Rev	Description
30/04/21	P01	Original Calculations

					Reference
Brow Details	Length	35	m		
	Height	2.72	m		Tyne Gangways
	Clear Width	2.4	m		
	Windage Area	20	%	(based on Galloper)	
	Tonnage	11.6	t		Tyne Gangways
Pressures	Pedestian	2.5	kPa		BS 6349-1-2
	Wind	0.61	kPa	(assuming peak values)	2048-BRL-02-XX-CA-C-0002
Friction Coefficient	Static	0.5	(steel on steel)		https://www.engineeringtoolb
	Dynamic	0.42			

ULS

Vertical Loads (per bearing)

		Unfactored Load		γ	Factored Load		
Dead	Self-Weight	28.35	kN	1.2	34.02	kN	
	Superimposed	1.42	kN	1.2	1.70	kN	(5% allowance for connections etc)
Live	Pedestrian	52.50	kN	1.35	70.88	kN	
				TOTAL	106.59	kN	

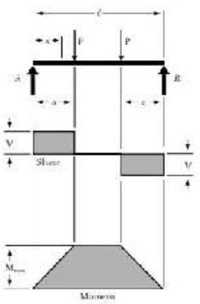
Horizontal Loads (per bearing)

		Unfactored Load		γ	Factored Load		
Friction	Static	41.13	kN	1	41.13	kN	(assumed factor as 1 due to static force)
[X-Axis]	Dynamic	34.55	kN	1.35	46.64	kN	
Wind [Y-Axis]		6.24	kN	1.5	9.36	kN	2048-BRL-02-XX-CA-C-0002
				TOTAL	56.00	kN	

Desin Bending and Shear Forces

Vertical

To be implemented in 2048-BRL-0-XX-CA-C-2201-D:



$R = V = P$

M_{max} (between loads) $= Pa$

M_x (when $x < a$) $= Px$

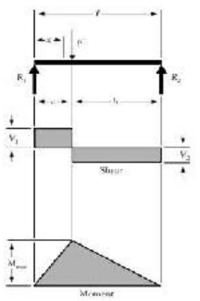
Δ_{max} (at center) $= \frac{Pa}{24EI}(3\ell^2 - 4a^2)$

Δ_x (when $x < a$) $= \frac{Px}{6EI}(3\ell a - 3a^2 - x^2)$

Δ_x (when $x > a$ and $< (\ell - a)$) $= \frac{Pa}{6EI}(3\ell x - 3x^2 - a^2)$

a	0.8	m
Med	85.27	kNm
Ved	106.59	kN

Horizontal



$R_1 = V_1$ (max when $a < b$) $= \frac{Pb}{\ell}$

$R_2 = V_2$ (max when $a > b$) $= \frac{Pa}{\ell}$

M_{max} (at point of load) $= \frac{Pab}{\ell}$

M_x (when $x < a$) $= \frac{Pbx}{\ell}$

Δ_{max} $\left(\text{at } x = \sqrt{\frac{a(a+2b)}{3}} \text{ when } a > b\right)$ $= \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EI\ell}$

Δ_a (at point of load) $= \frac{Pa^2b^2}{3EI\ell}$

Δ_x (when $x < a$) $= \frac{Pbx}{6EI\ell}(\ell^2 - b^2 - x^2)$

Δ_x (when $x > a$) $= \frac{Pa(\ell - x)}{6EI\ell}(2\ell x - x^2 - a^2)$

l	4	m
a	0.8	m
b	3.2	m
Med	35.84	kNm
Ved	44.80	kN

Quasi-Permenant

Vertical Loads (per bearing)

		Unfactored Load		ψ_2	Factored Load		
Dead	Self-Weight	28.35	kN	1	28.35	kN	
	Superimposed	1.42	kN	1	1.42	kN	(5% allowance for connections etc)
Live	Pedestrian	52.50	kN	0	0.00	kN	
				TOTAL	29.76	kN	

Horizontal Loads (per bearing)

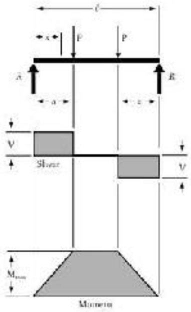
		Unfactored Load		γ	Factored Load		
Friction	Static	41.13	kN	0	0.00	kN	(assumed as 1 due to static force

[X-Axis] Dynamic	34.55 kN		0	0.00 kN	
Wind [Y-Axis]	6.24 kN		0	0.00 kN	2048-BRL-02-XX-CA-C-0002
		TOTAL		0.00 kN	

Desin Bending and Shear Forces

Vertical

To be implemented in 2048-BRL-0-XX-CA-C-2201-D:



$R = V = P$

M_{max} (between loads) $= Pa$

M_x (when $x < a$) $= Px$

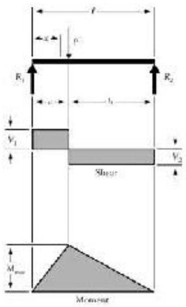
Δ_{max} (at center) $= \frac{Pa}{24EI}(3\ell^2 - 4a^2)$

Δ_x (when $x < a$) $= \frac{Px}{6EI}(3\ell a - 3a^2 - x^2)$

Δ_x (when $x > a$ and $< (\ell - a)$) $= \frac{Pa}{6EI}(3\ell x - 3x^2 - a^2)$

a	0.8	m
Med	23.81	kNm
Ved	29.76	kN

Horizontal



$R_1 = V_1$ (max when $a < b$) $= \frac{Pb}{\ell}$

$R_2 = V_2$ (max when $a > b$) $= \frac{Pa}{\ell}$

M_{max} (at point of load) $= \frac{Pab}{\ell}$

M_x (when $x < a$) $= \frac{Pbx}{\ell}$

Δ_{max} (at $x = \sqrt{\frac{a(a+2b)}{3}}$ when $a > b$) $= \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EI\ell}$

Δ_a (at point of load) $= \frac{Pa^2b^2}{3EI\ell}$

Δ_x (when $x < a$) $= \frac{Pbx}{6EI\ell}(\ell^2 - b^2 - x^2)$

Δ_x (when $x > a$) $= \frac{Pa(\ell - x)}{6EI\ell}(2\ell x - x^2 - a^2)$

l	4	m
a	0.8	m
b	3.2	m
Med	0.00	kNm
Ved	0.00	kN

Client:	Transport for London			Page	1
Project:	Hammersmith Ferry	Job No:	2048	Of	2
Subject:	Bankseat Structure - Loading			Rev	P01
Date: 02/06/2021	Made by: NS	Checked: OM	Approved by: HP	REFERENCE	
File Reference:	2048-BRL-02-XX-CA-C-2201-A (Beam Design - 5kPa Loading).xlsx				

					Reference
Brow Details	Length	35	m		
	Height	2.66	m		Tyne Gangways
	Clear Width	2.4	m		
	Windage Area	20	%	(based on Galloper)	
	Tonnage	11.6	t		Tyne Gangways
Pressures	Pedestian	5	kPa		BS 6349-1-2
	Wind	0.61	kPa	(assuming peak values)	2048-BRL-02-XX-CA-C-0002
Friction Coefficient	Static	0.5	(steel on steel)		https://www.engineeringtoolb
	Dynamic	0.42			

ULS

Vertical Loads (per bearing)

		Unfactored Load		γ	Factored Load			Reference
Dead	Self-Weight	28.42	kN	1.2	34.10	kN		
	Superimposed	1.42	kN	1.2	1.71	kN	(5% allowance for connections etc)	
Live	Pedestrian	105.00	kN	1.35	141.75	kN		
				TOTAL	177.56	kN		

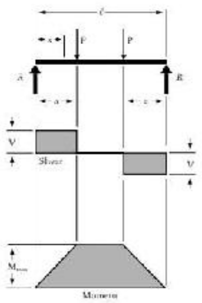
Horizontal Loads (per bearing)

		Unfactored Load		γ	Factored Load			Reference
Friction [X-Axis]	Static	67.42	kN	1	67.42	kN	(assumed as 1 due to static force	
	Dynamic	56.63	kN	1.35	76.45	kN		
Wind [Y-Axis]		6.24	kN	1.5	9.36	kN		2048-BRL-02-XX-CA-C-0002
				TOTAL	85.81	kN		

Desin Bending and Shear Forces

Vertical

To be implemented in 2048-BRL-0-XX-CA-C-2201-D:



$R = V = P$

M_{max} (between loads) $= Pa$

M_x (when $x < a$) $= Px$

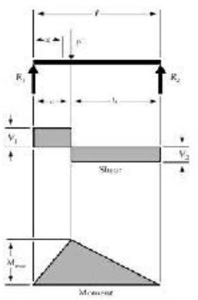
Δ_{max} (at center) $= \frac{Pa}{24EI}(3\ell^2 - 4a^2)$

Δ_x (when $x < a$) $= \frac{Px}{6EI}(3\ell a - 3a^2 - x^2)$

Δ_x (when $x > a$ and $< (\ell - a)$) $= \frac{Pa}{6EI}(3\ell x - 3x^2 - a^2)$

a	0.8	m
Med	142.05	kNm
Ved	177.56	kN

Horizontal



$R_1 = V_1$ (max when $a < b$) $= \frac{Pb}{\ell}$

$R_2 = V_2$ (max when $a > b$) $= \frac{Pa}{\ell}$

M_{max} (at point of load) $= \frac{Pab}{\ell}$

M_x (when $x < a$) $= \frac{Pbx}{\ell}$

Δ_{max} $\left(\text{at } x = \sqrt{\frac{a(a+2b)}{3}} \text{ when } a > b\right) = \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EI\ell}$

Δ_a (at point of load) $= \frac{Pa^2b^2}{3EI\ell}$

Δ_x (when $x < a$) $= \frac{Pbx}{6EI\ell}(\ell^2 - b^2 - x^2)$

Δ_x (when $x > a$) $= \frac{Pa(\ell - x)}{6EI\ell}(2\ell x - x^2 - a^2)$

l	4	m
a	0.8	m
b	3.2	m
Med	54.92	kNm
Ved	68.65	kN

Quasi-Permenant

Vertical Loads (per bearing)

		Unfactored Load		ψ_2	Factored Load		
Dead	Self-Weight	28.42	kN	1	28.42	kN	
	Superimposed	1.42	kN	1	1.42	kN	(5% allowance for connections etc)
Live	Pedestrian	105.00	kN	0	0.00	kN	
				TOTAL	29.84	kN	

Horizontal Loads (per bearing)

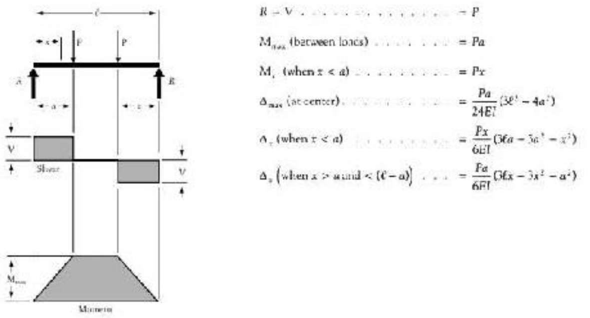
		Unfactored Load		γ	Factored Load		
Friction	Static	67.42	kN	0	0.00	kN	(assumed as 1 due to static force

[X-Axis]	Dynamic	56.63 kN		0	0.00 kN	
Wind [Y-Axis]		6.24 kN		0	0.00 kN	2048-BRL-02-XX-CA-C-0002
			TOTAL		0.00 kN	

Desin Bending and Shear Forces

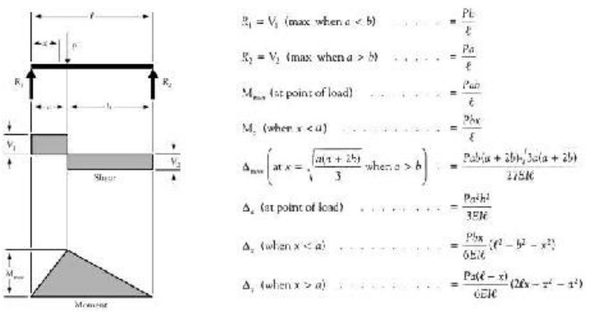
Vertical

To be implemented in 2048-BRL-0-XX-CA-C-2201-D:



a	0.8 m
Med	23.87 kNm
Ved	29.84 kN

Horizontal



l	4 m
a	0.8 m
b	3.2 m
Med	0.00 kNm
Ved	0.00 kN

South Bank (Barnes Pier)

Stratum	Top Elevation		Thickness	γ_{bulk}	γ_{sat}	φ'_{peak}	φ'_{crit}	C_u	c'	m_v	c_v	E_u	E'_d
	mAOD	mACD	m	kN/m^3	kN/m^3	°	°	kPa	kPa	m^2/MN	m^2/year	MPa	MPa
Made Ground (Granular)	4.61	6.29	1.4	17	17	-	28	-	0	-	-	-	5
Made Ground (Cohesive)	3.21	4.89	1.5	17	17	-	-	25	-	-	-	6.25	-
Alluvium	1.71	3.39	2.8	18	18	-	25	35	1	0.3	-	8	6.4
River Terrace Deposits (Kempton Park Gravel)	-1.09	0.59	2.4	17	19	37	32	-	0	-	-	-	30
London Clay	-3.49	-1.81	30+	20	20	25	23	70+4.7z (ave. 156)	0-2	0.04-0.08	2-7	V:32+2z H: 70+4.7z	V:25+1.7z H: 56+3.8z

GWT = 2.16mOD =

102963-PEF-BAS-ZZZ-REP-
Table 4.1, 5.14 & 6.1
BH101

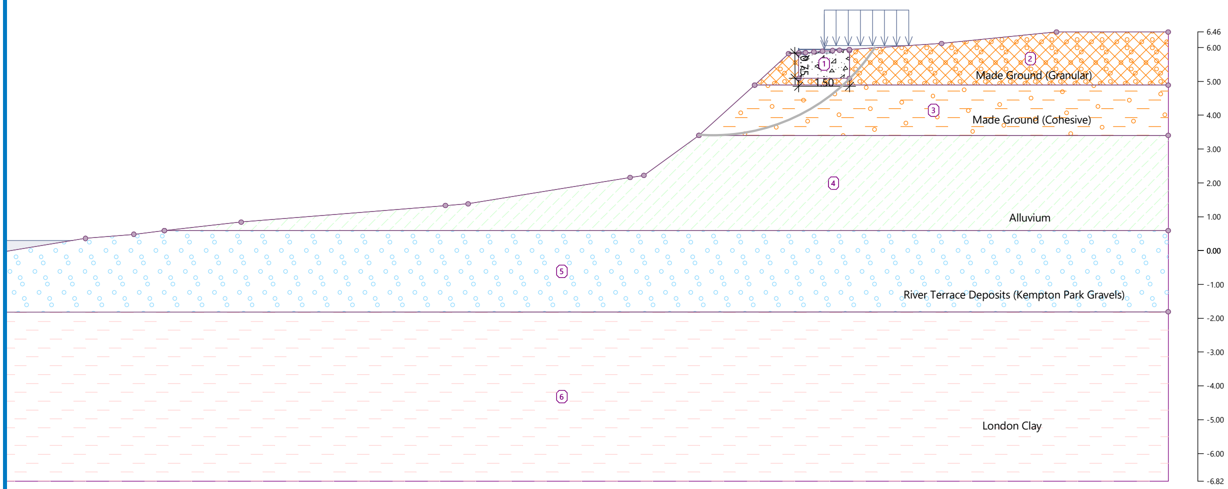
North Bank (Hammersmith Pier)

Stratum	Top Elevation		Thickness	γ_{bulk}	γ_{sat}	φ'_{peak}	φ'_{crit}	C_u	c'	m_v	c_v	E_u	E'_d
	mAOD	mACD	m	kN/m^3	kN/m^3	°	°	kPa	kPa	m^2/MN	m^2/year	MPa	MPa
Made Ground (Granular)	4.95	6.63	1.9	17	17	-	28	-	0	-	-	-	5
Made Ground (Cohesive)	3.05	4.73	0.4	17	17	-	-	25	-	-	-	6.25	-
River Terrace Deposits (Kempton Park Gravel)	2.65	4.33	3	17	19	37	32	-	0	-	-	-	30
London Clay	-0.35	1.33	30+	20	20	25	23	70+4.7z (ave. 156)	0-2	0.04-0.08	2-7	V:32+2z H: 70+4.7z	V:25+1.7z H: 56+3.8z

GWT = 0.02mOD = 1.70mCD

102963-PEF-BAS-ZZZ-REP-
Table 4.1, 5.14 & 6.1
BH102

Name :	**Stage - analysis : 1 - 1**



The slip surface after optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 109.95 kN/m

Sum of passive forces : F_p = 128.99 kN/m

Sliding moment : M_a = 625.63 kNm/m

Resisting moment : M_p = 733.98 kNm/m

Utilization : 85.2 %

Slope stability ACCEPTABLE

Some water surcharge overlaps with GWT above the terrain.

Combination 2

Sum of active forces : F_a = 82.43 kN/m

Sum of passive forces : F_p = 91.22 kN/m

Sliding moment : M_a = 469.05 kNm/m

Resisting moment : M_p = 519.03 kNm/m

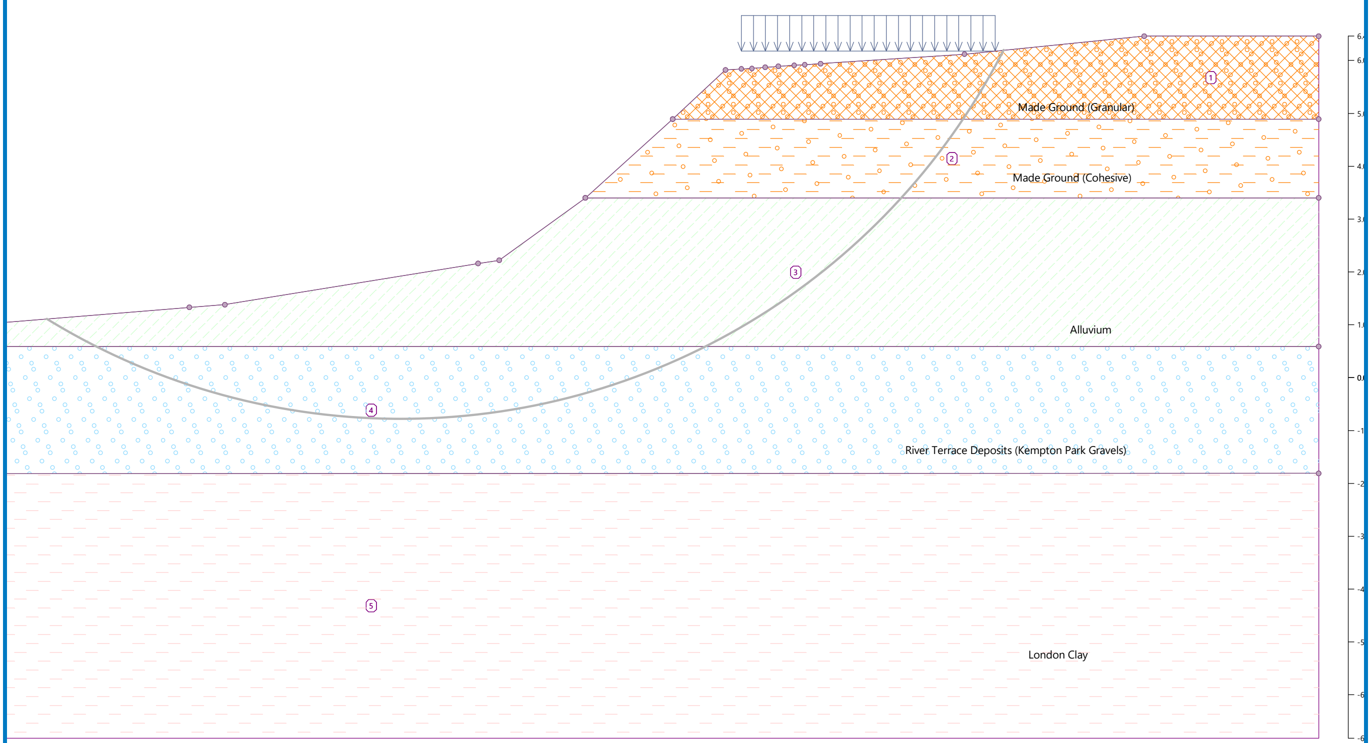
Utilization : 90.4 %

Slope stability ACCEPTABLE

Some water surcharge overlaps with GWT above the terrain.

Optimized slip surface for : Combination 2

Name : **Stage - analysis : 1 - 1**



The slip surface after optimization.

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 271.76 kN/m
Sum of passive forces : F_p = 371.63 kN/m

Sliding moment : M_a = 3481.24 kNm/m
Resisting moment : M_p = 4760.59 kNm/m
Utilization : 73.1 %

Slope stability ACCEPTABLE

Some water surcharge overlaps with GWT above the terrain.

Combination 2

Sum of active forces : F_a = 198.87 kN/m
Sum of passive forces : F_p = 302.00 kN/m

Sliding moment : M_a = 2137.87 kNm/m
Resisting moment : M_p = 3246.52 kNm/m
Utilization : 65.9 %

Slope stability ACCEPTABLE

Some water surcharge overlaps with GWT above the terrain.

Optimized slip surface for : Combination 1