**Thames Tideway Tunnel**
Thames Water Utilities Limited

# Application for Development Consent

Application Reference Number: WWO10001

# Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.02**

## Blackfriars Bridge Foreshore

APFP Regulations 2009: Regulation **5(2)(q)**

Hard copy available in

Box **57** Folder **A**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

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# Thames Tideway Tunnel

# Blackfriars Bridge Foreshore Navigational Issues and Preliminary Risk Assessment

## List of contents

**Page number**

## List of figures

**Page number**



## List of tables

**Page number**

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## Blackfriars Bridge Foreshore

### Main Report

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# 1 Executive summary

## 1.1 Purpose

1.1.1 This report documents the activities and assessments undertaken to identify the navigational issues, risks and mitigation measures for the proposed permanent and temporary structures at the site known as Blackfriars Bridge Foreshore as part of the Thames Tideway Tunnel project (the 'project').

1.1.2 It was developed through liaison and consultation with Port of London Authority (PLA) and the other key stakeholders. It is intended to support the application for development consent and identify the navigational issues at the site and how these are to be managed. The process was used to inform the design of the permanent and temporary works and a number of measures to address navigational hazards have been embedded into the design.

1.1.3 The preliminary risk assessment follows a project specific methodology proposed by the PLA rather than the generic methodology detailed within the PLA Safety Management System. The risk assessment reflects the level of development of the design in the application for development consent, which is, an outline design. The Contractor would be required to prepare detailed risk assessments and method statements and submit these to the PLA for approval before commencing any works in the river at this site.

1.1.4 The assessment was divided into four distinct project phases to assess hazards and develop risk reduction measures commensurate with the risk posed by different operations associated with the project. These phases were specific to this assessment and comprise:

a. Phase A: construction of cofferdam (including delivery of materials by barge)

b. Phase B: construction of drop shaft and other structures (including removal of excavated materials by barge)

c. Phase C: removal of cofferdam (including removal of materials by barge)

d. Phase D: permanent works site.

## 1.2 Issues to be addressed

1.2.1 Of all the sites within the project, the Blackfriars Bridge Foreshore in-river site probably has the greatest number of marine challenges, for the following reasons:

a. Intrusion: the permanent in-river structure protrudes further into the river than the existing Blackfriars Millennium Pier, several metres into the designated authorised channel and is close to the Blackfriars road and rail bridges.

b. Intrusion: the temporary works intrudes further into the river than the permanent works and there would be a requirement to close bridge arch No2 to certain vessel types during various stages of the project.

c. Construction of cofferdam: constructing the cofferdam results in construction equipment being placed within the authorised channel.

d. Closure of bridge arches: at various stages of the project closing arch No2 has been identified as a mitigation measure. The closure of arch No2 introduces a number of risks in its own right; i.e. restricted working and constrained water space.

e. Blackfriars Millennium Pier: in order for the works to take place at Blackfriars Bridge Foreshore, the existing pier would need to be moved. It is necessary to identify a suitable alternative location for the pier that does not have a negative impact on existing river users.

f. The President: the in-river structure requires the temporary relocation of the nearby conference/restaurant vessel the President.

## 1.3 Intrusion

1.3.1 To minimise the impact of the in-river site on existing river traffic, the site would be located as close to the existing embankment wall as the current design of the drop shaft and associated works allows. The design of the permanent works was revised to reduce the distance that the works intrudes into the river. Nevertheless, the permanent works would protrude further into the river than the existing Blackfriars Millennium Pier and the President and the temporary works would intrude even further.

1.3.2 This report examines the impact of the temporary and permanent in-river structures on all vessel types (freight, tugs and tows, high speed passenger vessels, passenger vessels, leisure craft and emergency vessels) transiting the study area, with particular attention given to tugs and tows because of their limited manoeuvrability and operating requirements in the area.

1.3.3 During ‘normal’ operating conditions, with all arches available to navigation, the risk posed by the permanent structure would fall within the As Low As Reasonably Practicable (ALARP) region. The potential for an incident to occur would increase when arch No3 is not open to navigation, either during planned maintenance or for an emergency closure. This would leave arch No2 as the only available arch for inbound traffic.

1.3.4 Tugs and tows normally pass through Blackfriars arch No3 on their inward bound transit and photographic evidence shows that barges would be approximately 67m from the permanent works, 55m from the temporary works sheet piling and 42m from the maximum extent of the temporary works site (encompassing jack-up and work vessels). This evidence provides assurance that the works would not affect reporting and other vessels passing through arch No3.

1.3.5 Routine/planned closure of arch No3 should be avoided during the temporary works due to duration of the works and the inspection routine. This would require the regular 6-yearly maintenance of the bridge (which

requires closure of the arches) to be carried out immediately prior to project construction works. This has been raised by the project team with the City of London and the intention is to raise this with Network Rail. However, there would be routine closures of arch No3 required once the permanent works are complete.

1.3.6 Existing Automatic Identification System (AIS) evidence shows that the majority of in-bound towed barges passing through arch No2 do not pass over the proposed site of the permanent structure, and on average clear the structure by 12m or more. Subject to agreement of the barge operators, this evidence provides assurance that in-bound towed barges passing through arch No2 would clear the permanent structure by 10m or more.

1.3.7 In the event of an emergency closure of arch No3 during the temporary works period, it could be possible to use arch No2 for inbound tugs and tows provided that project work vessels are cleared from the temporary works site and barges are individually towed through arch No2, with arch No4 being used for outbound tugs and tows.

1.3.8 Although AIS evidence shows outbound tugs and tows passing through arch No4, the alignment for arch No4 would be improved by relocating the Cory Environmental Ltd (further referred to as Cory) moorings that are currently upriver from Blackfriars arch No4. Further, analysis shows that dredging would not be required to maintain current levels of vessel traffic.

1.3.9 As a result of consultation with the PLA and various stakeholders the design of the permanent works structure was revised. This assessment is based on the permanent works structure as presented in the Permanent works layout drawing listed in Appendix A.

## 1.4 Flow

1.4.1 Any intrusion into the river would change river flow. Analysis involved measuring flow rates over a number of tidal conditions using a baseline of current flow against flow rates with the in river structures in place (both temporary and permanent).The analysis in this report considered the worst cases, combining the extreme fluvial and tidal flows. It was found that even in these extreme cases the change in the maximum flow is less than 1.2 knots for the temporary works and less than 0.5 knots for the permanent works. It should be noted that because the structures displace the flow pattern, the maximum flow is found in a different location.

1.4.2 Change in tide set and/or any change in the direction of the flow was identified as a potential issue for vessels transiting past this site. This report used information provided by HR Wallingford to assess potential changes in fluvial speed only.

## 1.5 Blackfriars Millennium Pier relocation

1.5.1 It is proposed to relocate Blackfriars Millennium Pier to the east of the Blackfriars bridges. From a navigation perspective for vessels using the pier, it is considered that this would be a better location than the current

location. This is because currently, vessels leaving the pier use arch No2 against the traffic flow when outbound, with limited visibility of inbound vessels approaching through arch No2. Locating the pier to the east of the bridge would not increase the number of crossing incidents; seen as a key navigational hazard by river users, however there would be a requirement on vessel operators using the relocated pier to adjust their operating procedures to take into account the approach required to berth/depart.

1.5.2 Whilst the new pier location would offer advantages, the proposed location is seen by stakeholders to increase the likelihood of upriver and arch No2 bound tug and tows colliding with Thames Clipper vessels temporarily moored along the pier whilst picking up/disembarking passengers. The proposed location of the pier was adjusted to address these concerns.

## 1.6 President relocation

1.6.1 It is proposed to move the President, currently permanently moored on PLA mooring 71d, to the site previously occupied by HMS Chrysanthemum, PLA mooring 71c, approximately 100 metres westwards during construction. This proposed temporary location was used, until the early 1990's, as a mooring position for its similarly sized sister vessel, HMS Chrysanthemum. The mooring is currently undergoing refurbishment and will be returned to use as a charter boat pier (by others). Review of the mooring position indicates that it is sufficiently set back from the authorised channel and therefore should not adversely affect existing navigational safety. This also applies to the vessel when it is returned to its current position along the river wall once construction is completed, albeit with an improved mooring and access arrangements.

# 2 Site overview

## 2.1 Purpose of this report

2.1.1 The purpose of this report is to provide information on the navigational issues, risk assessment and mitigation measures associated with the proposed Blackfriars Embankment Foreshore site. The report informs the *Transport Assessment and Environmental Statement* and the PLA approval process.

## 2.2 Introduction

2.2.1 The Thames Tideway Tunnel project (the 'project') comprises tunnels to store and transfer discharges from combined sewer overflows (CSOs) from West to East London for treatment at Beckton Sewage Treatment Works. The primary objective of the project is to control CSO discharges in order to meet the requirements of the EU Urban Waste Water Treatment Directive (91/271/EEC) (UWWTD) and the related UK Urban Waste Water Treatment Regulations.

2.2.2 The project comprises the following elements:

a. a main tunnel from Acton Storm Tanks to Abbey Mills Pumping Station requiring five main tunnel sites (one of the sites would also intercept flows from one CSO)

b. control of 18 CSOs by diverting intercepted flows into the main tunnel requiring 16 CSO sites; two long connection tunnels (Frogmore connection tunnel and Greenwich connect tunnel) and 11 short connection tunnels

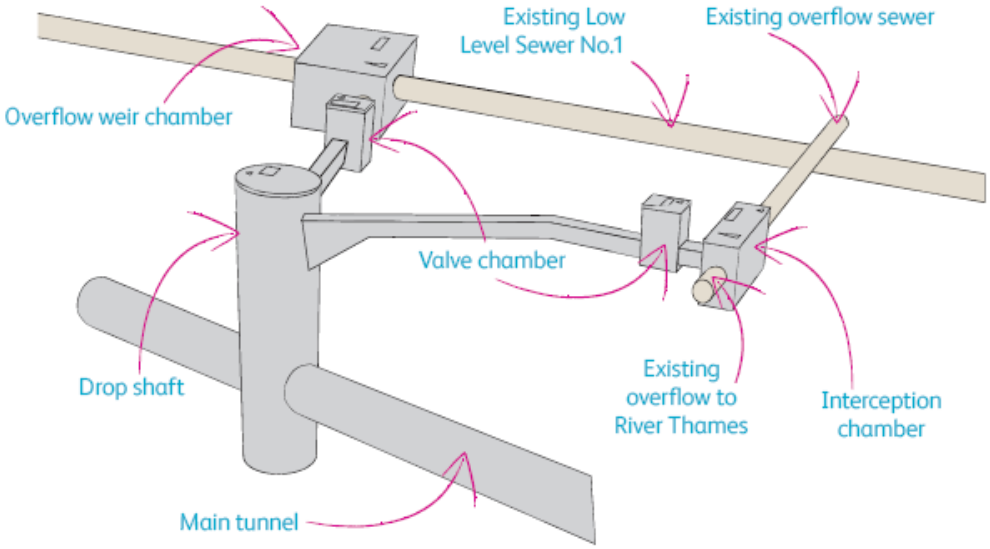
c. control of two CSOs by locally modifying the sewerage system requiring two system modification sites

d. works to drain down the system at Beckton Sewage Treatment Works.

2.2.3 The main tunnel would connect to the Lee Tunnel at Abbey Mills Pumping Station. All the flows from the Thames Tideway Tunnel and the Lee Tunnel would be transferred to Beckton Sewage Treatment Works via the Lee Tunnel.

2.2.4 The Blackfriars Bridge Foreshore CSO site would be required to intercept the Fleet CSO and also to control other CSOs located in central London via a connection to the northern Low Level Sewer No.1, and to connect to the main tunnel. The proposed structures at this site are illustrated in Figure 2.1.

**Figure 2.1 CSO site structures (below ground)**




2.2.5 It is proposed that the permanent in-river structure at the Blackfriars Bridge Foreshore site would accommodate:

a. An online CSO drop shaft – 24m internal diameter, approximately 53m deep

b. a connection to the Fleet Main CSO outfall

c. an overflow weir chamber on the northern Low Level Sewer No.1 located within the existing river wall structure

d. connection culverts and valve chambers

e. air management structures

f. a new section of river wall

2.2.6 A cofferdam would be constructed, which would include the following areas to enable construction of the permanent in-river structure:

a. excavated material storage and handling facilities

b. cranes

c. maintenance workshop and storage

d. internal site roads

e. site support and welfare.

## 2.3 Limits of land to be acquired or used

2.3.1 The proposed limits of land to be acquired or used (LLAU) for this site extends from the current location of the President running east and terminating approx. 20m to the east of Blackfriars (road) Bridge, measuring approx. 370m in length. It extends from the foreshore into the river approx. 70m at its furthest point which means it would extend approx. 45m into the authorised channel.

2.3.2 The LLAU encompasses the maximum working area required during construction. A cofferdam would be constructed within this area that would be in place for approximately 5 years during the construction phases. The permanent river wall works would take place within the cofferdam.

2.3.3 A separate LLAU for the relocation of Blackfriars Millennium Pier extends from a point approx. 20m to the east of Blackfriars Rail Bridge, running east and terminating approx. 110m west of the Millennium Footbridge. It extends from the foreshore into the river approx. 35m at its furthest point and is 15m outside the authorised channel at its closest point.

2.3.4 The LLAUs would be used intermittently, depending on the progress, method and phasing of construction.

2.3.5 Appendix A lists the various design, construction and site layout drawings. It also details the work undertaken by the project team to reduce the overall footprint of the permanent work structure and therefore the potential impact on existing river users.

## 2.4 Project phases

2.4.1 This assessment was divided into four construction phases to assess hazards and develop risk reduction measures commensurate with the risk posed by different operations associated with the project. These phases were identified for use during the navigation risk assessment:

a. Phase A: cofferdam construction (including delivery of materials by barge)

b. Phase B: drop shaft and other structures construction (including removal of excavated materials by barge)

c. Phase C: cofferdam removal (including removal of materials by barge)

d. Phase D: permanent works site.

2.4.2 The relocation of Blackfriars Millennium Pier will be conducted prior to construction activities commencing and will be subject to separate method statements and risk assessment.

## 2.5 Construction methodology

2.5.1 All works would be undertaken in accordance with the project's *Code of Construction Practice (CoCP)*.

2.5.2 The code sets out a series of objectives and measures to protect the environment and limit disturbance from construction activities as far as reasonably practicable. The topics covered by the *COCP* include but are not limited to: working hours, traffic management, noise and vibration, air quality, waste management, recycling, ecology, archaeology and settlement.

2.5.3 The methodologies, layouts and plant requirements outlined in this document are for illustrative purposes only and may be varied by subsequent design and build construction contractors.

## 2.6 Phase A: Cofferdam and piled platform construction

2.6.1 The cofferdam would be constructed by installing a sheet piled wall. It is currently envisaged that the cofferdam would be designed as a twin walled cofferdam to accommodate the various loading conditions including external tidal loading and internal plant/construction loading. A piled working platform would also be constructed at the western end of the site.

2.6.2 It is intended to use the river to access and service the cofferdam and piled platform construction activities, and a jack-up or spud leg barge would be mobilised at the site. A jack-up barge is a hydraulically operated self-elevating platform, which provides a stable platform from which marine piling works can be undertaken. The barge would be equipped with a crawler crane for off-loading and pitching the sheets for the sheet piled wall and tubular piles for the platform, a silent piling hammer, a small welfare cabin, a rescue boat and generated power.

## 2.7 Phase B: Drop shaft and other structures construction

2.7.1 The CSO drop shaft would be constructed by diaphragm wall construction techniques and have a cast in-situ secondary lining.

2.7.2 An attendant excavator would load the excavation material from the slurry separation plant into a dumper, which would deposit excavated material into the excavated material muck bin. A long reach excavator would load the excavated material into a barge moored alongside the cofferdam wall.

## 2.8 Phase C: Cofferdam removal

2.8.1 On completion of the CSO drop shaft and connection chambers, the permanent river wall would be constructed. The area between the cofferdam and permanent river wall would be excavated.

2.8.2 Concrete blinding would be installed and then the permanent river wall constructed.

2.8.3 Only once the permanent river wall is in place would the cofferdam on the riverside be removed in order to maintain flood protection. The cofferdam piled wall would then be dismantled by jack-up barge.

## 2.9 Phase D: Permanent works site

2.9.1 Once all temporary works structures have been removed and construction work is complete, a permanent in-river structure would remain at the site. Access to various elements of the site and underground works would be required for maintenance. River-based access during the permanent works phase would only be anticipated in the event of failure of the outer flap valves on the permanent river walls.

The permanent structure would extend approximately 30m into the river; and would encroach into the authorised channel by approximately 3m.

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# 3 Study aim and area

## 3.1 Study aim

3.1.1 The aim of this assessment is to identify and assess navigational hazards project-specific construction activities at the Blackfriars Bridge Foreshore site and to assess how the proposed phases of the project would likely impact on existing river users and river infrastructure.

3.1.2 This assessment considers all river users and the hazards that project activities could pose to navigation on the River Thames.

3.1.3 In compiling this assessment, the project undertook extensive consultation with the PLA and current river users, along with observations of current river operations.

3.1.4 In order to consider the navigation impact on the wider river community, the scope of this assessment comprised an area between Temple Stairs and the Millennium Footbridge. This study area captures the majority of vessel types likely to transit this section of the river and pass the worksite.

3.1.5 It is acknowledged that tug and tow operations are not new on this section of the Thames, with a number of freight services operating daily on the river, transporting a variety of materials in a variety of craft. This assessment does not assess those operations but examines the additional hazards that the four phases of this project present.

3.1.6 The project proposes to use barges during site set-up, drop shaft construction, and the completion of works and site restoration phases

## 3.2 General navigation

3.2.1 The Central London stretch of the River Thames is extensively used by commuter, passenger and private pleasure craft as well as tugs, barges and other working vessels that transport freight.

3.2.2 Safety is the responsibility of all river users; however, overall responsibility for facilitating the safety of navigation on the River Thames rests with the PLA.

3.2.3 As part of its activities in maintaining navigational safety, the PLA produces Notices to Mariners (NTMs), which provide essential, up-to-date information and advice to those navigating within the Port of London. NTMs can range from information on special events, notifications of works (eg, the Network Rail works on Blackfriars Bridge), and notification of new and updated navigation rules and regulations. A full list of extant NTMs is available on the PLA website, http://www.pla.co.uk/notice2mariners/index.cfm/site/navigation.

3.2.4 The River Thames becomes tidal downriver of Teddington Lock, with a tidal range of between five and seven metres at different locations.

3.2.5 On the flood tide, the tidal current flows up-river (ie, predominantly east to west) whereas on the ebb tide, the tidal current flows downriver (ie, predominantly west to east).

## 3.3 Blackfriars Road and Rail Bridges

3.3.1 Blackfriars Road Bridge has five main arches, three of which are available for navigation: arch No 2, 3 and 4 designated as working arches.

**Table 3.1 Individual bridge arch clearances to mean high water springs**

| Bridge Arch | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Bridge Clearance | Blackfriars Road | - | 6.1 m | 7.0 m | 5.9 m | 4.5 m |
| | Blackfriars Rail | - | 7.3 m | 7.3 m | 7.4 m | 7.3 m |

**Table 3.2 Main bridge arch clearance heights**

| Tide Set | Chart Datum | MHWN | MLWN | MLWS | HAT |
|---|---|---|---|---|---|
| Bridge Clearance | 13.9 m | 8.1 m | 12.7 m | 13.5 m | 6.5 m |
| | 14.2 m | 8.5 m | 13.0 m | 13.8 m | 6.8 m |

3.3.2 Smaller inward bound vessels normally use arch No2, and smaller outward bound vessels normally use arch No4, arch No3 is kept clear for larger and reporting vessels.

3.3.3 The main working arches of bridges on the Thames are identified by day and by night by two orange (or amber) lights placed side by side in the centre (highest part) of each arch.

3.3.4 Special Signal Lights are located on both the upstream and downstream sides of the main navigable arches in relation to the authorised channel, which are normally used by reporting vessels. On the Blackfriars Road and Rail Bridges arch No3 there is a Special Signal Light consisting of a high intensity white light, visible by day and by night, which is illuminated only when it is activated by a keying device on board a reporting vessel, or by London Vessel Tracking System (VTS).

3.3.5 Due to the close proximity of the road and rail bridges, very strong currents and eddies may be encountered by vessels transiting this area, particularly on the ebb tide.

3.3.6 The PLA recommend that great caution is exercised when negotiating this area of the river due to visibility being affected by the bend in the river coinciding with bridges crossing at this point.

## 3.4 The authorised channel

3.4.1 The authorised channel is marked on both Admiralty and PLA charts as a pair of pecked lines that define where the majority of commercial vessels generally navigate. However, vessels cannot always be expected to navigate 'within' the authorised channel.

3.4.2 In busy stretches of Central London, including this study area, the authorised channel is approximately 100m wide and incorporates the working arches of the various bridges. At peak times, the authorised channel can become very congested.

3.4.3 In 2010 the PLA updated their charts of this area. One of the main changes to the chart in this section of the river was the movement of the northern boundary of the authorised channel. In line with the eastern end of Blackfriars Millennium Pier the authorised channel on the 2003 chart was 38m, on the 2010 chart this was reduced to 30m measured from the northern river wall. In line with the western end of Blackfriars Millennium Pier the authorised channel on the 2003 chart was 41m, on the 2010 chart this was reduced to 30m from the northern river wall (i.e. the authorised channel was widened).

3.4.4 The Document *General Directions for Navigation in the Port of London 2011* states the following:

*36. REQUIREMENT TO USE THE AUTHORISED CHANNEL*

*(1) This Direction applies only to vessels navigating between the Margaretness Limit and Chelsea Embankment.*

*(2) Except in an emergency or for the purposes of overtaking, or with the permission of the Harbourmaster, or when manoeuvring to or from piers, wharves, anchorages or other berths, all reporting vessels and vessels of 13.7 metres or more in Length Overall shall normally navigate only in the authorised channel as identified on PLA charts.*

*(3) Where there is sufficient room, vessels less than 13.7m in Length Overall should normally navigate outside the authorised channel unless constrained by their draught or otherwise restricted in ability to manoeuvre, or in an emergency.*

## 3.5 Tide set

3.5.1 During consultation for this and other sites associated with the project, the project determined that the 'tide set' in the River Thames area surrounding the site should be taken into consideration when assessing navigational hazards.

3.5.2 The term 'tide set 'is used to describe the movement of water into the bight or outside edge of a bend of a river. In a tidal river like the River Thames, which is embanked in the central area of London, it also leads to an increase in velocity.

3.5.3 Every vessel is affected by tide set in varying degrees. Smaller, faster-moving craft are affected less than larger, slow-moving vessels such as

tugs and tows, which have to make course and steering adjustments to counteract the impact of tide set.

3.5.4 The embankments of the River Thames deflect the water flow towards the outside of the next bend. This effect manifests itself particularly in the section of the river that contains the various bridges.

3.5.5 This report assesses the Kings Reach section between Temple Stairs in the west and the Millennium Footbridge in the east, a distance of almost a kilometre that has an average width of approximately three hundred meters.

3.5.6 This part of the reach contains several floating moorings on the south side of the river outside the authorised channel, one passenger pier, some permanent moorings on the north bank, one road bridge, one railway bridge and the supporting columns of a disused and partially demolished bridge.

3.5.7 Appendix E provides more detailed explanation of the flood and ebb tide sets expected to be encountered in this location.

## 3.6 Existing river users

3.6.1 The Central London stretch of the River Thames is acknowledged as one of the busiest sections of the tidal Thames in terms of vessel movements.

3.6.2 There are a number of freight operators that provide regular freight services within the study area. Cory operates a daily (currently weekday) waste transfer service. At present, Cory transports containerised waste from Wandsworth, Cringle Dock, Northumberland Wharf and Wallbrook Wharf waste transfer stations to their new Riverside Energy from Waste facility at Belvedere. Cory typically operates a service consisting of three tugs with up to four barges (per tug) in inward and outward bound directions.

3.6.3 Additional freight operators that can be expected to operate within the study area include; Bennett's Barges, GPS Marine, JJ Prior and Livett's Launches.

3.6.4 Thames Clippers (fast ferries), timetabled passenger services, sightseeing tours and party boat tours all operate within the study area.

3.6.5 Blackfriars Millennium Pier is located at the proposed CSO foreshore site, offering commuter passenger services to the following destinations:

a. London Eye Pier to Woolwich Arsenal;
    i Monday to Friday (excluding Public Holidays)
    ii Thames Clippers – (www.thamesclippers.com)
b. Blackfriars Millennium Pier to Putney Pier;
    i Monday to Friday – (peak hours only)
    ii Thames River Taxi – (www.thamesrivertaxi.com)

3.6.6 Unscheduled cruises - Private hire cruise vessels transit past Blackfriars on occasion. While it is not feasible to state exact figures for these

vessels, it is assumed that vessels from the following companies operate in the study area:

a. Thames Cruises, Capital Pleasure Boats, Westminster Party Boats, London Party Boats, Thames Executive charters, Crown River Cruises and Viscount Cruises.

3.6.7 It is estimated that during peak operating periods up to 25 charter vessels may pass the site heading eastbound on any given day, and approximately the same number passing westbound.

3.6.8 The PLA actively encourages recreational boat users to use the tidal Thames, and hosts a dedicated website (www.boatingonthethames.co.uk) that provides advice, guidance and safety information to a wide variety of leisure users.

3.6.9 Recreational traffic on the River Thames that can be expected to transit within the study area includes narrow boats, motor yachts, rigid inflatable boats (RIBs), speed boats, rowing boats, kayaks and sailing yachts. RIB services are also intermittently offered from Blackfriars Pier.

## 3.7 Existing vessel traffic movements

3.7.1 The majority of inward bound freight movements can be expected to be in the study area between 2 and 3 hours before high water, providing them with a sufficient operating window to be at their final destination around an hour before the high water mark. Outbound freight can typically be found in the study area around high water.

3.7.2 The River Thames is used by tourists as a means of sightseeing and consequently traffic levels are seasonal, the greatest tourist traffic being around lunchtime in the summer months.

3.7.3 Charter vessels also have an element of seasonality with the majority of them operating in the summer months (April - September). There are some increases around the Christmas party season.

3.7.4 Observations and analysis of Cory tug and tow operations through Blackfriars Bridges were conducted. Full details of the analysis are contained within Annex C - Freight Tracks and AIS Analysis and photographic analysis in Section 5 - Current River Operations.

It should be noted that the project would generate barge traffic in addition to current movements. Appendix D summarises the project's current expected levels of barge traffic.

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# 4 Summary of navigational issues

## 4.1 Inbound tugs and tows making contact with structures

4.1.1 Tugs, whilst engaged in towing operations transiting the Blackfriars Bridge section of the river, could make contact with the proposed temporary works structure.

4.1.2 When proceeding inbound, tugs and tows transit the study area towards the north side of the river. The intrusion of the temporary and permanent works structures into the authorised channel results in reduced available river width and therefore an increase in the probability that contact with the structure would be made.

4.1.3 It is has been identified that smaller inbound vessels would no longer be able to use arch No2 during some periods of the work, leaving arch No3 as the only available navigable arch for inbound vessels.

4.1.4 With the permanent structure in place, it is assumed that inbound smaller vessels would still be able to use arch No2, which would leave arch No3 available for larger and reporting vessels.

## 4.2 Closure of arch No2 during construction

4.2.1 Closure of arch No2 during the construction and removal of the cofferdam and for the duration of the temporary works could have an adverse impact on vessel traffic and therefore navigational safety.

4.2.2 Arch No2 is currently designated as the arch to be used for smaller inbound vessels. Arch No3 is used by both inbound and outbound vessels with special signal lights located above the arch. Arch No4 is assigned for smaller outbound vessels if safe to do so.

4.2.3 Should there be a requirement to close arch No3 then arch No4 would be the only available arch for navigation in both directions of travel.

4.2.4 Arch No2 may need to be closed to all vessels during construction and removal of the cofferdam (i.e. phase A and C) and to certain vessels for while the temporary cofferdam is in place (phase B).

4.2.5 It has been observed that tugs and tows currently use arch No2, as well as arch No3 for inbound transit.

4.2.6 The methodology for construction of the cofferdam has been reviewed. This review identified a number of different options that would help to minimise the duration of closure of Arch No 2, such as the use of multiple piling rigs, or locating the jack-up barge on the ‘inside’ of the cofferdam where space allows. While the detailed methodology will be determined by the contractor, the requirement to maximise the duration that Arch No2 is open to smaller vessels will be imposed on the contractor through the Zones of Foreshore Working drawing in Appendix A.

## 4.3 Closure of arch No3 (planned maintenance or emergency closure)

4.3.1 Closure of arch No3 would have an adverse impact on vessel traffic - with the potential that the river would be closed to navigation for the duration of the closure.

4.3.2 It is likely that arch No2 would be closed for navigation to all vessels during at least part of the construction phase, as described in Section 4.2. As a result, if there is a need to close arch No3, (either planned or for an emergency situation, but not necessarily associated with the project), there would be an adverse impact on vessel traffic, potentially leading to the closure of the river to navigation until such time that the arch can be reopened, unless arch No4 is made available to all traffic.

## 4.4 Increase in river flow

4.4.1 Changes to the hydrodynamics of the river could affect passing vessels, particularly through the arches of Blackfriars Bridges and towards the western end of the development.

4.4.2 The shape, location and size of the permanent structure in the river at the Blackfriars Bridge Foreshore site would lead to a change in river velocity that could have an effect on existing passing river traffic and certain vessel types would likely be affected more than others.

4.4.3 During consultation with river users the potential change in the direction of flow was highlighted as being a factor that could lead to an incident. Appendix B summarises the results of the fluvial modelling.

## 4.5 Relocation of Blackfriars Millennium Pier

4.5.1 As part of the proposed works at the Blackfriars Bridge Foreshore site there would be a requirement to relocate Blackfriars Millennium Pier.

4.5.2 Investigation into the suitability of the proposed new location has been undertaken with several stakeholder engagement meetings undertaken. A number of issues were taken into consideration when finalising the new location of the pier, these being:

a. the ability for tug and tow to safely use arch No2 if arch No3 is closed or unavailable

b. the ability for tug and tow to safely pass the pier while aligning for passage of arch No2 and while a boat is moored alongside the pier

c. commuter and leisure boat operators' ability to easily access the pier

d. impact on other river users

e. relocation activities

f. although not a navigational issue, the proximity of the proposed new location to Blackfriars Road and Rail Bridges and the interchange with Blackfriars Station

4.5.3 The proposed location of the relocated pier is shown on the Permanent works layout listed in Appendix A. Blackfriars Millennium Pier is currently used by:

a. Thames Clippers - Monday to Friday - as part of the Woolwich to Embankment service;

b. Thames Clippers - Monday to Friday - 07:04 to 09:14 and 17:21 to 20:03 - Bankside to St George Wharf;

c. Capital Pleasure Boats - Monday to Friday - 08:25 to 09:25 and 17:10 to 19:10;

d. Various pleasure boat operators as a pick up/drop off location.

e. Rigid Inflatable Boats (RIBs) intermittently

4.5.4 The relocation of the pier has been divided into phases as follows:

a. Construct the new fixed structure pier and new pontoon;

b. Suspend services from the existing pier and commence services from the new pier location;

c. Decommission the old pier - remove existing fixed structure and pontoon.

## 4.6 Relocation of the President

4.6.1 In order for the project to have sufficient working area to construct and operate the cofferdam and temporary works site, the project proposes to temporarily relocate the President. It would be permanently reinstated in its current position when the construction works are complete.

4.6.2 The intention is to move the President, currently permanently moored on PLA mooring 71d, to the site previously occupied by Chrysanthemum, PLA mooring 71c, approximately 100 metres to the west.

4.6.3 The relocation of the President has been divided into three distinct phases, which would be repeated upon returning the vessel to its existing position after the works are completed. The assessment has been produced in order to provide a top level overview of the likely issues that need to be reviewed in greater detail once a method statement for moving the President has been produced. The three phases are detailed as:

a. Upgrade existing moorings and access system for new location.

b. Move the vessel by either:

i Option 1 - Tow the President to new location or

ii Option 2 - Winch the President to new location.

c. Decommission old access structure.

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# 5 Stakeholder consultation

## 5.1 Consultation meetings

5.1.1 Over the development of the design, the project team engaged with Cory Environmental as a key stakeholder with regard to river operations and impact upon the navigational channel.

5.1.2 In addition to ongoing direct discussions with Thames Clippers and Transport for London, consultations were undertaken with other key stakeholders. Appendix F contains details of meeting dates, venues, attendees and discussion notes.

## 5.2 Observation notes

5.2.1 Observations and analysis of Cory tug and tow operations through Blackfriars Bridges were conducted. Full details of the analysis are contained with Appendix C - Freight Tracks and AIS Analysis and photographic analysis in Section 6 - Current River Operations.

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# 6 Current river operations

## 6.1 Photographic analysis of inward bound freight: Single rank through Blackfriars Bridge arch No2

6.1.1 Visual analysis of inward bound tug and tow passages through Blackfriars Bridge arch No2 indicates that barges would clear the permanent structure location by at least approximately 10m. Inward bound tug and tow passages through Blackfriars Bridge arch No3 would clear the temporary cofferdam by 55m and clear the LLAU (encompassing jack-up and work vessels) by 42m. The following paragraphs summarise the analysis.

6.1.2 Figure 6.1: Distance to pier 26m, at this location the permanent structure intrudes 6m beyond the pier resulting in the distance to permanent structure of 20m.

**Figure 6.1 Tug with single rank of barges**

6.1.3 Figure 6.2: Distance to line of pier 30m, at this location the permanent structure intrudes 11m beyond the line of the pier, resulting in the distance to the permanent structure of 19m.

**Figure 6.2 Tug with single rank of barges**

## 6.2 Photographic analysis of inward bound freight: 3 barges through Blackfriars Bridge arch No2

6.2.1 Observation and analysis conducted in February and March 2012 indicates a distance to the line of the pier of 32m. The distance to the permanent structure would be 14m (at this location the permanent structure intrudes 18m beyond the line of the pier).

**Figure 6.3 Barges through arch No2**

## 6.3 Analysis of inward bound freight: 3 barges through Blackfriars Bridge arch No3

6.3.1 Observation and analysis conducted in February and March 2012 of inward bound tug and tow passage through Blackfriars Bridge arch No3 indicates the distance to the line of the pier of 85m, so a 3 barge tow would clear the temporary cofferdam by 55m and the LLAU (encompassing jack-up and work vessels) by approximately 35m.

**Figure 6.4 Barges through arch No3**

## 6.4 Detailed analysis of vessel tracks

6.4.1 Appendix C of this report contains detailed analysis of vessel tracks taken at the end of 2011 and 2012 through the Kings Reach area of the Thames, showing vessel track data (Observed and AIS) for Cory and the Thames Clippers service.

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# 7 Risk assessment

## 7.1 Risk assessment: Methodology

7.1.1 For each of the identified hazards, the associated risk was assessed and classified. The following definitions were applied for the purposes of this report:

a. Hazard: eg, an object, activity or phenomenon that can cause an adverse effect.

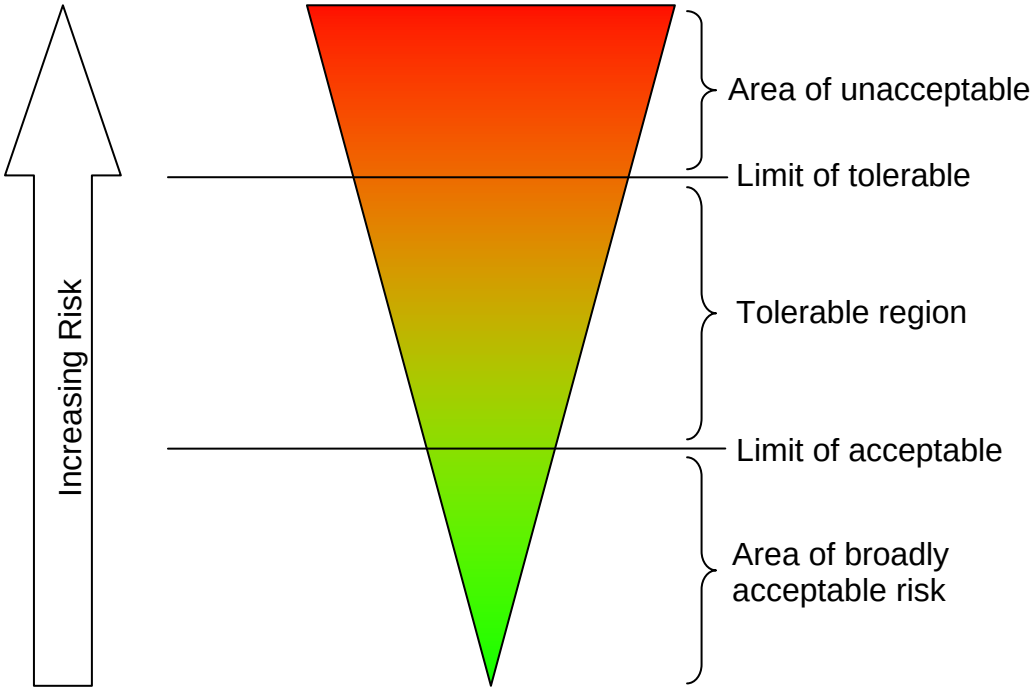
b. Risk: a relative measure of harm or loss, derived from the combination of the severity of a particular consequence together with the probability of the consequence occurring.

c. Consequence: a particular scenario (expressed as harm to people, damage to the environment, an operational impact and/or negative media attention) that results from a hazardous situation.

d. Probability: the 'chance' of a particular hazard consequence occurring, measured as a frequency (per year).

7.1.2 The assessment used the principle of reducing navigational risks to a level that is As Low As Reasonably Practicable (ALARP). ALARP is part of the Health and Safety at Work Act 1974 and involves assessing the acceptability of a risk against the difficulty, time and expense needed to control it. The ALARP concept is illustrated in Figure 7.1.

**Figure 7.1 The ALARP Principle**




7.1.3 At the lower end of the ALARP triangle, risks are small due to either low probability or insignificant consequences. These risks can generally be accepted provided that common safeguards are implemented. Moving up

the ALARP triangle to the tolerable region, risks increase in magnitude due to either an increase in probability or an increase in severity of consequences. Risks in the tolerable region can be accepted provided that risk controls are implemented that demonstrate that the risk is reduced to a level deemed to be ALARP; where any further risk reduction would be disproportionate in terms of cost, time and resources required to implement it compared to the benefit it would introduce. At the top of the ALARP triangle is a region of unacceptable risk that cannot be accepted without risk controls to reduce the risk to a tolerable and ALARP level.

7.1.4 This risk assessment was undertaken on a qualitative basis, using the engineering and operational judgement of representatives from the project team and representatives from river users and operators. Hazard consequences were considered based on most likely outcomes.

## 7.2 Risk assessment: Criteria

7.2.1 When commencing the assessment of the risk posed by the project's activities, the project's marine consultant recommended using the risk assessment criteria and methodology within the existing PLA Safety Management System (SMS). The rationale behind this recommendation was to provide the project team and the PLA with a consistent assessment score that could be transferred across into the PLA's existing SMS and enable an appreciation of the increase in risk resulting from the project's temporary and permanent works.

7.2.2 Consultation with the PLA highlighted the PLA's desire to use alternative, project specific risk terminology, as well as an alternative assessment matrix and risk classification scorecard. These changes have now been incorporated as requested.

7.2.3 This section details the risk criteria used throughout this assessment. The assessment process identifies four distinct areas of risk and the probable consequences associated with each hazard assessed in terms of harm or loss to:

a. people (life)

b. environment

c. operational impact

d. media attention.

7.2.4 Table 7.1 details the 'probability' criteria used to assess how likely each hazard is to occur in terms of average frequency in the PLAs jurisdiction.

**Table 7.1 Probability Criteria**

| | Frequency | Score |
|---|---|---|
| Rare | Has not occurred in the in the last ten years | 1 |
| Unlikely | Has not occurred in the in the last three years | 2 |
| Possible | Has not occurred in the in the last year | 3 |

| | | |
|---|---|---|
| Likely | Has occurred in the in the last year | 4 |
| Almost certain | Occurs several times per year | 5 |

7.2.5 Table 7.2 details the severity criteria applied to the safety- related consequences of each hazard.

| Table 7.2 Severity Criteria: People | Level |
|---|---|
| First aid case / medical treatment case | 1 |
| Restricted work case | 2 |
| Lost time injury / moderate permanent partial disability injury | 3 |
| Single fatality / severe permanent partial disability | 4 |
| Multiple fatalities | 5 |

7.2.6 Table 7.3details the severity criteria applied to the environmental loss related consequences of each hazard.

| Table 7.3 Severity Criteria: Environment | Level |
|---|---|
| Low impact with no lasting effect | 1 |
| Temporary effect / minor effect to small area | 2 |
| Short to medium term impact | 3 |
| Medium to long term effect / large area affected | 4 |
| Long term impact / severe impact on sensitive area | 5 |

7.2.7 Table 7.4 details the severity criteria applied to the property loss/damage related consequences of each hazard.

| Table 7.4 Severity operational impact | Level |
|---|---|
| Insignificant or no damage to vessel / equipment | 1 |
| Minor or superficial damage to vessel / equipment | 2 |
| Moderate damage to vessel / equipment requiring immediate repairs | 3 |
| Major damage to vessel / equipment and detention | 4 |
| Very serious damage to vessel or equipment possible criminal proceedings | 5 |

7.2.8 Table 7.5 details the severity criteria applied to negative media attention/coverage consequences of each hazard.

| Table 7.5 Severity Criteria: Media attention | Level |
|---|---|
| No coverage | 1 |
| Local coverage | 2 |
| Regional coverage | 3 |
| National coverage | 4 |
| International coverage | 5 |

## 7.3 Risk matrix

7.3.1 The risk matrix in Table 7.6 was used to provide a risk score, combining severity of a particular consequence with the likelihood (probability) of the consequence occurring.

**Table 7.6 Risk matrix**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Likelihood** | Rare | **1** | **2** | **3** | **4** | **5** |
| | Unlikely | **2** | **4** | **6** | **8** | **10** |
| | Possible | **3** | **6** | **9** | **12** | **15** |
| | Likely | **4** | **8** | **12** | **16** | **20** |
| | Almost Certain | **5** | **10** | **15** | **20** | **25** |
| | **Severity** | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |

7.3.2 The risk score in Table 7.7 indicates the magnitude and acceptability of the risk in accordance with the ALARP principle. The PLA method applies this to both individual and average risk.

**Table 7.7 Risk classification**

| Score | Classification | Definition |
|---|---|---|
| 1 to 2 | Slight | No action is required. |
| 3 to 4 | Minor | No additional controls are required, monitoring is required to ensure no changes in circumstances |
| 5 to 9 | Moderate | Efforts should be made to reduce risk to ALARP level. Job can be performed under direct supervision of Senior Officer. |

| | | |
|---|---|---|
| 10 to 14 | High | Efforts should be made to reduce risk to ALARP level. Job can only be performed after authorisation from Harbour Master and after further additional controls required under the circumstances. |
| 15 to 25 | Extreme | Intolerable risk. Job is not authorised. |

## 7.4 Hazard identification

7.4.1 A hazard can be defined as 'the potential for an adverse consequence', and may be associated with a situation that could cause harm to people, damage to the environment, an operational impact or negative media attention.

7.4.2 In order to facilitate a comprehensive overview of potential maritime hazards, various river users and operators were consulted throughout the risk assessment process, including:

a. Thames Clippers
b. Cory Environmental Limited
c. City Cruises
d. Livett's Launches
e. Bennett's Barges
f. London Duck Tours
g. Metropolitan Police Marine Policing Unit
h. Royal National Lifeboat Institute (RNLI).

7.4.3 The project also made several site visits to HR Wallingford's physical model during the risk assessment process. This provided Captain David Phillips (at the time, PLA Harbour Master (Upper)), freight (Cory Environmental) and commercial (Thames Clippers) operators with the opportunity to understand the impact of the proposed developments on the river flow patterns and to visualise the scale of the temporary and permanent work at various locations.

## 7.5 Mitigation strategy

7.5.1 Throughout the assessment process, it was evident that potential hazards presented by the project would require mitigation measures throughout the project lifecycle.

7.5.2 The following section will identify and detail the navigational issues and proposed mitigation measures.

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# 8 Navigational issues and mitigation measures

## 8.1 General

8.1.1 It is acknowledged that mitigation measures may themselves introduce further hazards that also require mitigation. Where appropriate, these have been considered.

8.1.2 Mitigation measures were developed with an emphasis on measures that are within the project's control (e.g. design of in-river structures).

8.1.3 For the purpose of this assessment, mitigation measures (risk control options) were classified as three types;

a. Design: measures that can be implemented by the project at the design stage.

b. Physical: measures that the project can implement during the construction and operational phases.

c. Operational: measures that the project can implement in conjunction with the PLA at all stages of the project.

8.1.4 Of course, some proposed mitigation measures would be beyond the project's control, such as emergency plans, operating procedures and NtMs.

8.1.5 Appendix C of this report contains detailed analysis of vessel tracks through the Kings Reach area of the River Thames, including track data (Observed and Thames AIS) for Cory and the passage plan routing for the Thames Clippers service.

8.1.6 In February and September 2012 Cory AIS data was captured offering a visualisation of Cory tug and barge movements through the study area. The data showed Cory tug and tows using arch No2 on an inbound transit and has allowed for assessment of proximity to the proposed work structures.

## 8.2 Inbound tugs and tows making contact with temporary structures or river-based plant (Phases A to C)

8.2.1 Tugs and tows, whilst engaged in towing operations transiting this section of the river, could make contact with the proposed temporary works structure, or with jack-up barges located within the river.

8.2.2 A tug and tow making contact with the cofferdam has the potential to lead to single or multiple fatalities and is considered an extreme ranking hazard prior to mitigation being put in place.

8.2.3 In order to facilitate safe navigation of bridges on the Thames, the PLA has published the *Mariners Guide to Bridges on the Tidal Thames* which details the bridge arches to be used and by whom. For Blackfriars Road Bridge, the following Navigation advice is provided:

a. outbound: arch No4 should normally be used by outbound traffic, leaving the centre arch clear for the larger, and reporting vessels

b. inbound: arch No2 should normally be used by inbound traffic, leaving the centre arch clear for the larger, and reporting vessels.

## Actions required

8.2.4 A number of actions, specific to the issues, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:

a. seeking agreement from stakeholders as to the safe separation distance from fixed structures

   i Evidence indicates that a single rank of barges through arch No2 would pass the permanent works structure by more than 13m.

   ii For a double rank of barges this separation distance would reduce to approximately 11m.

   iii Note: bridge pier spacing results in barge to bridge pier clearance of approximately 7 to 8m when passing under Westminster Bridge.

b. consultation with freight operators

c. analysis of current vessel tracks

d. assessment of temporary works damage resistance / structural integrity.

## Mitigation of issues: Design

8.2.1 Designing the project has been an iterative process, influenced by the ongoing navigational risk assessment process. Measures to eliminate or reduce navigational hazards identified in early risk assessments were embedded into the design of the temporary and permanent works to eliminate or reduce navigational hazards. This assessment therefore assesses the residual risk assuming the effective implementation of these measures. The embedded measures include:

a. The project team reviewed and altered the design and layout of the temporary works site to minimise the intrusion into the river. The extent that the permanent in-river structure (and therefore the temporary cofferdam) would extend into the river was reduced by approximately 4m during the design review process and following extensive consultation with river operators and the PLA. Appendix A lists drawings that show the change in design undertaken during the design review process.

b. Constraints have been placed on the working areas within the river, as identified on the Zones of Foreshore Working drawing (Appendix A) to minimise the duration and extent of encroachment into the authorised channel

8.2.2 The following sections set out the proposed mitigation measures to address the residual risks.

### Mitigation of issues: Physical

a. meeting with Cory to get their views on intrusion and if possible get confirmation that the temporary works structure does not impact on existing operations (in terms of transit times and operational requirements).

b. closure of arch No2 to all inbound traffic during certain phases of the construction and removal of the cofferdam (Phase A and C).

c. closure of arch No2 to all inbound freight and reporting vessels whilst the temporary works structure is in place (Phase B).

d. review of project barge operating procedures: recommend that tugs only pull a single rank of barges through this section of the river if arch No3 is also closed or unavailable to tugs and tows.

### Mitigation of issues: River operations

a. maintain arch No4 for navigation to allow for larger and reporting vessels to transit this area in the event that arch No3 is closed. The majority of larger and reporting vessels are currently able to navigate arch No4 on most states of the tide.

## 8.3 Inbound tugs and tows making contact with permanent structure (Phase D)

8.3.1 Tugs and tows, whilst engaged in towing operations transiting this section of the river, could make contact with the proposed permanent works structure.

8.3.2 A tug and tow making contact with the permanent works structure has the potential to lead to single or multiple fatalities and is considered an extreme ranking hazard.

### Actions required

8.3.3 A number of actions, specific to the issues, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:

a. Commissioning of further vessel tracking in autumn 2012 through arch No2 and by simulation the extent of the permanent foreshore structure and relocated Millennium Pier by buoys.

### Mitigation of issues: Design

8.3.4 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:

a. The project team reviewed and altered the design and layout of the permanent works structure to minimise the intrusion into the river as set out above.

8.3.5 The following sections set out the proposed mitigation measures to address the residual risks.

8.3.6 The project team will continue to review whether there is scope to further reduce the size of the permanent works in the river.

### Mitigation of issues: Physical

a. A meeting was held with Cory to discuss the impact on intrusion and confirmation that the permanent works structure does not impact on existing operations (in terms of transit times and operational requirements). However it has not been possible to reach an agreement on acceptable clearing distances. The relocation of Millennium Pier is covered in Section 8.8.

### Mitigation of issues: River operations

8.3.7 None identified

## 8.4 Closure of arch No2 (Phases A to C)

8.4.1 Closure of arch No2 of Blackfriars Road Bridge and Blackfriars Rail Bridge during construction phases of the project could have an adverse impact on vessel traffic and therefore navigational safety.

8.4.2 Closure of arch No2 during these phases of the project would mean that all inbound traffic would be required to use arch No3, therefore increasing the density of traffic in this area and potentially increasing the risk of collision or river incident.

8.4.3 With arch No2 closed, should there be an emergency requirement to close arch No3, then arch No4 would be the only available arch for navigation in both directions of travel. The closure of arch No3 is covered in more detail in Section 8.5.

### Actions required

8.4.4 A number of actions, specific to the issues, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:

a. consultation with freight operators

b. clarification as to which vessels using arch No2 are likely to be affected by an arch closure

c. clarification as to the duration over which there is insufficient under keel clearance in arch No4 for navigation

d. investigation of the benefits of dredging arch No4

e. investigation of the options for opening arch No4.

### Mitigation of issues: Design

8.4.5 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:

a. Constraints have been placed on the working areas within the river, as identified on the Zones of Foreshore Working drawing (shown in

Appendix A) to maximise the duration that Arch 2 is open to smaller vessels.

b. Planned closure of the bridge arches should not take place during the works (phase A to C). General bridge inspections are carried out every two years, but do not require closure of the arches. Principal bridge inspections are carried out every six years. Principal bridge inspections will be conducted immediately prior to project work commencing.

8.4.6 The following sections set out the proposed mitigation measures to address the residual risks.

### Mitigation of issues: Physical

a. none identified

### Mitigation of issues: River operations

a. A Notice to Mariners would be issued, informing river users of the planned closures and the lights/markings to expect.

## 8.5 Closure of arch No3 (Phases A to C)

8.5.1 The closure of arch No3 (either planned or for an emergency situation) could have an adverse impact on vessel traffic, potentially leading to the closure of the river to navigation until such times that the arch can be re-opened.

8.5.2 Arch No3 is designated as being the arch used by both inbound and outbound larger, and reporting vessels, with special signal lights located the above the arch.

8.5.3 Arch No2 is assigned to smaller inbound vessels with arch No4 assigned for smaller outbound vessels (if safe to do so).

### Actions required

8.5.4 A number of actions, specific to the issues, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:

a. consultation with the bridge owners to establish schedule of planned closure of arch No3

b. clarification as to which vessels would likely be affected and the duration over which there would be insufficient under-keel clearance in arch No4 for navigation (for vessels of a given draught)

c. investigation of the benefits of dredging arch No4

d. investigation, of the options for opening arch No4.

### Mitigation of issues: Design

8.5.5 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:

a. Planned closure of the bridge arches should not take place during the works (phase A to C). General bridge inspections are carried out every 2 years, but do not require closure of the arches. Principal bridge inspections are carried out every six years. Principal bridge inspections will be conducted immediately prior to project work commencing.

8.5.6 The following sections identify proposed mitigation to address the residual risks.

### Mitigation of issues: Physical

a. In the event of closure of arch No3, relocate the Cory Environmental moorings (currently opposite the proposed permanent works site) to either Georges Stairs Lower or Hot Pole moorings.

### Mitigation of issues: River operations

a. A harbour service launch should be in attendance maintaining a continuous VHF watch on Channel 14 in the event of arch No3 closure.

b. Maintain arch No4 to allow for navigation of inbound and outbound for larger and reporting vessels in the event that arch No3 is closed (emergency or planned closure).

c. issue a Notice to Mariners informing river users of the planned closures and the lights/markings to expect

   i arch No3 has been closed at various times during the Network Rail Blackfriars Bridge construction project with two other arches available to navigation

   ii NTMs have previously been issued for this situation stating ‘When two navigable arches are closed to navigation, local traffic control will be established from a Port of London Authority Harbour Services Launch operating in the area. Vessels wishing to pass through the remaining open navigable arch of Blackfriars Road and Railway Bridges or operating between London and Waterloo Bridges are to call “Thames Patrol” on VHF Channel 14’

## 8.6 Closure of arch No3 (Phase D)

8.6.1 Once the construction of the drop shaft, culvert and associated infrastructure is complete and the cofferdam has been removed a permanent structure would be left in its place.

8.6.2 The permanent structure would be smaller in scale to that of the temporary cofferdam, however due to the size of the drop shaft and the requirement to access the site for maintenance the structure would still intrude into the river.

8.6.3 The asset owners need to regularly inspect the Blackfriars bridges, resulting in bridge arches being closed every six years. These inspections involve inspection from below using boats and access platforms, or from

above using abseilers or special bridge inspection vehicles that sit on the bridge deck and support an under-slung access platform.

### Actions required

8.6.4 A number of actions, specific to the issues, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:

a. consultation with the bridge owners to establish schedule of planned closure of arch No3;

b. undertake additional vessel tracking through arch No2 with the permanent structure and relocated Blackfriars Millennium Pier simulated by marker buoys.

### Mitigation of issues: Design

8.6.5 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:

a. The project team reviewed and altered the design and layout of the temporary works site to minimise the intrusion into the river. The extent that the permanent in-river structure would extend into the river was reduced by approximately 4m during the design review process and following extensive consultation with river operators and the PLA so as to allow the use of Arch 2 by tug and tow in the event that Arch 3 is closed.

8.6.6 The following sections identify proposed mitigation to address the residual risks.

### Mitigation of issues: Physical

a. none identified

### Mitigation of issues: River operations

a. issue a Notice to Mariners informing river users of the planned closures and the lights/markings to expect;

## 8.7 Increased flow effect on passing vessels: All phases

8.7.1 The shape, location and size of the temporary works and permanent works in the river at the Blackfriars Bridge Foreshore site would lead to an increase in river flow that could have an adverse impact on existing river users.

8.7.2 The project understands that the increase in river flow could be of concern to the PLA and a number of river users due to the effect that it would have on existing passing river traffic.

8.7.3 Flow changes have been analysed by HR Wallingford, the analysis involved simulating flow rates over a number of tidal conditions using a

baseline of current flow against flow rates with the in river structures in place (both temporary and permanent).

8.7.4 The analysis, summarised below, indicates that the introduction of the proposed temporary and permanent works structures at this site would have a minimal effect on existing river users. The changes in flow are expected to be low with the majority of vessels using this area likely to be unaffected.

8.7.5 During the design process, the site layout and outline shape of the permanent work site has changed. The change in permanent work takes into consideration earlier recommendations to 'streamline' the structure. This alteration reduced the overall effect that the new structure would have on the overall river flow.

8.7.6 The analysis has established the following:

a. The greatest change in maximum flow for the temporary works across a given cross section in the Blackfriars area is approximately 0.2 knots in line with the bridge piers and approximately 0.6 knots adjacent to the widest part of the permanent structure. These changes are associated with a peak ebb spring tide with strong river flow (800$m^3$/s).

b. The greatest change in maximum flow for the permanent across a given cross section in the Blackfriars area is approximately 0.2 knots in line with the bridge piers and also approximately 0.2 knots adjacent to the widest part of the permanent structure. These changes are associated with a peak ebb spring tide with strong river flow (800$m^3$/s).

8.7.7 Further Fluvial Modelling analysis is provided in Appendix B, including a tabulation of the changes in maximum flow for the available tidal and fluvial conditions. These results were shared with river operators to highlight the small predicted changes in flow.

## Actions required

8.7.8 A number of actions, specific to the issues, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:

a. inform the PLA of further design development regarding river flow.

b. conduct consultation and review with freight river operators.

## Mitigation of issues: Design

8.7.9 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:

a. The project team reviewed and altered the design and layout of the temporary works site to minimise the intrusion into the river. The extent that the permanent in-river structure (and therefore the temporary cofferdam) would extend into the river was reduced by approximately 4m during the design review process and following extensive consultation with river operators and the PLA, which has reduced the effect on peak velocities in the river.

b. 3D and computational modelling of in-river structures was carried out to predict the changes in velocity.

c. Analysis of modelling results was undertaken to determine likely increases/decreases in flow and vessel types most likely to be affected by changes.

d. The design of the temporary and permanent structures includes the provision of ladders, safety grab chains and other lifesaving equipment around the work sites to aid emergency egress from the river, in accordance with the PLA's guidance document *Review of Lifesaving Provisions Along the River Thames*

8.7.10 The following sections identify measures to address the residual risk.

### Mitigation of issues: Physical

a. none identified

### Mitigation of issues: River operations

a. none identified

## 8.8 Relocation of Blackfriars Millennium Pier

8.8.1 As part of the proposed works at the Blackfriars Bridge Foreshore site the project would need to permanently relocate Blackfriars Millennium Pier.

8.8.2 Investigation into the suitability of the proposed new location has been undertaken including several stakeholder engagement meetings. A number of issues were taken into consideration when finalising the new location of the pier as outlined in Section 4.6

### Actions required

8.8.3 A number of actions, specific to the issues, have been commenced or completed in order to assist the project to provide a robust and evidence-based assessment to the PLA. These actions include:

a. consultation with PLA and river freight operators regarding safe navigation, and TfL/City of London regarding land based access requirements

b. analysis of tracks with Cory tug and tow passing the site using Arch 2 without constraint

c. analysis of vessel tracking of Cory vessels passing the site whilst marking the location of the pier and permanent in-river structure by buoys

d. investigation of the dredging requirements associated with moving the pier.

### Mitigation of issues: Design

8.8.4 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:

a. Constraints have been placed on the working areas within the river, as identified on the Zones of Foreshore Working drawing (shown in Appendix A) to minimise the duration that Arch 2 is closed to facilitate the relocation works.

b. Relocation of the pier as close as practical to the river wall to facilitate safe passage of tug and tows and while limiting the extent of dredging required, and therefore minimising the need for ongoing dredging to keep the pier operational. The pontoon was moved to the east following review of unconstrained barge tracks and then moved north following review of the tracks carried out with buoys in place in order to increase the distance between the pier and passing barges.

c. Inclusion of a fendered pile to enable vessels to moor on the eastern end of the pier safely, with one end of the vessel in contact with the pontoon and the other end in contact with the fendered pile, thereby increasing the distance between moored vessels and passing barges when tug and tow are using Arch 2

8.8.5 The following sections set out the proposed mitigation measures to address the residual risks.

### Mitigation of issues: Physical

a. none identified.

### Mitigation of issues: River operations

a. Amend operational procedures for vessels using Blackfriars Pier to require vessels to moor on the eastern extent of the pier, with one end of the vessel on the pier, when tug and tow are using Arch 2.

b. Co-ordinate works so that arch No2 closures do not coincide with scheduled maintenance work/inspections at arch No 3 and 4.

c. Issue a Notice to Mariners, informing river users of the planned closures and in-river works.

## 8.9 Relocation of the President

8.9.1 In order for the project to have sufficient working area to construct and operate the cofferdam and temporary works site, the project proposes to temporarily relocate the President. The President would be permanently reinstated in its current position when the construction works are complete.

### Actions required

8.9.2 Inform the PLA of further design developments if applicable.

### Mitigation of issues: Design

8.9.3 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:

a. The project team reviewed and altered the design, layout and location of the permanent relocation to minimise the intrusion into the river. The location of the reinstated vessel was set back from the authorised channel and from the line of the proposed river wall so as not to offer any navigational hazards, while offering improved gradients on the access brows.

The following sections identify measures to address the residual risk.

## Mitigation of issues: Physical

a. None identified.

## Mitigation of issues: River operations

a. issue a Notice to Mariners to advise of relocation operations and temporary mooring location.

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# 9 General navigational hazards

9.1.1 In addition to the 'navigation issues' considered within this report, navigational hazards associated with day-to-day river operations were also identified. These hazards relate to the interaction of the project-related marine traffic with existing river users.

9.1.2 'Worst Credible' consequences and the probability of the consequences were considered in the assessment. As a result, in some cases the Worst Credible score was lower than the 'Most Likely' score. This is explained by the probability that a 'moderate injury', for example, is higher than the probability of a 'single fatality'.

9.1.3 Full hazard details contained in Annex A through to Annex I as follows:

## 9.2 Project phases A to C: Most likely

**Table 9.1 Most likely hazard log summary**

| | | | | Score | | | |
|---|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **Phase** | **People** | **Environment** | **Operational** | **Media** |
| 1 | Restricted working - work intrudes into authorised channel and constrains traffic | During construction of cofferdam, the projects associated infrastructure (cofferdam, jack up rig etc) extends into the authorised channel, therefore constraining available water space for existing traffic. Due to the reduced channel width a river incident occurs. | A | 12 | 6 | 9 | 12 |
| | | | B | 12 | 6 | 9 | 12 |
| | | | C | 12 | 6 | 9 | 12 |
| 2 | Emergency arch closure - | During construction of the | A | 9 | 6 | 9 | 9 |
| | | | B | 9 | 6 | 9 | 9 |

| | | | | Score | | | |
|---|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **Phase** | **People** | **Environment** | **Operational** | **Media** |
| | arch No3 | cofferdam there may be an emergency requirement to close arch No3. | C | 9 | 6 | 9 | 9 |
| 3 | Planned arch closure - arch No3 | During construction of the cofferdam, the project may propose to close arch No3 for maintenance. | A | 6 | 4 | 6 | 8 |
| | | | B | 8 | 4 | 8 | 8 |
| | | | C | 6 | 4 | 6 | 8 |
| 4 | Planned arch closure - arch No2 | During construction of the cofferdam it is proposed that arch No2 is closed to all navigation. | A | 9 | 6 | 12 | 12 |
| | | | B | 9 | 6 | 12 | 12 |
| | | | C | 9 | 6 | 12 | 12 |
| 5 | Increase in Flow | Changes to the hydrodynamics of the river may affect passing vessels, particularly through the arches of Blackfriars Bridges. | A | 9 | 6 | 6 | 9 |
| | | | B | 9 | 6 | 6 | 9 |
| | | | C | 9 | 6 | 6 | 9 |
| 6 | Contact - High Speed Craft / Class V passenger vessel with Temporary work site | A High Speed Craft / Class V passenger vessel comes into contact with Thames Tunnel temporary worksite at Blackfriars Embankment during construction / removal of temporary cofferdam. | A | 6 | 4 | 6 | 8 |
| | | | B | 9 | 6 | 9 | 12 |
| | | | C | 6 | 4 | 6 | 8 |
| 7 | Contact - Tug | A Tug and Tow | A | 6 | 4 | 6 | 8 |

| | | | | Score | | | |
|---|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **Phase** | **People** | **Environment** | **Operational** | **Media** |
| | and Tow with Temporary work site | comes into contact with Thames Tunnel temporary worksite at Blackfriars Embankment during construction / removal of temporary cofferdam. | B | 9 | 6 | 9 | 12 |
| | | | C | 6 | 4 | 6 | 6 |
| 8 | Contact - Private leisure vessel with Temporary work site | Private leisure vessels, including narrow boats, comes into contact with Thames Tunnel temporary worksite at Blackfriars Embankment during construction / removal of temporary cofferdam (section A). | A | 9 | 6 | 9 | 9 |
| | | | B | 9 | 6 | 9 | 12 |
| | | | C | 9 | 6 | 9 | 9 |
| 9 | Collision with commercial freight operator | A vessel conducting project construction activities collides with a commercial freight operator in vicinity of Blackfriars Bridge Foreshore. | A | 9 | 9 | 6 | 9 |
| | | | B | 9 | 9 | 6 | 9 |
| | | | C | 9 | 9 | 6 | 9 |
| 10 | Collision with tug and tow | A vessel conducting project | A | 9 | 6 | 9 | 9 |
| | | | B | 9 | 9 | 9 | 9 |

| Hazard Id | Hazard Title | Hazard Description | Phase | Score | | | |
|---|---|---|---|---|---|---|---|
| | | | | People | Environment | Operational | Media |
| | | construction activities collides with a tug and tow in vicinity of Blackfriars Bridge Foreshore. | C | 9 | 6 | 9 | 9 |
| 11 | Contact with Blackfriars Bridge (Road and Rail) | A vessel conducting project construction activities makes contact with Blackfriars Road or Rail Bridge, including arches, abutments and any associated bridge superstructure. | A | 6 | 3 | 6 | 6 |
| | | | B | 6 | 3 | 6 | 6 |
| | | | C | 6 | 3 | 6 | 6 |
| 12 | Contact - High Speed Craft / Class V passenger vessel with Temporary work site | A High Speed Craft / Class V passenger vessel comes into contact with project temporary work site at Blackfriars Bridge Foreshore. | A | 6 | 4 | 6 | 6 |
| | | | B | 9 | 6 | 9 | 9 |
| | | | C | 6 | 4 | 6 | 6 |
| 13 | Contact - Tug and Tow with Temporary work site | A Tug and Tow comes into contact with project temporary work site at Blackfriars Bridge Foreshore during construction / removal of cofferdam. | A | 6 | 4 | 6 | 6 |
| | | | B | N/A | N/A | N/A | N/A |
| | | | C | 6 | 4 | 6 | 6 |
| 14 | Contact - Private | Private leisure vessels, including | A | 8 | 2 | 8 | 6 |
| | | | B | N/A | N/A | N/A | N/A |

| | | | | Score | | | |
|---|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **Phase** | **People** | **Environment** | **Operational** | **Media** |
| | leisure vessel with Temporary work site | narrow boats, come into contact with Thames Tunnel temporary work site at Blackfriars Embankment during construction / removal of temporary cofferdam. | C | 8 | 2 | 8 | 6 |
| 15 | Contact with moored vessel in vicinity of Blackfriars (President / Cory barges/ Passenger boat moorings etc) | A vessel in transit makes contact with a moored vessel (eg. Moored Barge, President or moored passenger boat) in vicinity of Blackfriars Bridge Foreshore. | A | 8 | 4 | 6 | 8 |
| | | | B | 8 | 4 | 6 | 8 |
| | | | C | 8 | 4 | 6 | 8 |
| 16 | Vessels subject to increased interaction during periods of low water | Due to the intrusion of the temporary works into the authorised channel, the available water space for vessels to manoeuvre in is reduced. At periods of low water this is particularly relevant | A | 6 | 2 | 6 | 6 |
| | | | B | 9 | 3 | 9 | 9 |
| | | | C | 6 | 2 | 6 | 6 |
| 17 | Grounding - All vessels | At periods of low water, vessels may | A | 6 | 2 | 6 | 6 |
| | | | B | 9 | 3 | 9 | 9 |

| Hazard Id | Hazard Title | Hazard Description | Phase | Score | | | |
|---|---|---|---|---|---|---|---|
| | | | | People | Environment | Operational | Media |
| | due to 'Squat Effect' | be affected by the 'Squat Effect', causing them to be closer to the river bed than expected. | C | 6 | 2 | 6 | 6 |
| 18 | Contact with moored vessel at relocated Blackfriars Millennium Pier | A vessel in transit makes contact with a vessel moored at the relocated Blackfriars Millennium Pier. | A | 8 | 2 | 8 | 8 |
| | | | B | 12 | 3 | 12 | 12 |
| | | | C | 8 | 2 | 8 | 8 |

## 9.3 Project phases A to C: Worst credible

**Table 9.2 Worst credible hazard log summary**

| Hazard Id | Hazard Title | Hazard Description | Phase | Score | | | |
|---|---|---|---|---|---|---|---|
| | | | | People | Environment | Operational | Media |
| 1 | Restricted Working - Work intrudes into | During construction of cofferdam, associated infrastructure | A | 15 | 9 | 15 | 12 |
| | | | B | 15 | 12 | 15 | 15 |

| Hazard Id | Hazard Title | Hazard Description | Phase | Score | | | |
|---|---|---|---|---|---|---|---|
| | | | | People | Environment | Operational | Media |
| | authorised channel and constrains traffic | (cofferdam, jack up rig etc) extends into the authorised channel, therefore constraining available water space for existing traffic. Due to the reduced channel width a river incident occurs. | C | 15 | 9 | 15 | 12 |
| 2 | Emergency arch closure - arch No3 | During construction of the cofferdam there may be an emergency requirement to close arch No3. | A | 15 | 9 | 15 | 12 |
| | | | B | 12 | 12 | 15 | 15 |
| | | | C | 15 | 9 | 15 | 12 |
| 3 | Planned arch closure - arch No3 | During construction of the cofferdam there may be a requirement to close arch No3 for maintenance. | A | 10 | 6 | 10 | 8 |
| | | | B | 8 | 8 | 10 | 10 |
| | | | C | 8 | 6 | 10 | 8 |
| 4 | Planned arch closure - arch No2 | During construction of the cofferdam it is proposed that arch No2 is closed to all navigation. | A | 10 | 6 | 10 | 10 |
| | | | B | 12 | 12 | 15 | 15 |
| | | | C | 10 | 6 | 10 | 10 |
| 5 | Increase in Flow | Changes to the hydrodynamics of the river may affect passing vessels, particularly through the arches of Blackfriars Bridges. | A | 15 | 9 | 15 | 12 |
| | | | B | 12 | 12 | 12 | 15 |
| | | | C | 15 | 9 | 15 | 12 |
| 6 | Collision with High Speed | A vessel conducting project construction | A | 10 | 6 | 10 | 10 |
| | | | B | 15 | 9 | 12 | 12 |

| | | | | Score | | | |
|---|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **Phase** | **People** | **Environment** | **Operational** | **Media** |
| | Passenger Vessel | activities collides with a High Speed Passenger Vessel (e.g. Thames Clipper) in the vicinity of Blackfriars | C | 10 | 6 | 10 | 10 |
| 7 | Collision with Class V passenger vessel | A vessel conducting project construction activities collides with a Class V passenger vessel in vicinity of Blackfriars Bridge Foreshore. | A | 10 | 6 | 10 | 10 |
| | | | B | 15 | 9 | 12 | 15 |
| | | | C | 10 | 6 | 10 | 10 |
| 8 | Collision with private leisure vessel | A vessel conducting project construction activities collides with a private leisure vessel in vicinity of Blackfriars Bridge Foreshore. | A | 15 | 6 | 15 | 15 |
| | | | B | 15 | 9 | 12 | 15 |
| | | | C | 15 | 6 | 15 | 15 |
| 9 | Collision with commercial freight operator | A vessel conducting project construction activities collides with a commercial freight operator in vicinity of Blackfriars Bridge Foreshore. | A | 15 | 9 | 15 | 15 |
| | | | B | 15 | 9 | 15 | 15 |
| | | | C | 15 | 9 | 15 | 15 |
| 10 | Collision with tug and tow | A vessel conducting project construction activities collides with a tug and tow in vicinity of Blackfriars Bridge Foreshore. | A | 15 | 9 | 15 | 15 |
| | | | B | 15 | 9 | 15 | 15 |
| | | | C | 15 | 9 | 15 | 15 |
| 11 | Contact with Blackfriars | A vessel conducting project construction | A | 8 | 6 | 8 | 8 |
| | | | B | 12 | 9 | 12 | 12 |

| | | | | Score | | | |
|---|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **Phase** | **People** | **Environment** | **Operational** | **Media** |
| | Bridge (Road and Rail) | activities makes contact with Blackfriars Road or Rail Bridge, including arches, abutments and any associated bridge superstructure. | C | 8 | 6 | 8 | 8 |
| 12 | Contact - High Speed Craft / Class V passenger vessel with Temporary work site | A High Speed Craft / Class V passenger vessel comes into contact with project temporary work site at Blackfriars Bridge Foreshore. | A | 15 | 9 | 15 | 15 |
| | | | B | 15 | 9 | 15 | 15 |
| | | | C | 15 | 9 | 15 | 15 |
| 13 | Contact - Tug and Tow with Temporary work site | A Tug and Tow comes into contact with project temporary work site at Blackfriars Bridge Foreshore during construction / removal of cofferdam. | A | 10 | 6 | 8 | 8 |
| | | | B | N/A | N/A | N/A | N/A |
| | | | C | 10 | 6 | 8 | 8 |
| 14 | Contact - Private leisure vessel with Temporary work site | Private leisure vessels, including narrow boats, comes into contact with project temporary work site at Blackfriars Bridge Foreshore. | A | 10 | 2 | 8 | 10 |
| | | | B | N/A | N/A | N/A | N/A |
| | | | C | 10 | 2 | 8 | 10 |
| 15 | Contact with moored | A vessel in transit makes contact with | A | 10 | 6 | 6 | 10 |
| | | | B | 8 | 6 | 6 | 10 |

| | | | | Score | | | |
|---|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **Phase** | **People** | **Environment** | **Operational** | **Media** |
| | vessel in vicinity of Blackfriars (President / Cory barges/ Passenger boat moorings etc) | a moored vessel (E.g. Moored Barge, President or moored passenger boat) in vicinity of Blackfriars Bridge Foreshore. | C | 10 | 6 | 6 | 10 |
| 16 | Vessels subject to increased interaction during periods of low water | Due to the intrusion of the temporary works into the authorised channel, the available water space for vessels to manoeuvre in is reduced. At periods of low water this is particularly relevant | A | 8 | 6 | 8 | 8 |
| | | | B | 8 | 6 | 8 | 10 |
| | | | C | 8 | 6 | 8 | 8 |
| 17 | Grounding - All vessels due to 'Squat Effect' | At periods of low water, vessels may be affected by the 'Squat Effect', causing them to be closer to the river bed than expected. | A | 8 | 6 | 8 | 8 |
| | | | B | 8 | 6 | 8 | 8 |
| | | | C | 8 | 6 | 8 | 8 |
| 18 | Contact with moored vessel at relocated Blackfriars Millennium Pier | A vessel in transit makes contact with a vessel moored at the relocated Blackfriars Millennium Pier. | A | 10 | 2 | 10 | 10 |
| | | | B | 10 | 3 | 10 | 10 |
| | | | C | 10 | 6 | 10 | 10 |

## 9.4 Project phase D: Most likely

**Table 9.3 Most likely hazard log summary**

| | | | Score | | | |
|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **People** | **Environment** | **Operational** | **Media** |
| 1D | Restricted Working - Work intrudes into authorised channel and constrains traffic | Intrusion into authorised channel by permanent works structure constrains available water space for existing traffic. Due to the reduced channel width a river incident occurs. | 12 | 6 | 12 | 12 |
| 2D | Emergency arch closure - Arch No3 | With the permanent work structure in place, there may be an emergency requirement to close arch No3. | 9 | 6 | 9 | 9 |
| 3D | Planned arch closure - arch No3 | With the permanent work structure in place there would be requirements for scheduled maintenance of arch No3 resulting in arch closure. | 6 | 6 | 6 | 6 |
| 4D | Planned arch closure - arch No2 | With the permanent work structure in place there would be requirements for scheduled maintenance of arch No2 resulting in arch closure. | N/A | N/A | N/A | N/A |

| | | | Score | | | |
|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **People** | **Environment** | **Operational** | **Media** |
| 5D | Emergency arch closure - arch No2 | With the permanent work structure in place, there may be an emergency requirement to close arch No2. | N/A | N/A | N/A | N/A |
| 6D | Change in River Flow | The permanent structure is of sufficient area and shape to have an affect on the fluvial flow of the river in the area around Blackfriars. | 9 | 6 | 9 | 9 |
| 7D | Contact - High Speed Craft / Class V passenger vessel with Permanent work site | A High Speed Craft / Class V passenger vessel comes into contact with project Permanent work site at Blackfriars Bridge Foreshore. | 9 | 6 | 9 | 12 |
| 8D | Contact - Tug and Tow with permanent work site | A Tug and Tow comes into contact with project permanent work site at Blackfriars Bridge Foreshore. | 9 | 6 | 9 | 9 |
| 9D | Contact - Private leisure vessel with Permanent work site | Private leisure vessels, including narrow boats, comes into contact with project permanent work site at Blackfriars Bridge Foreshore. | 12 | 3 | 12 | 12 |
| 10D | Contact with moored | A vessel in transit makes contact with | N/A | N/A | N/A | N/A |

| | | | Score | | | |
|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **People** | **Environment** | **Operational** | **Media** |
| | vessel in vicinity of Blackfriars (President / Cory barges / Passenger boat moorings etc) | a moored vessel (E.g. Moored Barge, President or moored passenger boat) in the vicinity of Blackfriars Embankment during the construction of the shaft and culvert. | | | | |
| 11D | Vessels subject to increased interaction during periods of low water | Due to the intrusion of the temporary works into the authorised channel, the available water space for vessels to manoeuvre in is reduced. At periods of low water this is particularly relevant | 9 | 3 | 9 | 9 |
| 12D | Contact with moored vessel at relocated Blackfriars Millennium Pier | A vessel in transit makes contact with a vessel moored at the relocated Blackfriars Millennium Pier. | 12 | 3 | 12 | 12 |

## 9.5 Project phase D: Worst credible

**Table 9.4 Worst credible hazard log summary**

| | | | Score | | | |
|---|---|---|---|---|---|---|
| **Hazard Id** | **Hazard Title** | **Hazard Description** | **People** | **Environment** | **Operational** | **Media** |
| 1H | Restricted Working - Work intrudes into authorised channel and constrains traffic | Intrusion into authorised channel by permanent works structure constrains available water space for existing traffic. Due to the reduced channel width a river incident occurs. | 15 | 9 | 12 | 15 |
| 2H | Emergency arch closure - arch No3 | With the permanent work structure in place, there may be an emergency requirement to close arch No3. | 8 | 6 | 8 | 10 |
| 3H | Planned arch closure - arch No3 | With the permanent work structure in place there would be requirements for scheduled maintenance of arch No3 resulting in arch closure. | 8 | 6 | 6 | 8 |
| 4H | Planned arch closure - arch No2 | With the permanent work structure in place there would be requirements for scheduled maintenance of arch No2 resulting in arch closure. | N/A | N/A | N/A | N/A |

| Hazard Id | Hazard Title | Hazard Description | Score | | | |
|---|---|---|---|---|---|---|
| | | | People | Environment | Operational | Media |
| 5H | Emergency arch closure - arch No2 | With the permanent work structure in place, there may be an emergency requirement to close arch No2. | N/A | N/A | N/A | N/A |
| 6H | Change in river flow | The permanent structure is of sufficient area and shape to have an affect on the fluvial flow of the river in the area around Blackfriars. | 15 | 9 | 12 | 12 |
| 7H | Contact - High Speed Craft / Class V passenger vessel with Permanent work site | A High Speed Craft / Class V passenger vessel comes into contact with project Permanent work site at Blackfriars Bridge Foreshore. | 10 | 6 | 10 | 10 |
| 8H | Contact - Tug and Tow with permanent work site | A Tug and Tow comes into contact with project permanent work site at Blackfriars Bridge Foreshore. | 15 | 9 | 12 | 12 |
| 9H | Contact - Private leisure vessel with Permanent work site | Private leisure vessels, including narrow boats, comes into contact with project permanent work site at Blackfriars Bridge Foreshore. | 15 | 9 | 12 | 12 |

| Hazard Id | Hazard Title | Hazard Description | Score | | | |
|---|---|---|---|---|---|---|
| | | | People | Environment | Operational | Media |
| 10H | Contact with moored vessel in vicinity of Blackfriars (President / Cory barges / Passenger boat moorings etc) | A vessel in transit makes contact with a moored vessel (E.g. Moored Barge, President or moored passenger boat) in the vicinity of Blackfriars Embankment during the construction of the shaft and culvert. | N/A | N/A | N/A | N/A |
| 11H | Vessels subject to increased interaction during periods of low water | Due to the intrusion of the temporary works into the authorised channel, the available water space for vessels to manoeuvre in is reduced. At periods of low water this is particularly relevant | 12 | 6 | 12 | 15 |
| 12H | Contact with moored vessel at relocated Blackfriars Millennium Pier | A vessel in transit makes contact with a vessel moored at the relocated Blackfriars Millennium Pier. | 12 | 6 | 12 | 15 |

# 10 Mitigation measures

## 10.1 Existing controls and mitigation

10.1.1 Existing safeguards (measures that manage the risk) in the form of control measures and relevant PLA guidance, are set out in Table 10.1 together with any additional controls deemed desirable or necessary to reduce risk to a level that is ALARP. The risk is assessed taking account of the impact of these various safeguards and controls.

**Table 10.1 Existing safeguards**

| | |
|---|---|
| • Boat Masters License | • Vessel Master Experience |
| • MCA - MGN 199 (M) Dangers of Interaction | • Permanent/Temporary Notice to Mariners |
| • Aids to Navigation | • Passage Planning |
| • Safe Systems of Work | • Tug Operator Procedures |
| • Contractors Risk Assessment | • BML Local Knowledge Endorsement |
| • River Bylaws | • General Directions |
| • VTS Qualification | • VHF Communications |
| • Bridge Special Signal Lights | • Ship Towage Code of Practice |
| • VTS Navigational Broadcast | • Emergency Plans and Procedures |
| • Thames AIS | • Oil Spill Contingency Plan |
| • PLA Bridge Guide | • Maintenance / Inspection Routines |
| • Admiralty Charts | • COLREGs |
| • Tide Gauges | • Qualified Crew |
| • Tide Tables | • Barge Operators daily check lists |
| • Accurate Tidal Information | • High Speed Craft Code |
| • Code of practice for Craft Towage Operations 2011 | • Code of Safe Working Practices for Merchant Seamen(MCA) |
| • IMSBC Code | • |

10.1.2 The above list is not exhaustive but was used to highlight the measures that are most relevant to project operations.

## 10.2 Proposed mitigation

10.2.1 The proposed risk reduction/mitigation measures were divided into three categories: design, physical and river operations. This is to provide the PLA with assurance that the measures proposed throughout this assessment have regard to the project's responsibility to reduce risk rather than focussing on local authorities' and existing river users' responsibilities.

## 10.3 Design

10.3.1 The following measures are embedded in the designs and this assessment therefore only assesses the residual risk assuming the effective implementation of these measures:

a. The footprint of the temporary and permanent works (and therefore encroachment into the channel) was reduced by approximately 4m, reducing the potential impact on navigation through arch No2.

b. Computational modelling of in-river structures and analysis was carried out to determine likely increases/decreases in flow and vessel types most likely to be affected by changes.

c. A full 'principal Inspection' of the Blackfriars Bridges would be conducted immediately prior to Thames Tideway Tunnel project construction work commencing avoiding the need for planned closures of arch No3 during construction works.

d. Constraints were placed on the working areas within the river to minimise the duration and extent of encroachment into the authorised channel

e. The pier was relocated as close as practical to the river wall to facilitate safe passage of tug and tows and while limiting the extent of dredging required, and therefore minimising the need for ongoing dredging to keep the pier operational.

f. A fendered pile was included to the east of the relocated pier to enable vessels to moor on the eastern end of the pier safely.

g. The location of the reinstated President vessel was set back from the authorised channel and from the line of the proposed river wall so as not to offer any navigational hazards, while offering improved gradients on the access brows.

h. The design of the temporary and permanent structures includes the provision of ladders, safety grab chains and other lifesaving equipment around the work sites to aid emergency egress from the river, in accordance with the PLA's guidance document *Review of Lifesaving Provisions Along the River Thames*

10.3.2 The following sections identify proposed mitigation to address the residual risks.

## 10.4 Physical

a. relocate the Cory Environmental moorings (currently opposite the proposed temporary works) in the event of closure of arch No 3 to either Georges Stairs Lower or Hot Pole moorings

b. suspend project barge operations, at this site, for duration of emergency closure of arch No3, unless agreed otherwise with PLA

c. construction method of the cofferdam was reviewed and options for constructing the cofferdam 'from within' were investigated. The phasing of construction of the cofferdam should allow arch No2 to be open to smaller vessels for the majority of the construction phases

d. closure of arch No2 to certain vessel types at various stages of the construction of the temporary works cofferdam.

e. closure of arch No2 to all inbound freight and reporting vessels while the temporary works structure is in place (Phase B).

f. during temporary works all inbound tugs and tows should use Blackfriars Bridge arch No3 (Phase A, B and C).

g. planned closure of arch No3 should not take place during the construction phase

h. continued liaison with Cory to get their views on intrusion and if possible get confirmation that the temporary works structure does not impact on existing operations (in terms of transit times and operational requirements)

i. review of barge operating procedures: recommend that tugs only pull a single rank of barges through this section of the river if arch No3 is closed during construction phase

## 10.5 River Operations

a. Maintain arch No4 for navigation to allow for larger and reporting vessels to transit this area in the event that arch No3 is closed.

b. Harbour service launch to be in attendance maintaining a continuous VHF watch on Channel 14 in the event of arch No3 closure

c. Amend operational procedures for vessels using Blackfriars Pier to require vessels to moor on the eastern extent of the pier, with one end of the vessel on the pier, when tug and tow are using arch No2.

d. Co-ordinate works so that arch No2 closures do not coincide with scheduled maintenance work/inspections at arch No 3 and 4.

e. issue a Notice to Mariners informing river users of the planned closures and the lights/markings to expect:

    i Arch No3 has been closed at various times during the Network Rail Blackfriars Bridge construction project and with two other arches available to navigation.

ii Previous NTMs have been issued for this situation stating ‘When two navigable arches are closed to navigation, local traffic control will be established from a Port of London Authority Harbour Services Launch operating in the area. Vessels wishing to pass through the remaining open navigable arch of Blackfriars Road and Railway Bridges or operating between London and Waterloo Bridges are to call “Thames Patrol” on VHF Channel 14’.

**Table 10.2 Mitigation measures within the project team’s control**

| Procedural | Informational | Qualifications / Personnel | Guidance / Publications | Site Specific |
|---|---|---|---|---|
| Safe systems of work | Sound warnings | Berth Master (term to be defined) | Temporary Notice to Mariners | Grab chains |
| Contractors risk assessment | Light warnings | Qualifications / competence of on-site personnel | Permanent Notice to Mariners | Fendering |
| Site working practises | Anemometer at site | | | Impact protection - temporary works |
| Scheduling of barge movements to assist with existing river events | | | | Impact protection - permanent works |
| | | | | New tide gauges / markers |
| | | | | Safety boat |
| | | | | Guard boat |

# 11 Conclusion

## 11.1 Assessment

11.1.1 This *Navigation Issues and Preliminary Risk Assessment* has assessed the potential impact of the proposed works at Blackfriars Bridge Foreshore on existing river users.

11.1.2 The project's approach to this assessment comprised stakeholder engagement, analysis of Automatic Identification System (AIS) data, observation of current river operations including a desktop review of hazards and development of potential mitigation measures.

11.1.3 The issues have been presented to the PLA during a number of hazard review meetings.

11.1.4 The risk assessment criteria, assessment matrix, terminology and risk classification were provided by the PLA. This assessment follows the Formal Safety Assessment (FSA) methodology including;

a. stakeholder consultation
b. identification of hazards
c. hazard analysis.

## 11.2 Stakeholder engagement

11.2.1 A number of issues were identified throughout the risk assessment process for this site including:

a. intrusion into the river of temporary and permanent works
b. closure of Bridge arches at various stages of the project
c. reduction in river width, reduced river to manoeuvre in
d. impact of additional vessel movements on current operations
e. increase of river flow velocity.

## 11.3 Risk analysis

11.3.1 Hazards at various stage of the project were assessed and scored using the risk matrix and scorecard provided by the PLA in terms of 'Most Likely' and 'Worst Credible' scenarios.

11.3.2 Annexes A - H provide full details of the hazards identified and their overall scores. The analysis is summarised in below tables:

**Table 11.1 Hazard Overview: Most likely**

| Most Likely | Phase A | Phase B | Phase C | Phase D |
|---|---|---|---|---|
| Extreme: Intolerable risk. Job is not authorised | 0 | 0 | 0 | 0 |
| High: Efforts should be made to reduce risk to ALARP level. Job can only be performed after authorisation from Harbour Master and after further additional controls required under the circumstances | 6 | 12 | 6 | 7 |
| Moderate: Efforts should be made to reduce risk ALARP. Job can be performed under direct supervision of Senior Officer | 52 | 49 | 31 | 29 |
| Minor: No additional controls are required, monitoring is required to ensure no changes in circumstances | 8 | 4 | 5 | 4 |
| Slight: No action is required | 2 | 0 | 2 | 0 |

**Table 11.2 Hazard Overview: Worst credible**

| Worst Credible | Phase A | Phase B | Phase C | Phase D |
|---|---|---|---|---|
| Extreme: Intolerable risk. Job is not authorised | 12 | 18 | 10 | 10 |
| High: Efforts should be made to reduce risk to ALARP level. Job can only be performed after authorisation from Harbour Master and after further additional controls required under the circumstances | 28 | 28 | 15 | 11 |
| Moderate: Efforts should be made to reduce risk ALARP level. Job can be performed under direct supervision of Senior Officer | 27 | 21 | 18 | 17 |
| Minor: No additional controls are required, monitoring is required to ensure no changes in circumstances | 1 | 1 | 1 | 2 |
| Slight: No Action is required | 0 | 0 | 0 | 0 |

11.3.3 Most of the hazards (within the Most Likely assessment) fell within the ‘moderate risk’ category, requiring effort to be made to reduce the risk to ALARP level.

11.3.4 For ‘Worst Credible’ scenarios, the majority of hazards fell within the ‘high risk’ category, indicating that the work could only be performed after authorisation from the Harbour Master.

## 11.4 Overall

11.4.1 It is widely acknowledged that the Central Pool area of London is one of the busiest sections of the river with a diverse range of vessels currently operating through it. It is an area of the river that the PLA is particularly concerned with in respect to navigational safety and considers one of the most hazardous sections within their area of responsibility.

11.4.2 The proposed works would introduce additional freight movements on the river, place a large cofferdam structure in close proximity to a bridge, reduce the available river width and leave in place a structure that would intrude further into the river than the existing pier currently at the site. All these issues have been analysed during the preliminary risk assessment process with mitigation proposed to reduce the probability of an incident occurring or reducing the consequence of an incident.

11.4.3 The navigational issues have been summarised below:

a. intrusion: the permanent in-river structure would protrude further into the river than the existing pier, several metres into the authorised channel and close to the Blackfriars bridges

b. intrusion: The temporary works would intrude into the authorised channel and there would be a requirement to close arch No2 to certain vessel types at certain phases of the project.

c. construction of the temporary cofferdam would result in infrastructure within the authorised channel and a requirement to close arch No2 to all traffic.

d. closing arch No2 has been identified as a mitigation measure at various stages of the project. The closure of arch No2 would introduce further risks in its own right, e.g. restricted working and constrained water space

e. relocation of Blackfriars Millennium Pier to the east would introduce a number of navigational concerns including proximity to the authorised channel and proximity to passing freight traffic. However, these concerns are being addressed in consultation with the PLA and the pier location was moved further away from the navigational channel as a result of analysis of tracking of tug and tow through arch No2.

11.4.4 This report provides an evidenced based assessment of current river operations and the likely impact that project operations would have on existing river users.

11.4.5 The overall responsibility for safety on the River Thames lies with the Port of London Authority which needs to determine whether the issues and hazards detailed set out in this report present a ‘tolerable’ navigational risk

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# 12 Recommendations

12.1.1 It was acknowledged that the Thames Tideway Tunnel project presents many challenges, both to existing operators and to those involved in the project. A number of recommendations have been made throughout the assessment process and have been captured below.

12.1.2 **Design Review:** The current design of the temporary and permanent structures result in a reduction of the available river width at this location. The project team continues to review the design to consider any further potential to minimise the extent of intrusion and potential impacts on river operation.

12.1.3 **Scheduling of barge movements to assist with existing river events:** Consultation between the PLA and the contractor is recommended in order to identify specific events that are likely to see an increase in river traffic, require additional consideration or introduce extra navigational safety requirements. This consultation would allow the contractor to schedule barge movements in a manner as to reduce the impact of project's activities on these events.

a. Events that may impact on the Blackfriars site include:

   i Admiral of the Port's Challenge

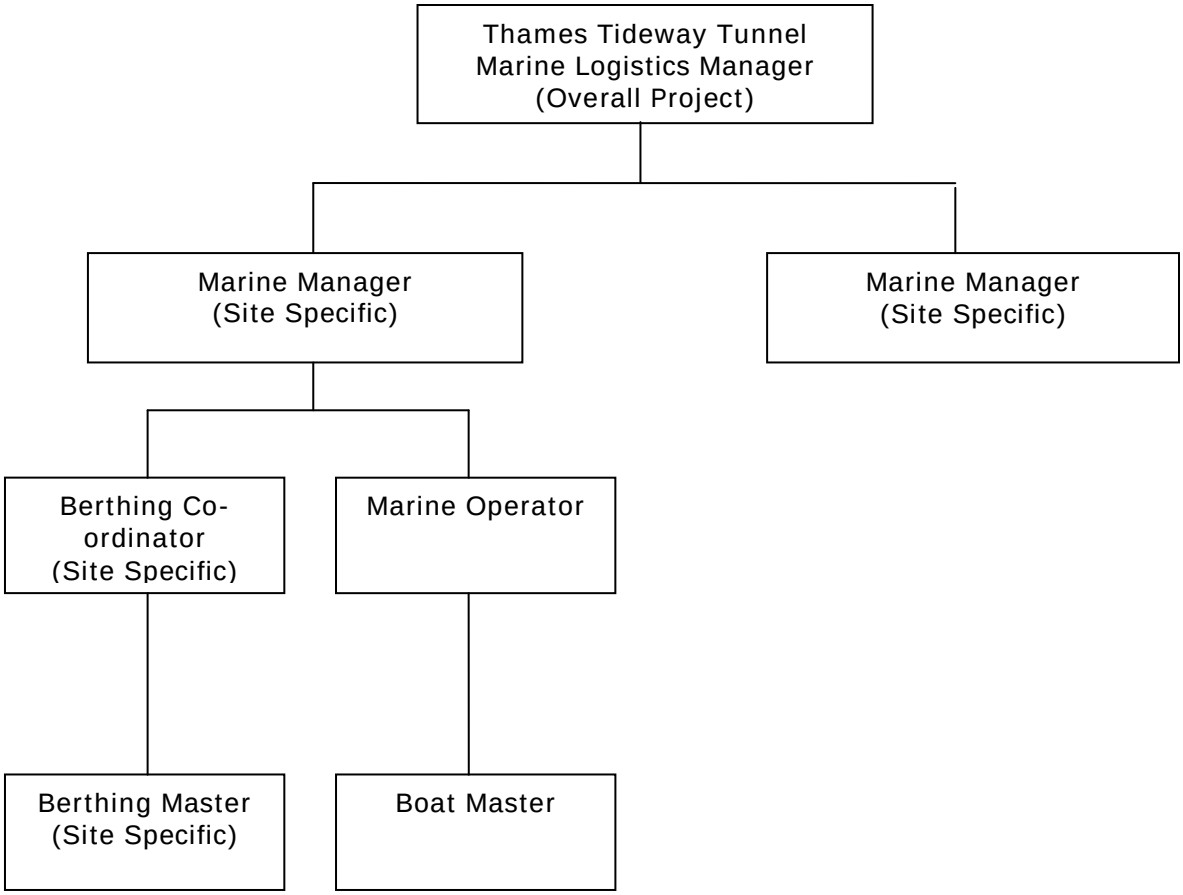
   ii Port of London Challenge

   iii Tow Barge Driving Match.

12.1.4 **Berthing Co-ordinator:** The project recommends appointing a Berthing Co-ordinator to communicate with all commercial operators in order to facilitate safe berthing and departures from berths in close proximity to the project's operations. The co-ordinator would be co-ordinating departures so that all freight operators, including project barges, depart on time but do not adversely impact on navigation on the tidal Thames.

12.1.5 A potential organisational structure for the project is shown in the following figure:

**Figure 12.1 Potential organisation chart**




12.1.6 One responsibility of the Berth Co-ordinator would be to liaise regularly with the PLA and local stakeholders. Clear lines of delegation and responsibilities would need to be established prior to commencing project works to ensure that potential conflict of interest issues would be managed and to prevent confusion to mariners and authorities from various traffic control systems

12.1.7 Overall safety on the river is the PLA's responsibility: the Thames Barrier Navigational Control's (TBNC) assists the PLA by managing and directing traffic from Crayfordness to Teddington Lock.

12.1.8 **Bridge arch closures:** At various stages of the project there would be a requirement to close Blackfriars Bridge arches to navigation.

12.1.9 A planned closure of arch No2 and an emergency closure of arch No3 would leave arch No4 as the only available navigable arch. Several controls would need to be put in place to allow navigation of the river to remain, these include:

a. the project to suspend its barge movements at the Blackfriars site

b. Active vessel control required in area – VTS/PLA

c. Safety boat in attendance in area

d. Restriction on tug/barge movements through area.

12.1.10 Phase A: Construction of cofferdam:

a. Arch No2: Closed to all traffic during parts of the phase, closed to freight and reporting vessels during the whole phase

b. Arch No3: Open to larger, reporting inbound and outbound vessels. No planned closures.

c. Arch No4: Open to outbound vessels. No planned closures

12.1.11 Phase B: Construction of drop shaft and other structures:

a. Arch No2: Closed to all freight and reporting vessels, open to smaller, non-reporting inbound vessels

b. Arch No3: Open to larger, reporting inbound and outbound vessels. No planned closures

c. Arch No4: Preferred arch for outbound smaller vessels, standby arch for outbound reporting vessels. No planned closures.

12.1.12 Phase C: Removal of cofferdam:

a. Arch No2: Closed to all traffic dependant on phase of construction

b. Arch No3: Open to larger, reporting inbound and outbound vessels. No planned closures

c. Arch No4: Preferred arch for outbound smaller vessels, standby arch for outbound reporting vessels.

12.1.13 Phase D: Permanent works

a. Arch No2: Open to smaller, non-reporting inbound vessels. Standby arch for inbound reporting vessels

b. Arch No3: Preferred arch for inbound and outbound reporting vessels. Possible planned closures throughout life of works;

c. Arch No4: Preferred arch for outbound smaller vessels, standby arch for outbound reporting vessels.

12.1.14 Arch No4 can be used by outbound larger, reporting vessels for the majority of the tide with the exception of around half an hour either side of low water.

12.1.15 Arch No4 can be used by outbound non-reporting vessels at all states of the tide.

12.1.16 **Relocation of Cory Environmental Mooring:** The Cory Environmental mooring facility (PLA No 146) is located opposite Blackfriars Millennium Pier. Cory uses the mooring as a lay-up facility. The mooring allows Cory to work barges to Wallbrook Wharf. In the event of closure of arch No3 during phases A to C, this mooring would be relocated to either Georges Stairs Lower or Hot Pole moorings.

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# Abbreviations

| | |
|---|---|
| AIS | Automatic Identification System |
| ALARP | As low as reasonably practicable |
| CSO | Combined sewer overflow |
| LLAU | Limits of land to be acquired or used |
| NtM | Notice to Mariners |
| PLA | Port of London Authority |

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# Appendices

**List of appendices in order**

**Appendix A: Project drawings**

**Appendix B: HR Wallingford analysis**

**Appendix C: Freight tracks and AIS analysis**

**Appendix D: Thames Tideway Tunnels vessel movements**

**Appendix E: Tide Set**

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**Thames Tideway Tunnel**
Thames Water Utilities Limited

# Application for Development Consent

Application Reference Number: WWO10001

# Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.02**

## Blackfriars Bridge Foreshore

### Appendix A

APFP Regulations 2009: Regulation **5(2)(q)**

Hard copy available in

Box **57** Folder **A**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

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# Appendix A: Project drawings

| Drawing title | Phase |
|---|---|
| Construction phases - Site setup – main works | Phase A |
| Construction phases - Site setup – pier relocation | Phase A |
| Construction phases - Shaft construction | Phase B |
| Construction phases - Construction of other structures | Phase B |
| Construction phases - Site demobilisation | Phase C |
| Permanent works layout Sheet 1 of 5 | Phase D |
| Permanent works layout Sheet 2 of 5 | Phase D |
| Permanent works layout Sheet 3 of 5 | Phase D |
| Permanent works layout Sheet 4 of 5 | Phase D |
| Permanent works layout Sheet 5 of 5 | Phase D |
| Pontoon relocated | Phase D |
| Barge tracking past proposed structures | |
| River foreshore zones of working Sheet 1 of 2 | |
| River foreshore zones of working Sheet 2 of 2 | |

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Keyplan:


Coordinates are to be Ordance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

## Key:

- Limits of land to be acquired or used (LLAU)
- Hoarding
- Maximum extent of working area
- Existing public right of way
- Route of temporary diversion of right of way
- Site access
- Existing sewers
- Sheet piles

## Sheet Layout


10m 0 40m

Scale 1:500 at A1
1:1000 if reproduced at A3

## Notes :

1. These construction phasing plans have been prepared to illustrate possible site layouts for the principal construction phases. Contractors may choose to lay sites out differently during construction depending on their preferred construction methods subject to any controls on layout imposed through the planning submission and approval process.
2. Traffic management plans for construction phases of the work would be submitted to the appropriate authority for approval. Where appropriate, outline traffic management arrangements are shown.
3. Utility supplies for the construction of the works would be agreed with the relevant utility company.
4. Additional noise mitigation including noise barriers may be required but is not shown on this drawing.
5. Gate position to alter to suit construction progress.
6. Existing flood defence levels to be maintained at all times.

ILLUSTRATIVE

Location
**Blackfriars Bridge Foreshore**
City of London

Document Information
**Application for Development Consent**
Construction phases - phase 1
Site setup sheet 1 of 2 - main works
Book of plans - section 19
DCO-PP-17X-BLABF-190047
January 2013

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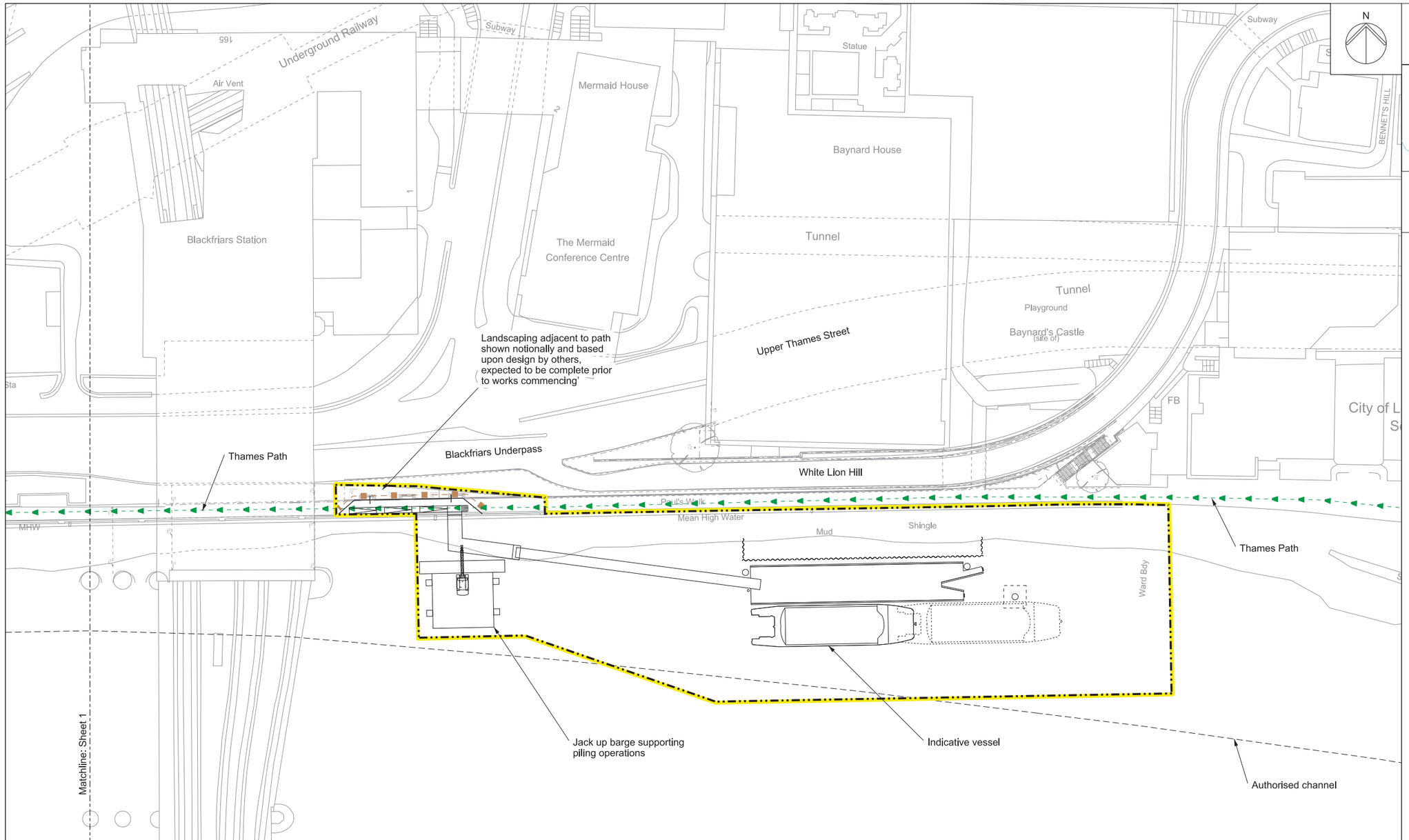
Thames Water

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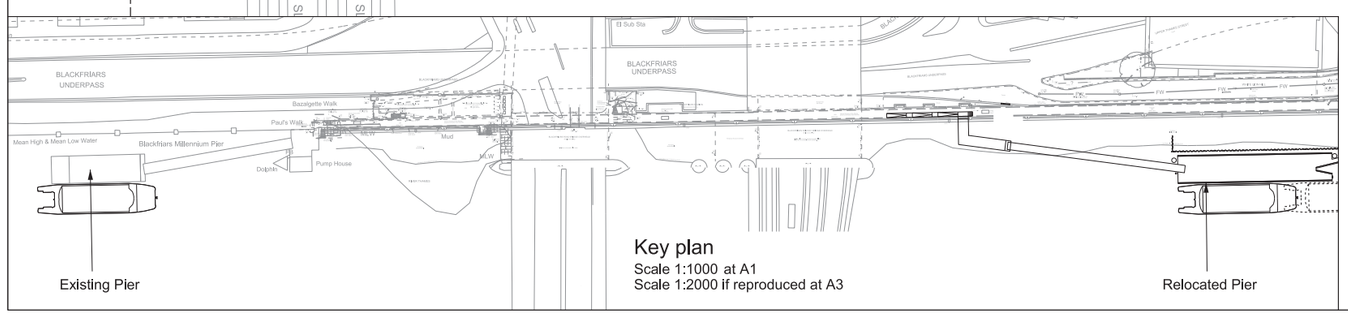


Key plan
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- Limits of land to be acquired or used (LLAU)
- Hoarding
- Maximum extent of working area
- Existing public right of way
- Route of temporary diversion of right of way
- Existing sewers

## Sheet Layout

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|---|---|

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Location
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Construction phases - phase 1
Site setup sheet 2 of 2 - pier relocation
Book of plans - section 19

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January 2013

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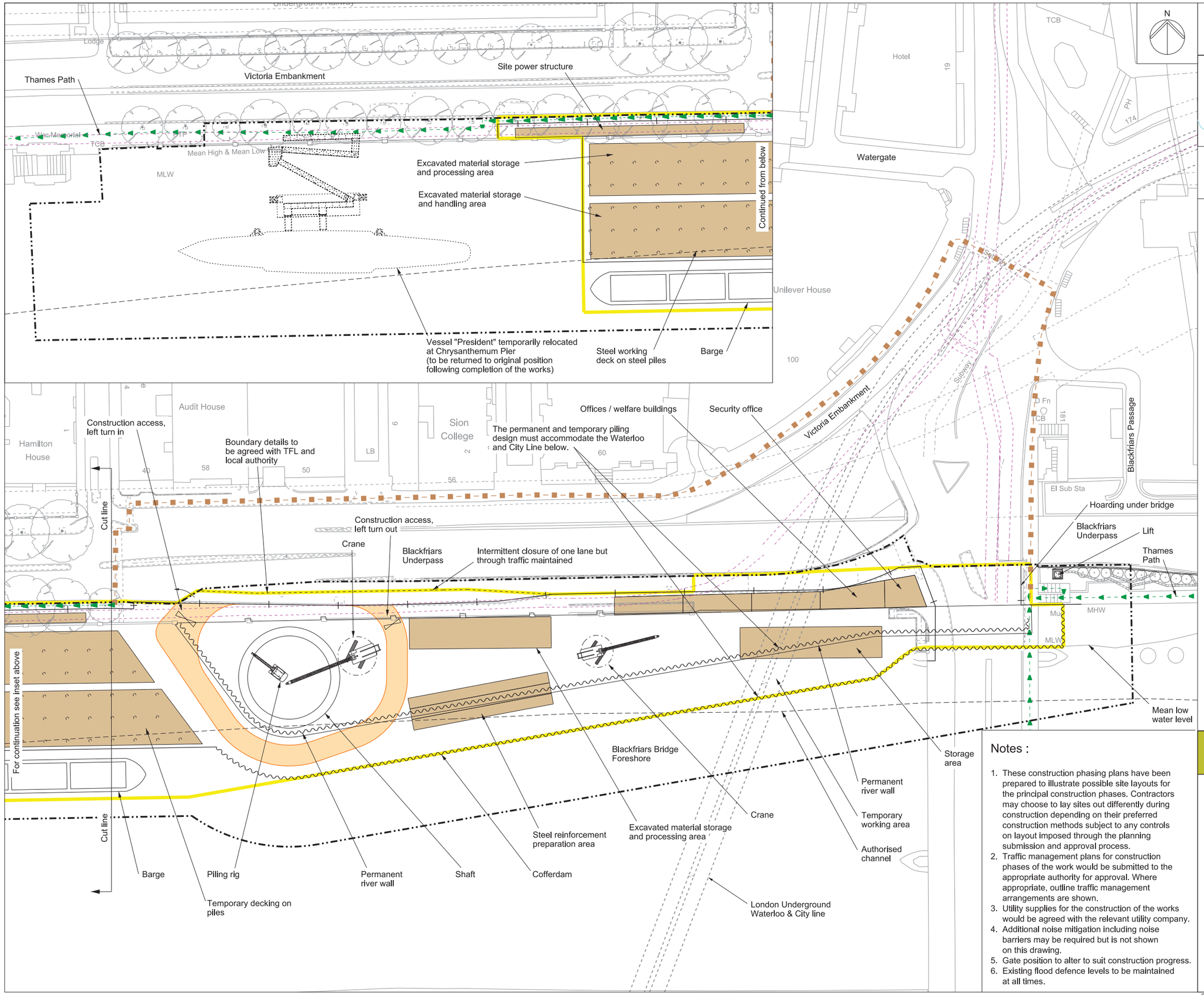




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## Key:

- Limits of land to be acquired or used (LLAU)
- Hoarding
- Maximum extent of working area
- Existing public right of way
- Route of temporary diversion of right of way
- Site access
- Access / haul route
- Existing sewers
- Sheet piles

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1:1000 if reproduced at A3

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2. Traffic management plans for construction phases of the work would be submitted to the appropriate authority for approval. Where appropriate, outline traffic management arrangements are shown.
3. Utility supplies for the construction of the works would be agreed with the relevant utility company.
4. Additional noise mitigation including noise barriers may be required but is not shown on this drawing.
5. Gate position to alter to suit construction progress.
6. Existing flood defence levels to be maintained at all times.

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Construction phases - phase 2
Shaft construction
Book of plans - section 19

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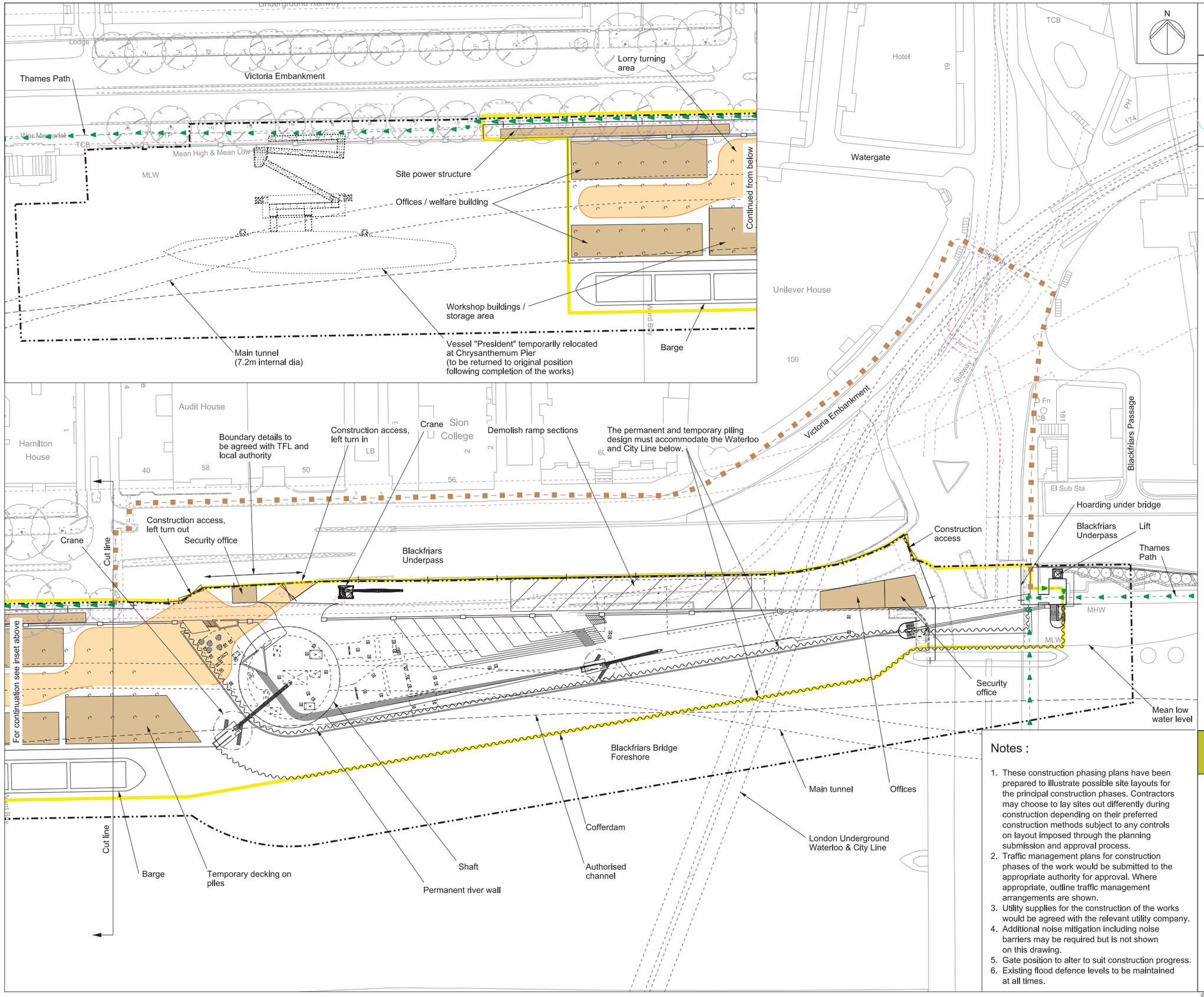
Thames Water



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- Limits of land to be acquired or used (LLAU)
- Hoarding
- Maximum extent of working area
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- Route of temporary diversion of right of way
- Site access
- Access / haul route
- Existing sewers
- Sheet piles

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5. Gate position to alter to suit construction progress.
6. Existing flood defence levels to be maintained at all times.

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**Blackfriars Bridge Foreshore**
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Construction phases - phase 3
Construction of other structures
Book of plans - section 19

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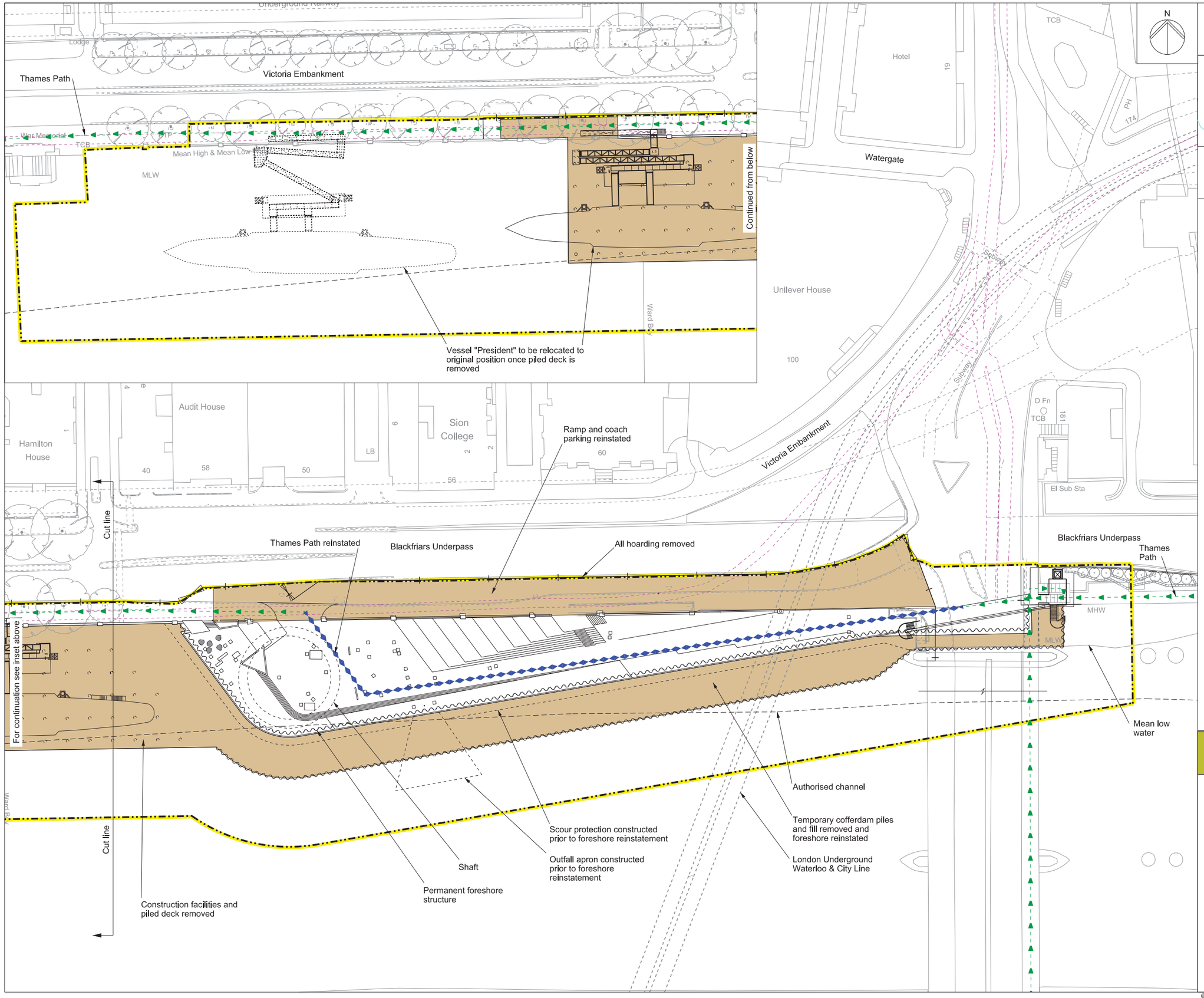




Keyplan:


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## Key:

- Limits of land to be acquired or used (LLAU)
- Hoarding
- Maximum extent of working area
- Existing public right of way
- Site access
- Existing sewers
- Sheet piles
- Provision of permanent permissive right of way

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**Application for Development Consent**
Construction phases - phase 4
Site demobilisation
Book of plans - section 19

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January 2013

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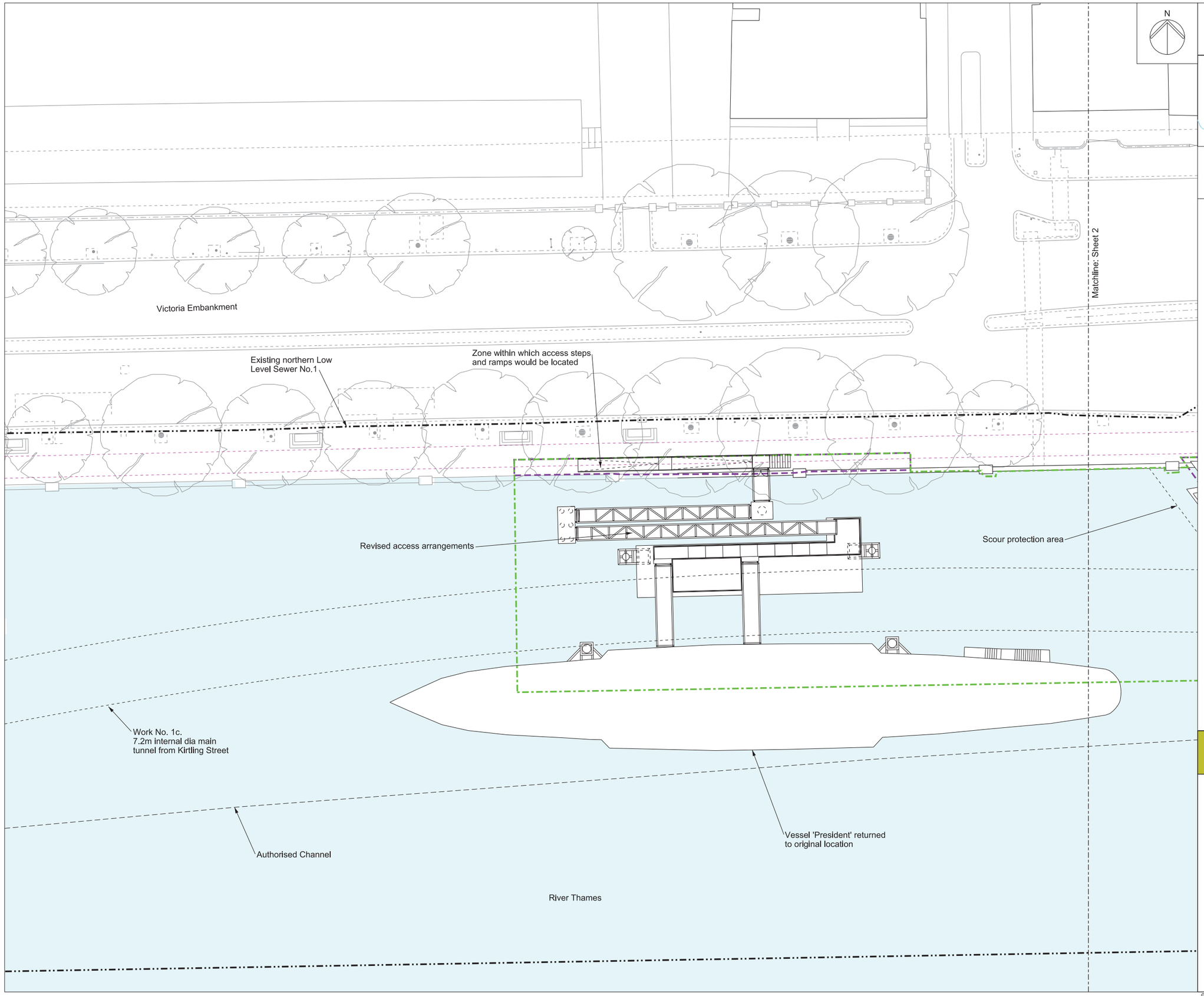
Thames Water






Keyplan:


Coordinates are to be Ordance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

## Key:

- Limits of land to be acquired or used (LLAU)
- Existing sewers
- Zone within which all permanent site structures would be located
- Zone within which permanent above ground structures would be located

## Notes:

1. All dimensions and levels are approximate.
2. Any discrepancy between the location of structures and the parameters marked on the drawings are due to differences between the Ordnance Survey base and topographical survey base, both of which have been used in the preparation of this drawing.
3. This drawing shows permanent site structures only. Landscaping hard works and soft works are shown on the Proposed landscape plan and/or Proposed site features plan.

## Sheet Layout

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ILLUSTRATIVE

Location
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City of London

Document Information
**Application for Development Consent**
Permanent works layout
Sheet 1 of 5
Book of plans - section 19
DCO-PP-17X-BLABF-190012
January 2013

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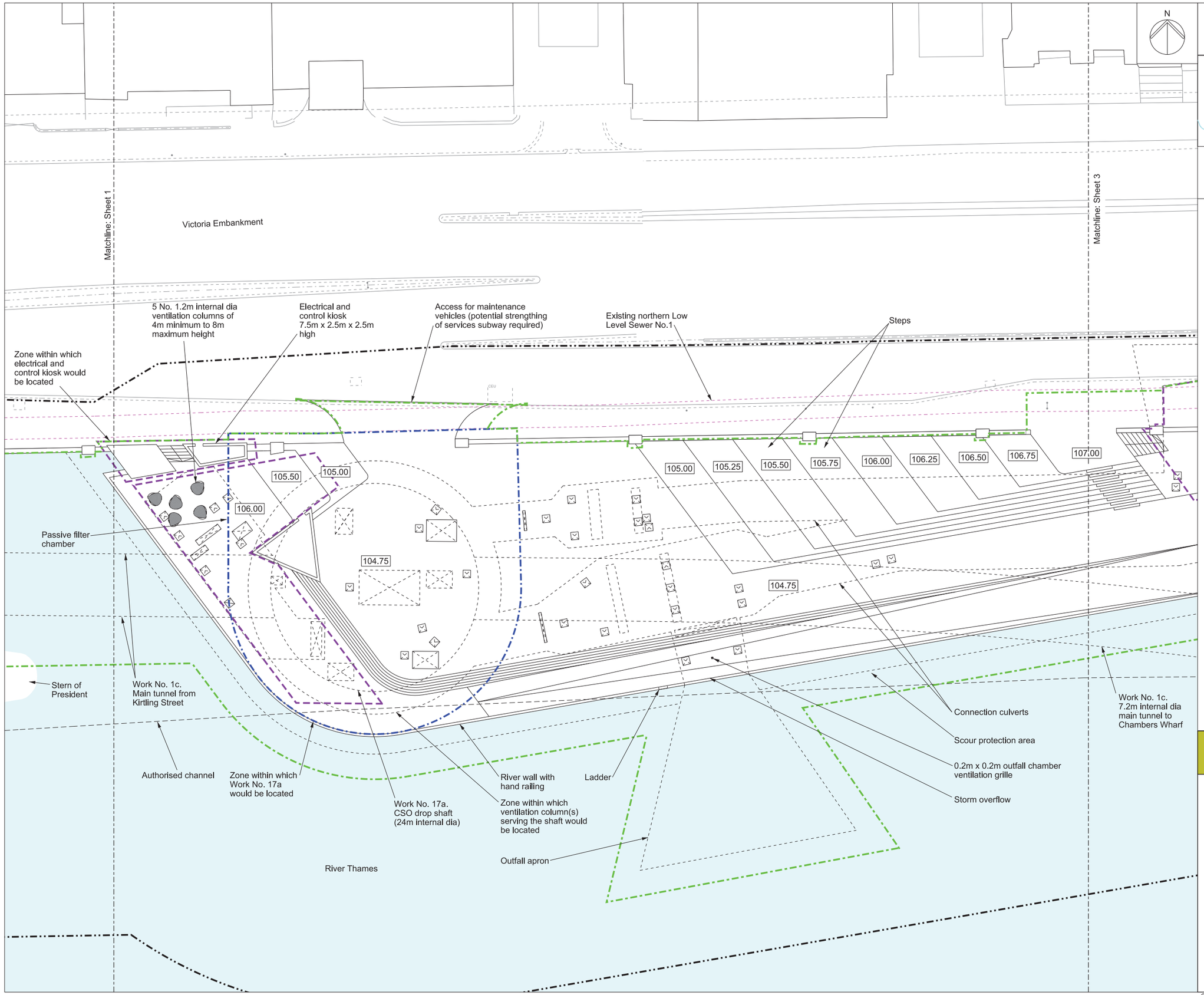




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ILLUSTRATIVE

Location

**Blackfriars Bridge Foreshore**
City of London

Document Information

**Application for Development Consent**

Permanent works layout
Sheet 2 of 5
Book of plans - section 19

DCO-PP-17X-BLABF-190013
January 2020

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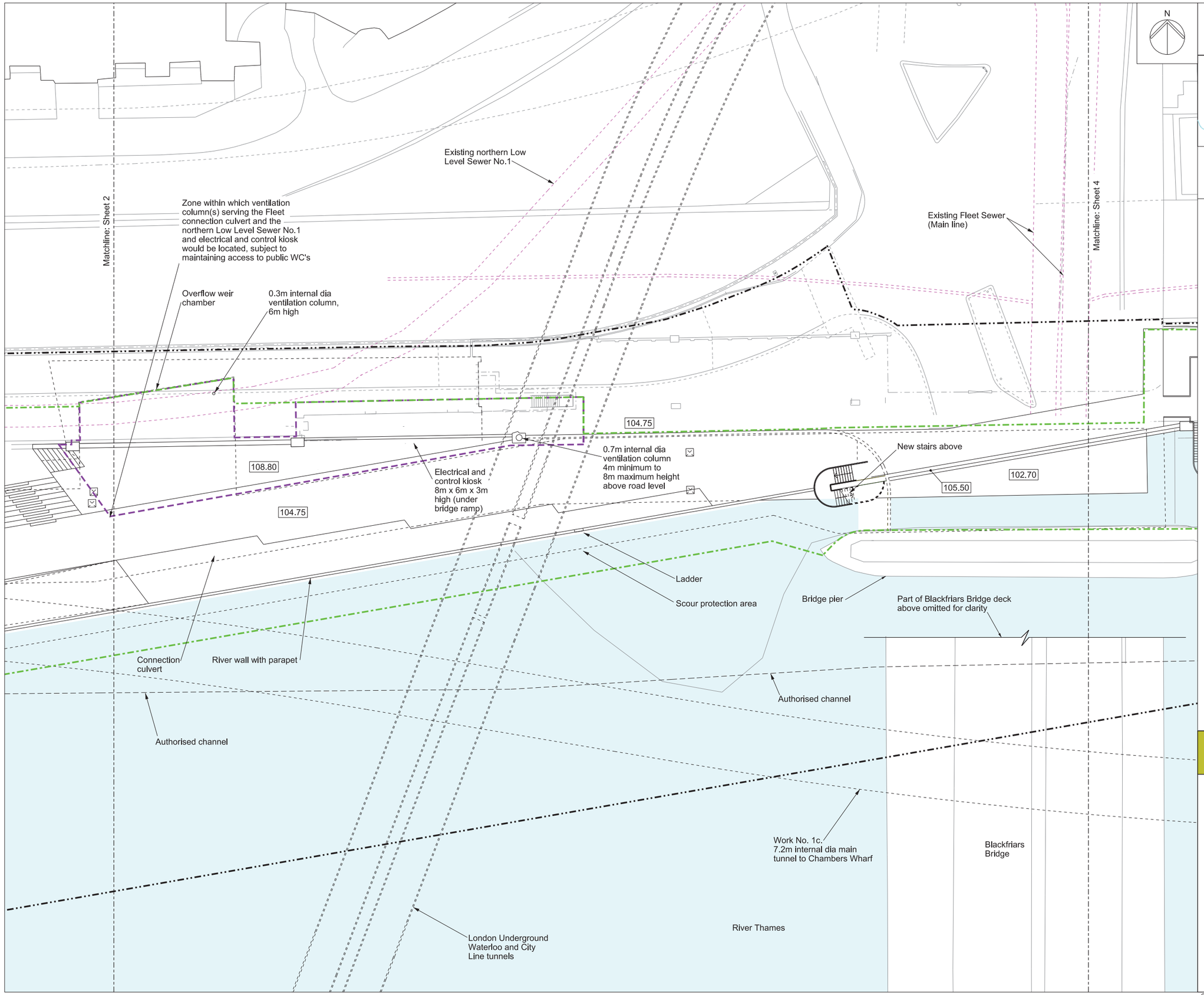
Thames Water

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Keyplan:


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|---|---|---|---|---|

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ILLUSTRATIVE

Location

**Blackfriars Bridge Foreshore**
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**Application for Development Consent**

Permanent works layout
Sheet 3 of 5
Book of plans - section 19

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January 2021

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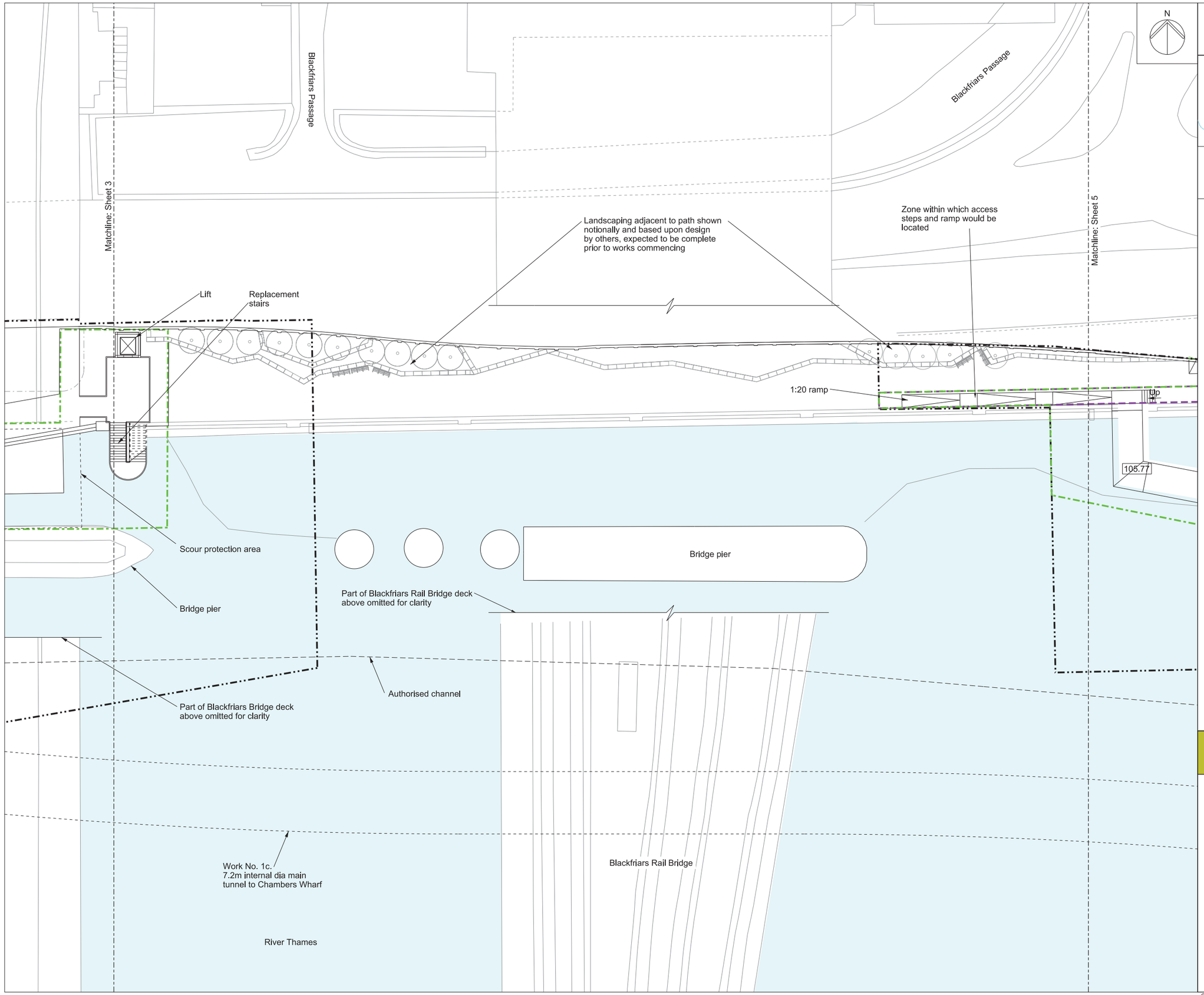




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## Key:

- Limits of land to be acquired or used (LLAU)
- Existing sewers
- Zone within which all permanent site structures would be located
- Zone within which permanent above ground structures would be located

## Notes:

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2. Any discrepancy between the location of structures and the parameters marked on the drawings are due to differences between the Ordnance Survey base and topographical survey base, both of which have been used in the preparation of this drawing.
3. This drawing shows permanent site structures only. Landscaping hard works and soft works are shown on the Proposed landscape plan and/or Proposed site features plan.

## Sheet Layout

| Sheet 1 | Sheet 2 | Sheet 3 | Sheet 4 | Sheet 5 |
|---|---|---|---|---|

10m 0 10m

Scale 1:200 at A1
1:400 if reproduced at A3

ILLUSTRATIVE

Location

**Blackfriars Bridge Foreshore**
City of London

Document Information

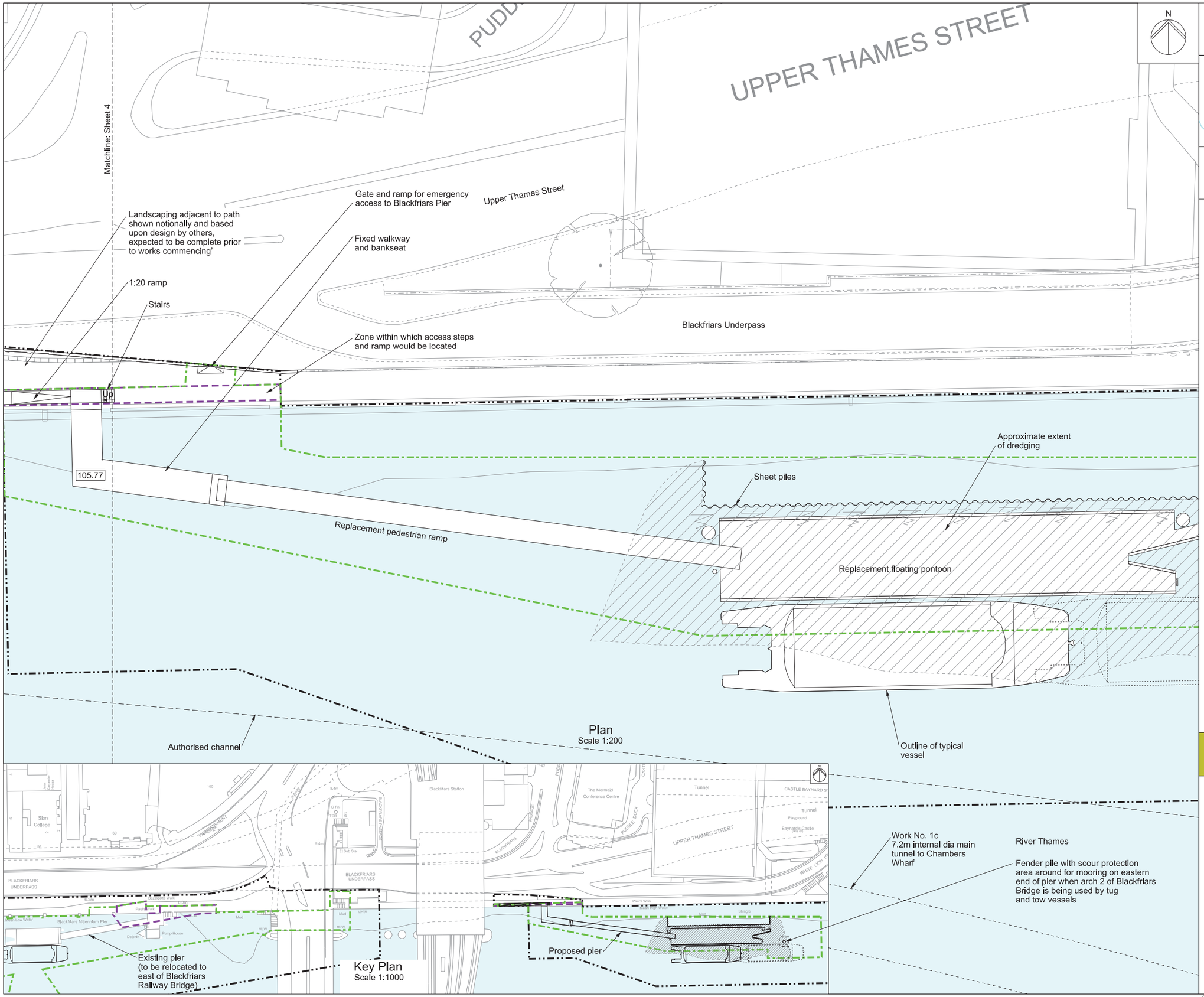
**Application for Development Consent**

Permanent works layout
Sheet 4 of 5
Book of plans - section 19

DCO-PP-17X-BLABF-190015
January 2013

Thames Tideway Tunnel
Creating a cleaner, healthier River Thames

Thames Water






Keyplan:


Coordinates are to be Ordance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

## Key:

- Limits of land to be acquired or used (LLAU)
- 104.50 — Proposed level (shown in metres above tunnel datum)
- Zone within which all permanent site structures would be located
- Zone within which permanent above ground structures would be located
- Approximate extent of dredging

## Notes:

1. All dimensions and levels are approximate.
2. Any discrepancy between the location of structures and the parameters marked on the drawings are due to differences between the Ordnance Survey base and topographical survey base, both of which have been used in the preparation of this drawing.
3. This drawing shows permanent site structures only. Landscaping hard works and soft works are shown on the Proposed landscape plan and/or Proposed site features plan.
4. Design to current river flood defence level 105.41m above tunnel datum (ATD).
5. Landing stage proposed level as existing stage.

## Sheet Layout

| Sheet 1 | Sheet 2 | Sheet 3 | Sheet 4 | Sheet 5 |
|---|---|---|---|---|

ILLUSTRATIVE

Location

**Blackfriars Bridge Foreshore**
City of London

Document Information

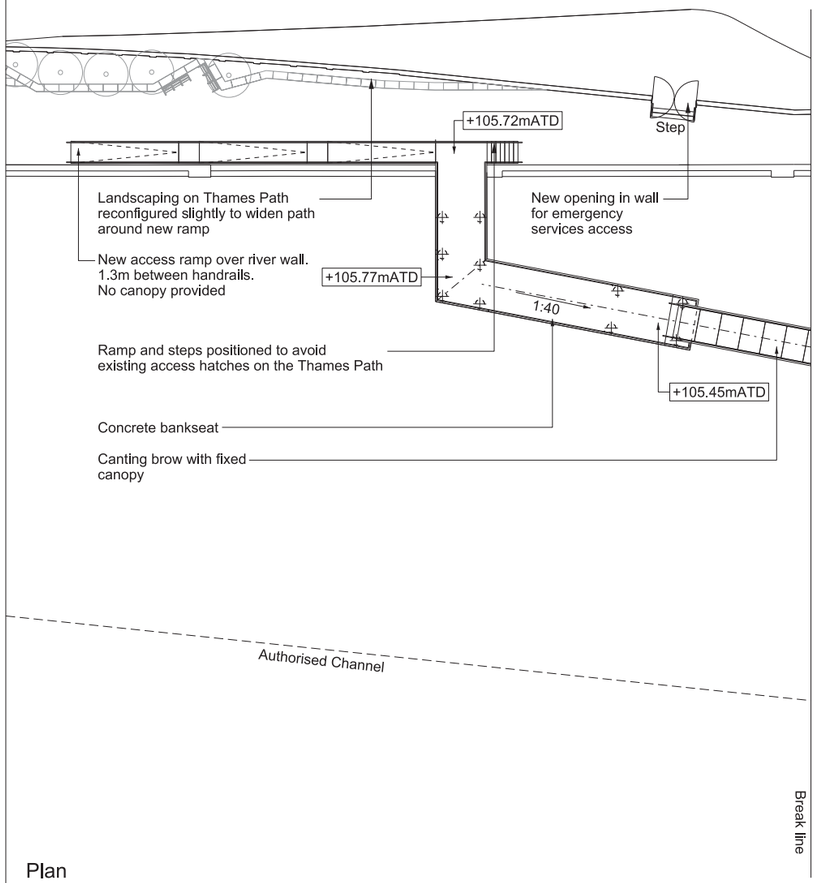
**Application for Development Consent**

Permanent works layout
Sheet 5 of 5
Book of plans - section 19

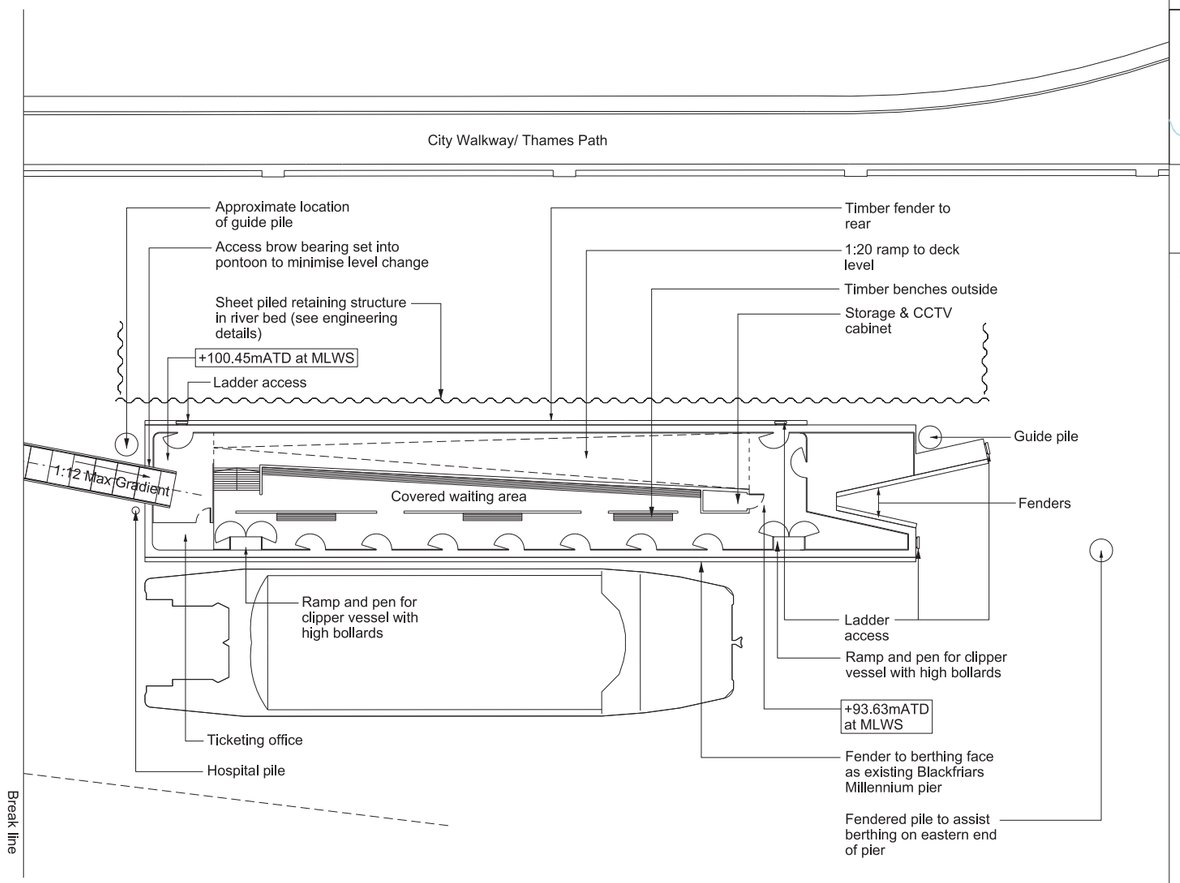
DCO-PP-17X-BLABF-190016
January 2013

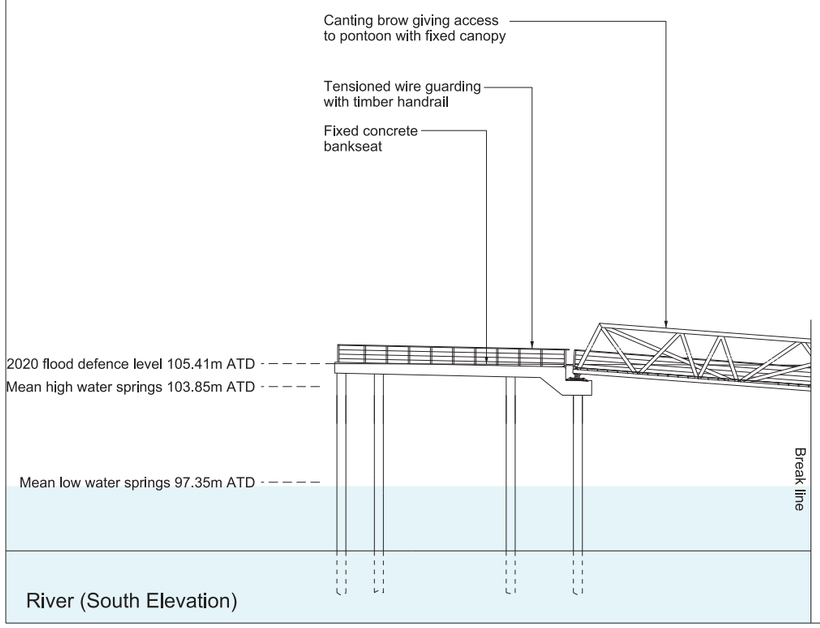
Thames Tideway Tunnel
Creating a cleaner, healthier River Thames

Thames Water

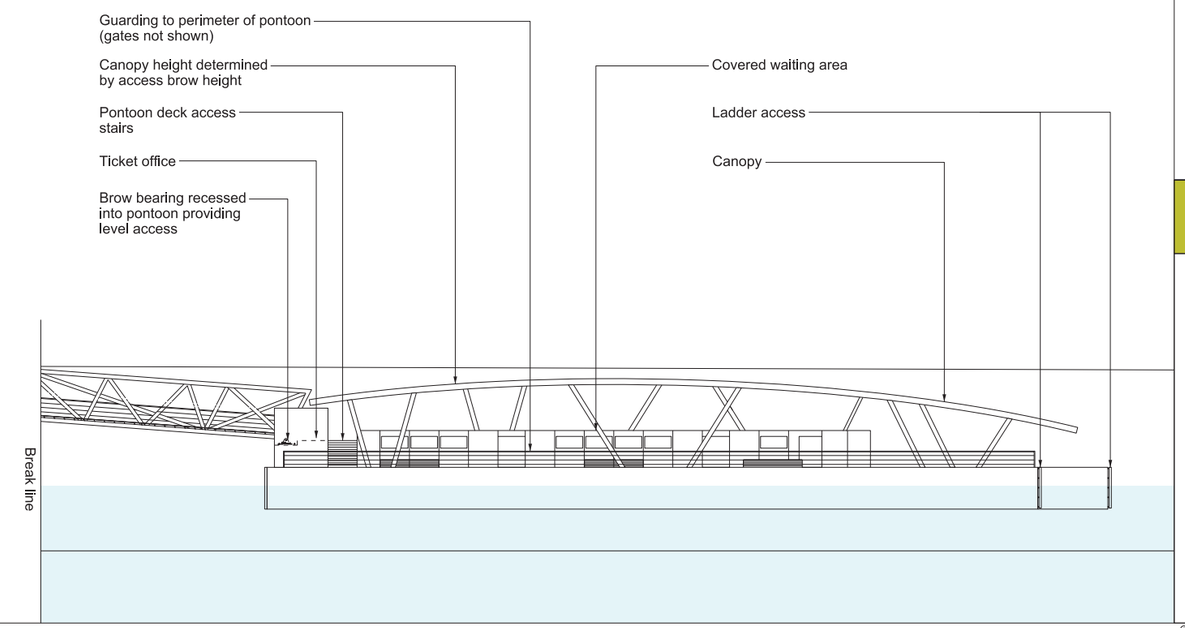



Plan




River (South Elevation)






Keyplan:


Coordinates are to be Ordance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

## Notes:

1. All dimensions and levels are approximate.
2. The following are to be provided in agreement with TFL London River Services:

   a. Bird wire to the roof of pier and brow
   b. Nonslip surfaces on all decks and walkways
   c. Grab chains on the water line
   d. Navigation lights masts with counter - balanced mast or winch to change bulbs easily
   e. CCTV Cameras covering all areas of the pier, brows and entrance with 1 pan and tilt camera on the berth front
   f. Poster frames for safety and passenger information
   g. Fire and fresh water hoses
   h. Flag poles and banner poles and TfL designed gate entrances
   j. Electronic real time signs
   k. Utilities: Lighting, electricity, water, telephone (PSTN), CCTV to the pontoon.

10m 0 10m

Scale 1:200 at A1
1:400 if reproduced at A3

ILLUSTRATIVE

Location

**Blackfriars Bridge Foreshore**
City of London

Document Information

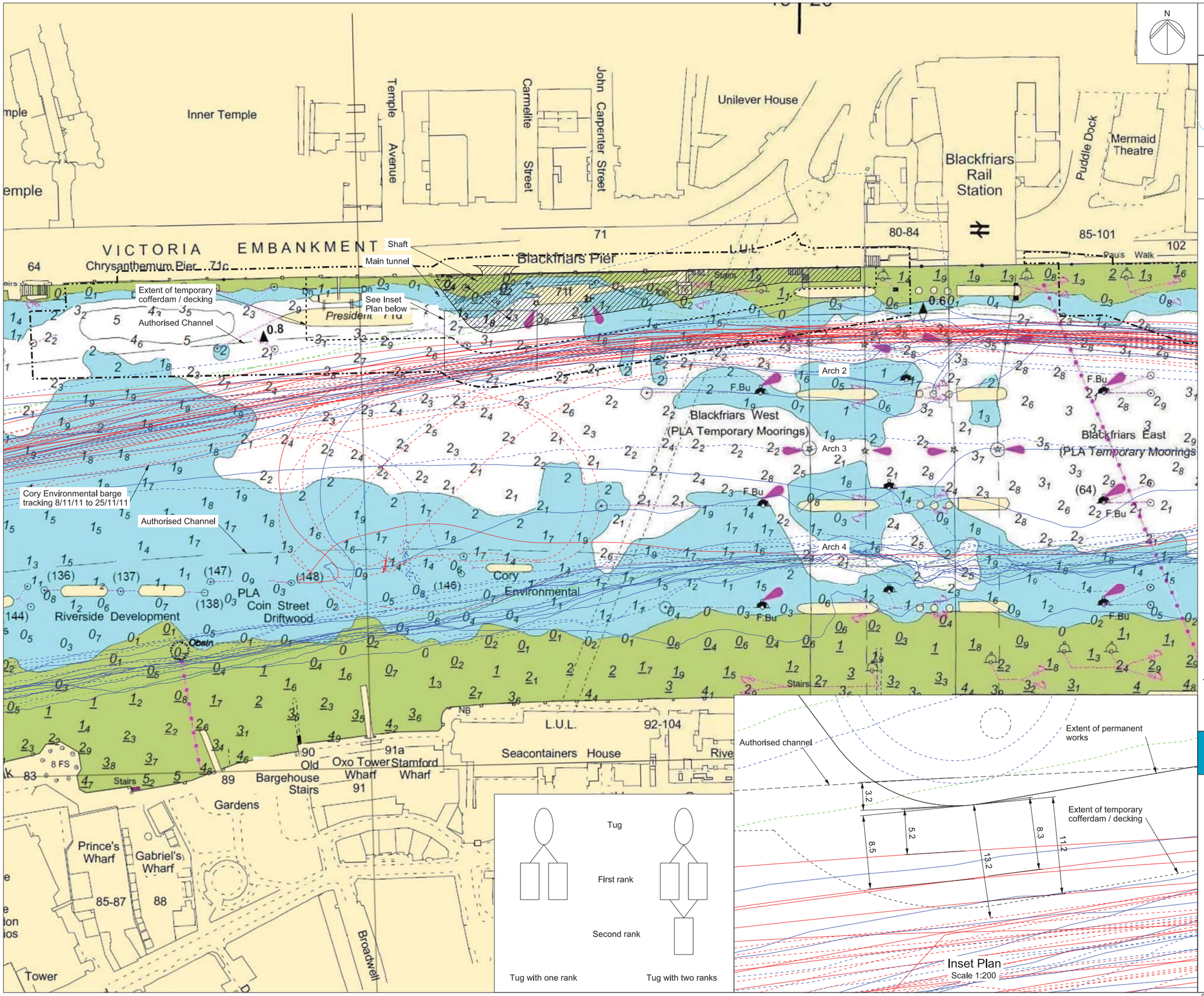
**Application for Development Consent**

Pontoon relocated
Blackfriars Pier
Book of plans - section 19

DCO-PP-17X-BLABF-190046
January 2013

Thames Tideway Tunnel
Creating a cleaner, healthier River Thames

Thames Water






Keyplan:


Coordinates are to be Ordance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

## Key:

- Limits of land to be acquired or used (LLAU)
- Tug with one rank
- Tug with two ranks

## Notes:

1. Tracks provided by Cory Environmental Ltd.
2. Transponder was located on the starboard side of the outermost barge, approximately 1.5m from the extremity of the barge.
3. All levels are in metres and relate to chart datum.
4. Background information shown on this drawing is taken from:

   River Thames - Kings Reach

   Port of London Authority Hydrographic Service

   H.O. Ref. No....113-317-100....Date....11/01/2011

10m 0 100m

Scale 1:1000 at A1
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# FOR INFORMATION

Location

**Blackfriars Bridge Foreshore**
City of London

Document Information

**Application for Development Consent**

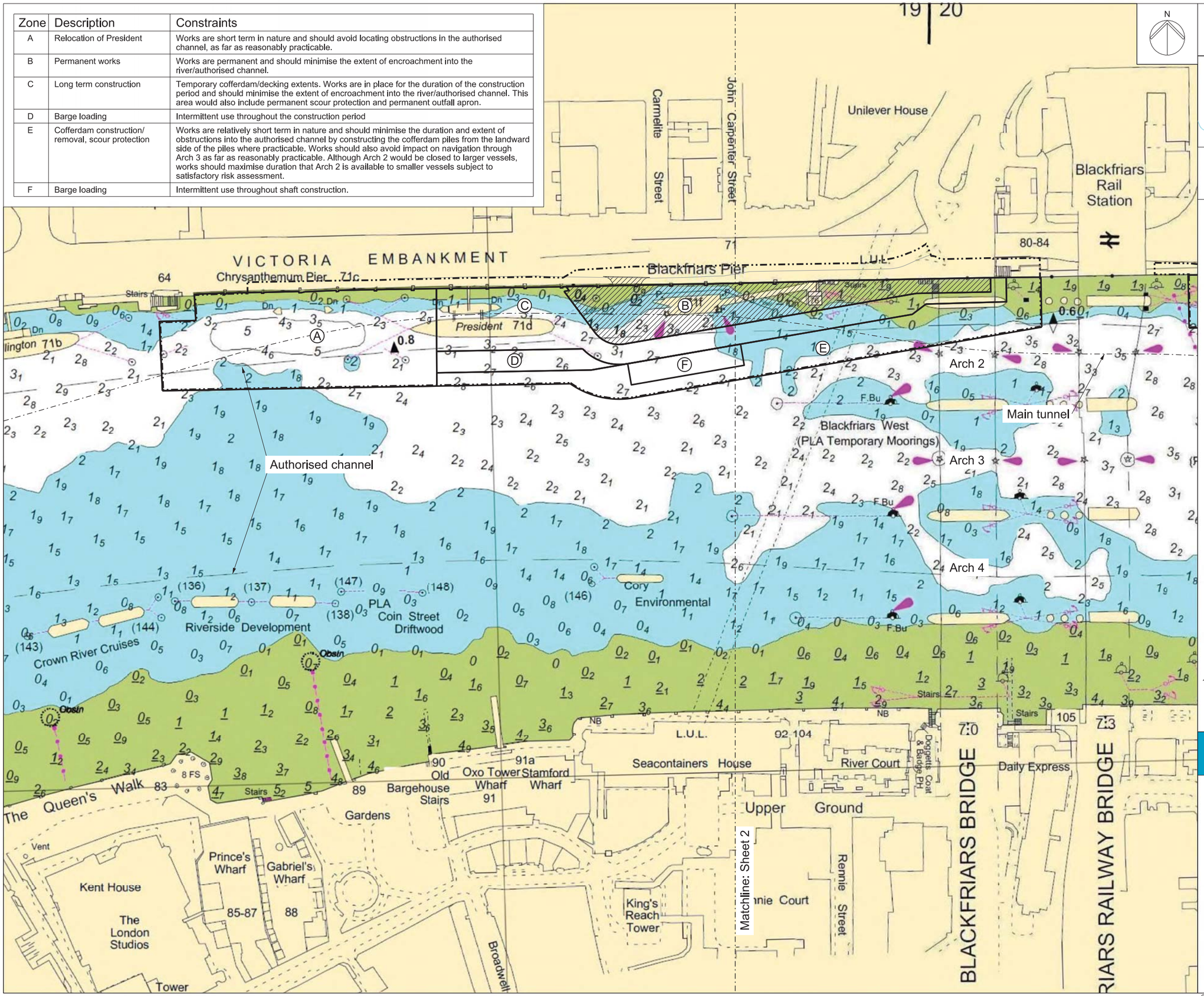
Barge tracking past proposed structures

DCO-PP-17X-BLABF-190056
January 2013

Thames Tideway Tunnel
Creating a cleaner, healthier River Thames

Thames Water

| Zone | Description | Constraints |
|---|---|---|
| A | Relocation of President | Works are short term in nature and should avoid locating obstructions in the authorised channel, as far as reasonably practicable. |
| B | Permanent works | Works are permanent and should minimise the extent of encroachment into the river/authorised channel. |
| C | Long term construction | Temporary cofferdam/decking extents. Works are in place for the duration of the construction period and should minimise the extent of encroachment into the river/authorised channel. This area would also include permanent scour protection and permanent outfall apron. |
| D | Barge loading | Intermittent use throughout the construction period |
| E | Cofferdam construction/ removal, scour protection | Works are relatively short term in nature and should minimise the duration and extent of obstructions into the authorised channel by constructing the cofferdam piles from the landward side of the piles where practicable. Works should also avoid impact on navigation through Arch 3 as far as reasonably practicable. Although Arch 2 would be closed to larger vessels, works should maximise duration that Arch 2 is available to smaller vessels subject to satisfactory risk assessment. |
| F | Barge loading | Intermittent use throughout shaft construction. |






Keyplan:


Coordinates are to be Ordance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

## Key:

Limits of land to be acquired or used (LLAU)

## Notes:

1. All levels are in metres and relate to chart datum.
2. Background information shown on this drawing is taken from:

   River Thames - Kings Reach

   Port of London Authority Hydrographic Service

   H.O. Ref. No....113-317-100....Date....11/01/2011

10m 0 100m

Scale 1:1000 at A1
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## FOR INFORMATION

Location
**Blackfriars Bridge Foreshore**
City of London

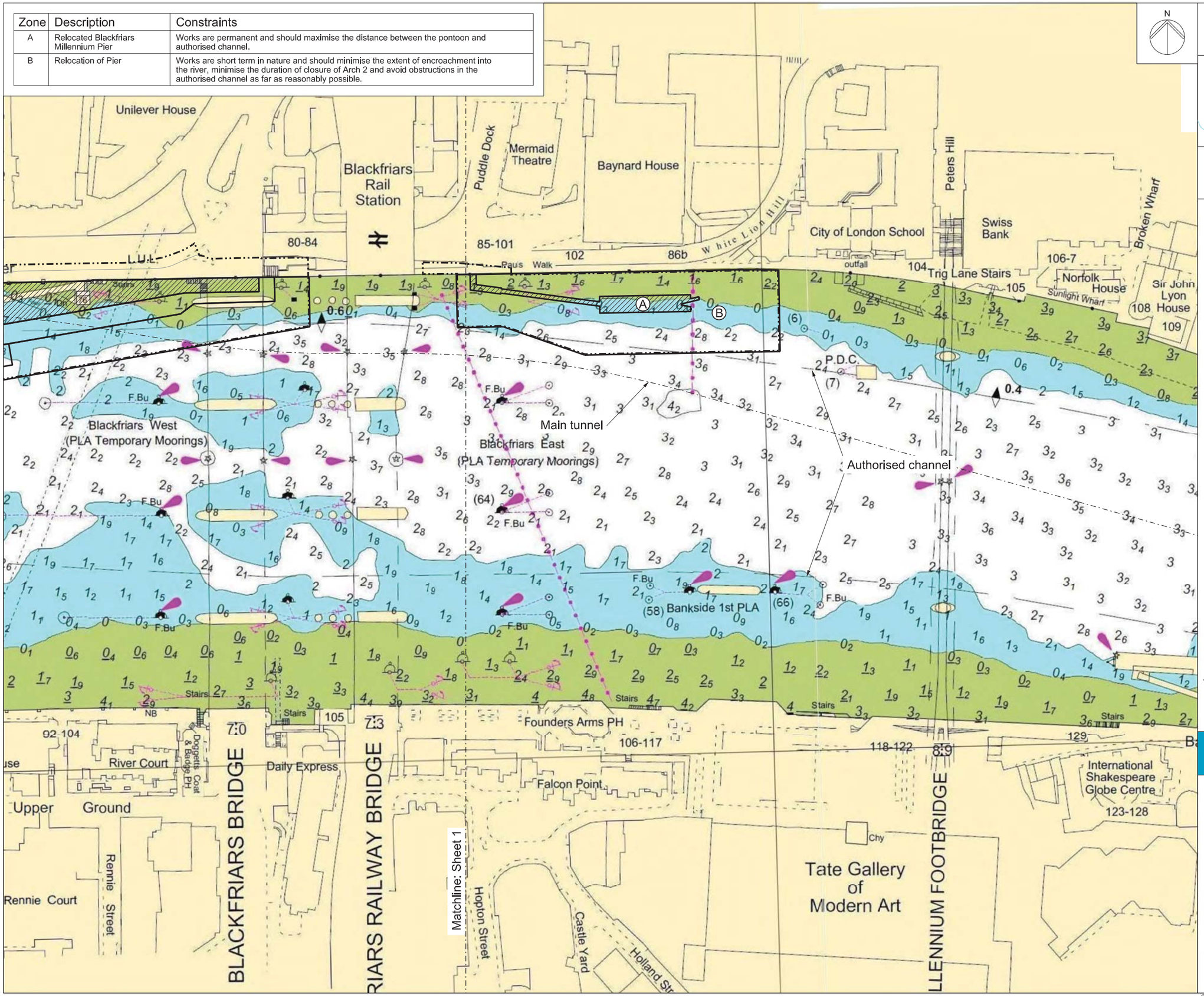
Document Information
**Application for Development Consent**
River foreshore zones of working
Sheet 1 of 2

DCO-PP-17X-BLABF-190054
January 2013

Thames Tideway Tunnel
Creating a cleaner, healthier River Thames

Thames Water

| Zone | Description | Constraints |
|---|---|---|
| A | Relocated Blackfriars Millennium Pier | Works are permanent and should maximise the distance between the pontoon and authorised channel. |
| B | Relocation of Pier | Works are short term in nature and should minimise the extent of encroachment into the river, minimise the duration of closure of Arch 2 and avoid obstructions in the authorised channel as far as reasonably possible. |






Keyplan:


Coordinates are to be Ordance Survey Datum OSGB36. All levels are in metres and relate to the Tunnel Datum which is 100 metres below Ordnance Datum Newlyn.

## Key:

Limits of land to be acquired or used (LLAU)

## Notes:

1. All levels are in metres and relate to chart datum.
2. Background information shown on this drawing is taken from:

   River Thames - Kings Reach

   Port of London Authority Hydrographic Service

   H.O. Ref. No....113-317-100....Date....11/01/2011

10m 0 100m

Scale 1:1000 at A1
1:2000 if reproduced at A3

## FOR INFORMATION

Location
**Blackfriars Bridge Foreshore**
City of London

Document Information
**Application for Development Consent**
River foreshore zones of working
Sheet 2 of 2

DCO-PP-17X-BLABF-190055
January 2013

Thames Tideway Tunnel
Creating a cleaner, healthier River Thames

Thames Water

**Thames Tideway Tunnel**
Thames Water Utilities Limited

# Application for Development Consent

Application Reference Number: WWO10001

# Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.02**

## Blackfriars Bridge Foreshore

### Appendix B

APFP Regulations 2009: Regulation **5(2)(q)**

Hard copy available in

Box **57** Folder **A**
January 2013

Thames Tideway Tunnel

Creating a cleaner, healthier River Thames

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# Appendix B: HR Wallingford Analysis

## B.1 Introduction

### HR Wallingford studies

B.1.1 In January 2009 HR Wallingford were commissioned by the Thames Tideway Tunnel Delivery Team to undertake detailed fluvial modelling and simulations of conditions at proposed sites for the interception of selected Combined Sewer Overflows (CSOs) in the proposed Thames Tideway Tunnel project.

B.1.2 As part of a Navigational Risk Assessment for the Blackfriars Bridge Foreshore Site the results of HR Wallingford's modelling and simulations were analysed. This was conducted to provide an evidence based approach on the potential impact that proposed in river structures may have on the flow of the river and subsequently on vessels in transit past the site.

B.1.3 The following flow scenarios were modelled by HR Wallingford:

a. Large Flood Tide - a typical spring tide range with 65$m^3$/s flow at Teddington (65$m^3$/s being the annual mean freshwater flow)

b. Extreme Ebb Tide - a typical spring tide range with 800$m^3$/s flow at Teddington (800$m^3$/s was measured in the winter of 1894 and is considered to represent an approximately 1 in 100 year flow)

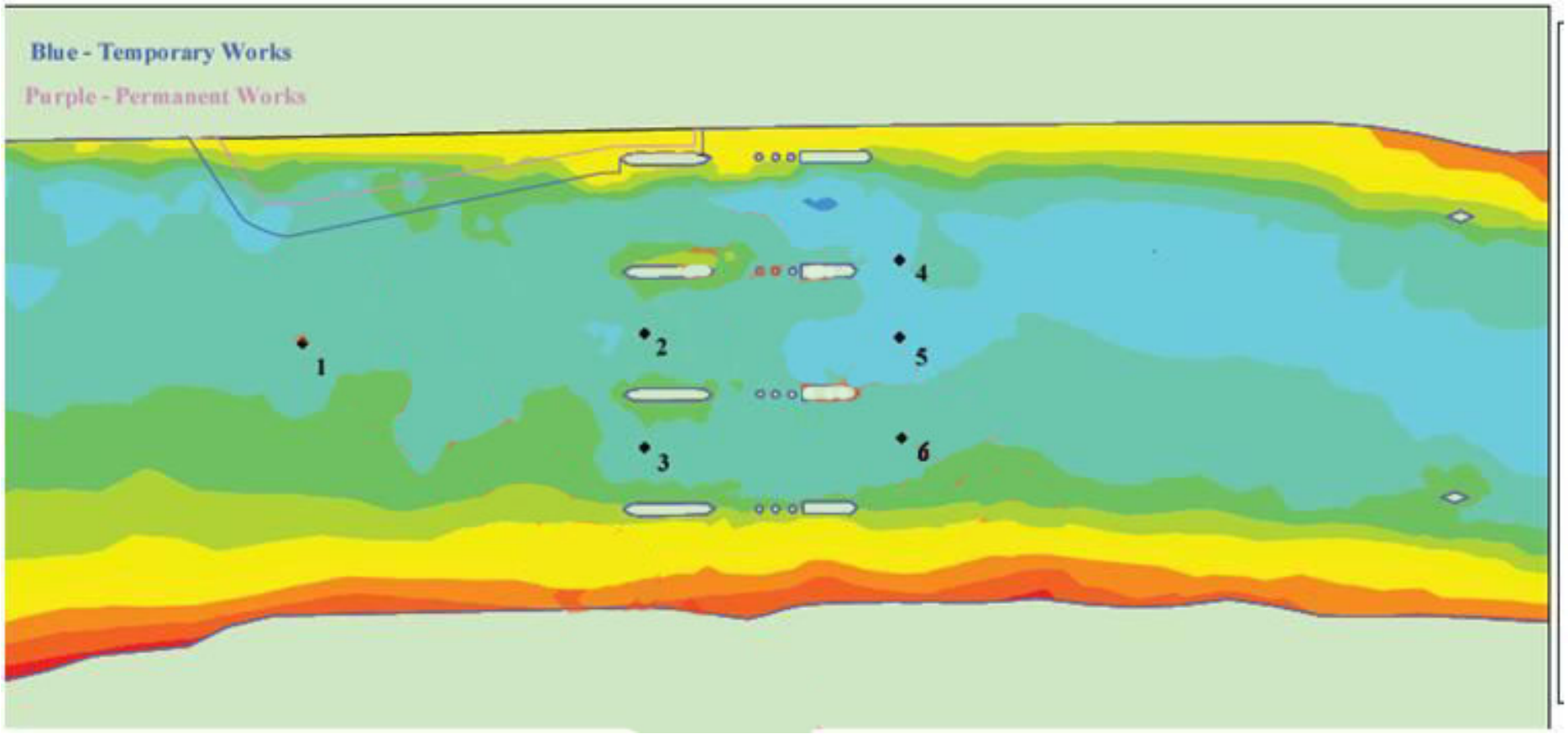
c. Spring tide range enhanced by passage of surge and 65$m^3$/s flow at Teddington.

B.1.4 Typical tidal conditions used comprised a series of spring tides of ranging from 5.06m to 5.86m at Southend-on-Sea.

B.1.5 HR Wallingford's study simulations of high current conditions were required for combinations of extreme tides and fluvial flows for which the Thames Barrier would **NOT** be closed.

B.1.6 The analysis points, as used by HR Wallingford are shown in Figure B.1 below.

**Figure B.1 HR Wallingford analysis points**



## B.2 Summary of HR Wallingford analysis

B.2.1 The results of the simulations are summarised in the following tables, showing the peak through tide currents:

a. 1 m/s = 1.943844 knots

b. 0.10 m/s = 0.194 knots

c. Maximum change recorded = 0.72 knots

**Table B.1 Baseline observations**

| Simulation | | Peak speed at analysis point (knots) | | | | | |
|---|---|---|---|---|---|---|---|
| **Tide** | **Freshwater Flow $m^3/s$** | 1 | 2 | 3 | 4 | 5 | 6 |
| Typical Spring | 65 | 2.94 | 3.71 | 3.13 | 2.35 | 2.80 | 2.74 |
| Typical Spring | 800 | 2.70 | 3.23 | 2.90 | 1.69 | 3.15 | 3.07 |
| Large Flood | 65 | 3.23 | 4.04 | 3.42 | 2.59 | 3.05 | 2.74 |

**Table B.2 Temporary work observations**

| Simulation | | Peak speed at analysis point (knots) and change compared with the baseline | | | | | |
|---|---|---|---|---|---|---|---|
| **Tide** | **Freshwater Flow $m^3/s$** | 1 | 2 | 3 | 4 | 5 | 6 |
| Typical Spring | 65 | 3.36 (+0.42) | 3.81 (+0.10) | 3.36 (+0.23) | 2.25 (-0.10) | 2.94 (+0.14) | 2.95 (+0.21) |
| Typical Spring | 800 | 3.42 (+0.72) | 3.44 (+0.21) | 3.17 (+0.27) | 1.34 (-0.35) | 3.32 (+0.17) | 3.30 (+0.23) |
| Large Flood | 65 | 3.69 (+0.46) | 4.16 (+0.12) | 3.65 (+0.23) | 2.45 (-0.14) | 3.03 (-0.02) | 2.95 (+0.21) |

**Table B.3 Permanent work observations**

| Simulation | | Peak speed at analysis point (knots) and change compared with the baseline | | | | | |
|---|---|---|---|---|---|---|---|
| **Tide** | **Freshwater Flow $m^3/s$** | 1 | 2 | 3 | 4 | 5 | 6 |
| Typical Spring | 65 | 3.13 (+0.19) | 3.75 (+0.04) | 3.25 (+0.12) | 2.31 (-0.04) | 2.88 (+0.08) | 2.86 (+0.12) |
| Typical Spring | 800 | 3.05 (+0.35) | 3.34 (+0.11) | 3.03 (+0.13) | 1.56 (-0.13) | 3.25 (+0.10) | 3.19 (+0.12) |
| Large Flood | 65 | 3.48 (+0.25) | 4.10 (+0.06) | 3.54 (+0.12) | 2.53 (-0.06) | 3.05 (+0.00) | 2.86 (+0.12) |

## B.3 Results

### HR Wallingford Analysis

B.3.1 By adding a pair of lines crossing the river (one in line with the development and one under the Blackfriars road bridge) it was possible to analyse the changes in flow rate along these lines in addition to the 6 points identified in Figure B.1. Images were produced to represent each of the current flow diagrams for the Wallingford report and these have been included in the sections below.

B.3.2 Current patterns would be affected by the proposed developments, however analysis shows that significant changes to current patterns would typically be in close proximity (within a few meters) to either the bridge arches or the development itself.

B.3.3 In areas further from the arches or the development, changes to the flow would typically be an increase, with very little to no change to direction of flow.

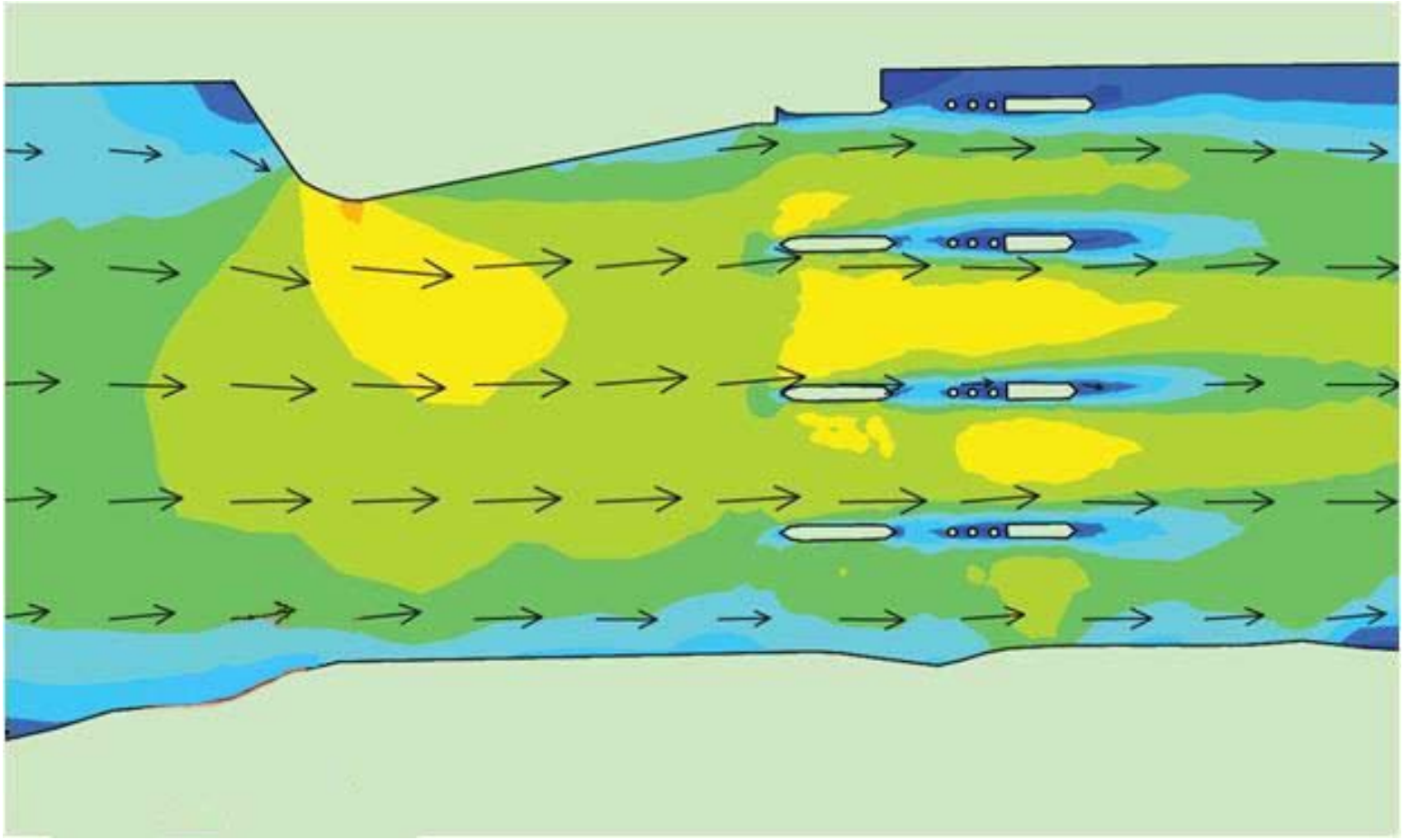
B.3.4 Considering the change in maximum flow, for the temporary works, the greatest change in maximum flow under the road bridge (across a given cross section) would be approximately 0.4 knots. This would be associated with a peak ebb spring tide with strong river flow (800$m^3$/s). This would increase to approximately 1.2 knots immediately adjacent to the widest part of the development.

B.3.5 Considering the change in maximum flow, for the permanent works, the greatest change in maximum flow under the road bridge (across a given cross section) in the Blackfriars area would be approximately 0.3 knots, this would be associated with a peak ebb spring tide with 65m3/s river flow, in line with the widest part of the development. This would increase to approximately 0.5 knots immediately adjacent to the widest part of the development.

B.3.6 The change in maximum flow under the road bridge would be less than 0.4 knots for both the temporary and permanent works. The greatest change in maximum flow would occur immediately adjacent to the temporary works where the flow would increase by 1.2 knots (0.5 knots at the permanent works). Although the increases in maximum flow could be considered small (except where immediately adjacent to the temporary works), the maximum flow would be experienced in a different location and the flow pattern would change. It is recommended that notices to mariners should be issued warning of these changes.

B.3.7 It should be noted that the change in maximum flow at the road was assessed for each arch in turn and for all arches, and the worst case has been tabulated. This provides the worst case increase in flow that the mariner would experience when passing under the bridge.

**Figure B.2 BMT analysis point**



## Table B.4 Temporary work: changes in maximum flows

| Reference | Flow Conditions | Change in maximum flow in line with development | Change in maximum flow in line with Road Bridge |
|---|---|---|---|
| Fig B.3 | Peak Ebb currents - spring tide, 65m3/s river flow | 0.8 knots | 0.4 knots |
| Fig B.4 | Peak Flood currents - spring tide, 65 m3/s river flow | 0.8 knots | 0.4 knots |
| Fig B.5 | Peak Ebb currents - spring tide, 800 m3/s river flow | 1.2 knots | 0.4 knots |
| Fig B.6 | Peak Flood currents - spring tide, 800 m3/s river flow | 0.5 knots | 0.1 knots |
| Fig B.7 | Peak Ebb currents - large flood tide rise with 65m3/s river flow | 0.7 knots | 0.4 knots |
| Fig B.8 | Peak Flood currents - large flood tide rise with 65m3/s river flow | 0.8 knots | 0.4 knots |

## Table B.5 Permanent works: changes in maximum flows

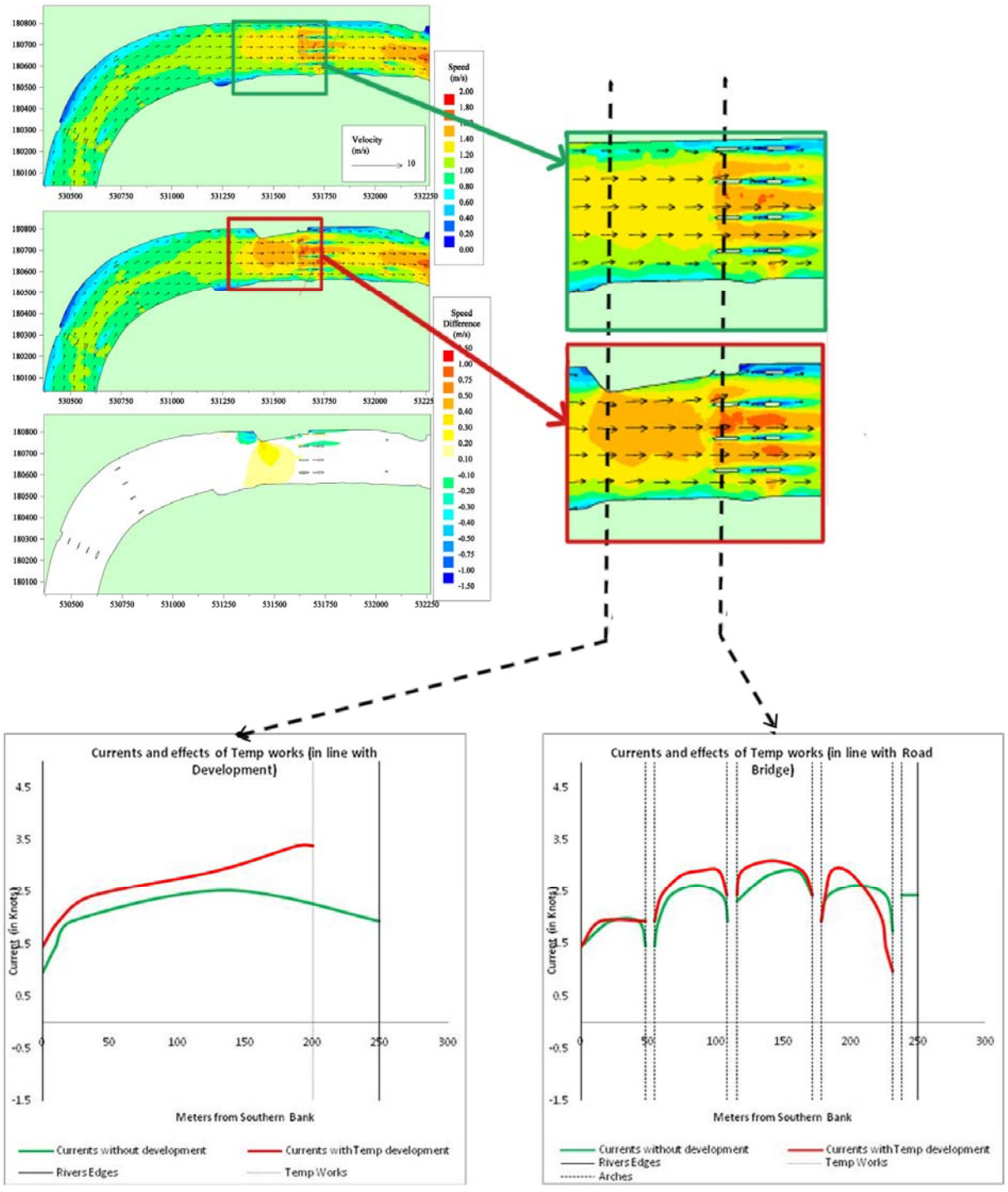
| Reference | Flow Conditions | Change in maximum flow in line with development | Change in maximum flow in line with Road Bridge |
|---|---|---|---|
| Fig B.9 | Peak Ebb currents - spring tide, 65m3/s river flow | 0.5 knots | 0.3 knots |
| Fig B.10 | Peak Flood currents - spring tide, 65 m3/s river flow | 0.2 knots | 0.1 knots |
| Fig B.11 | Peak Ebb currents - spring tide, 800 m3/s river flow | 0.3 knots | 0.3 knots |
| Fig B.12 | Peak Flood currents - spring tide, 800 m3/s river flow | 0.3 knots | 0.0 knots |
| Fig B.13 | Peak Ebb currents - large flood tide rise with 65m3/s river flow | 0.3 knots | 0.2 knots |
| Fig B.14 | Peak Flood currents - large flood tide rise with 65m3/s river flow | 0.4 knots | 0.2 knots |

B.3.8 Temporary Works - Peak Ebb currents - Spring tide, 65m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.6 knots. The increase in maximum flow would be 0.8 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.2 knots. The increase in maximum flow would be 0.4 knots.

**Figure B.3 Temporary works - peak ebb currents – spring tide, 65m3/s river flow**

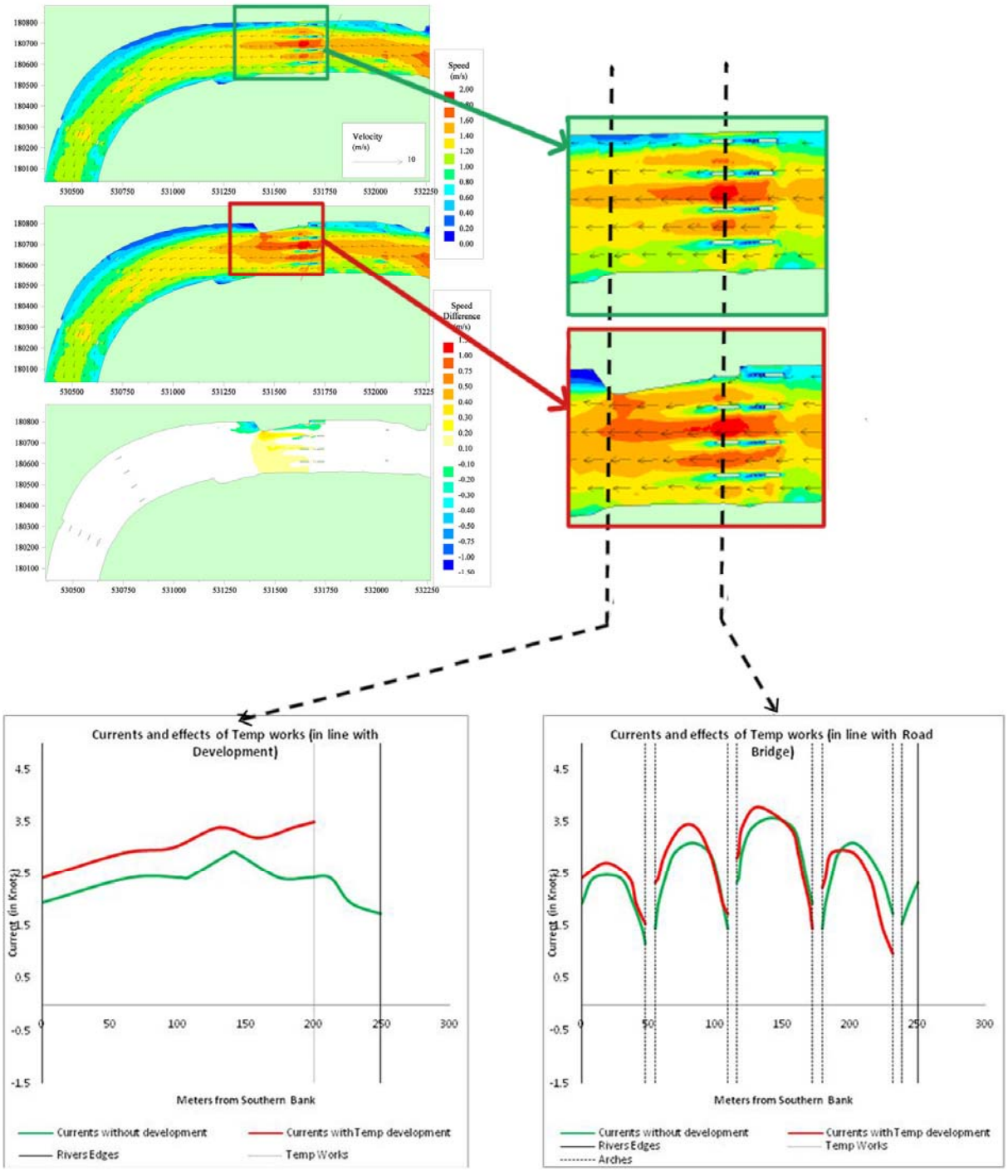


B.3.9 Temporary Works - Peak Flood currents - Spring tide, 65m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.7 knots. The increase in maximum flow would be 0.8 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.1 knots. The increase in maximum flow would be 0.4 knots.

**Figure B.4 Temporary works - peak flood currents – spring tide, 65m$^3$/s river flow**

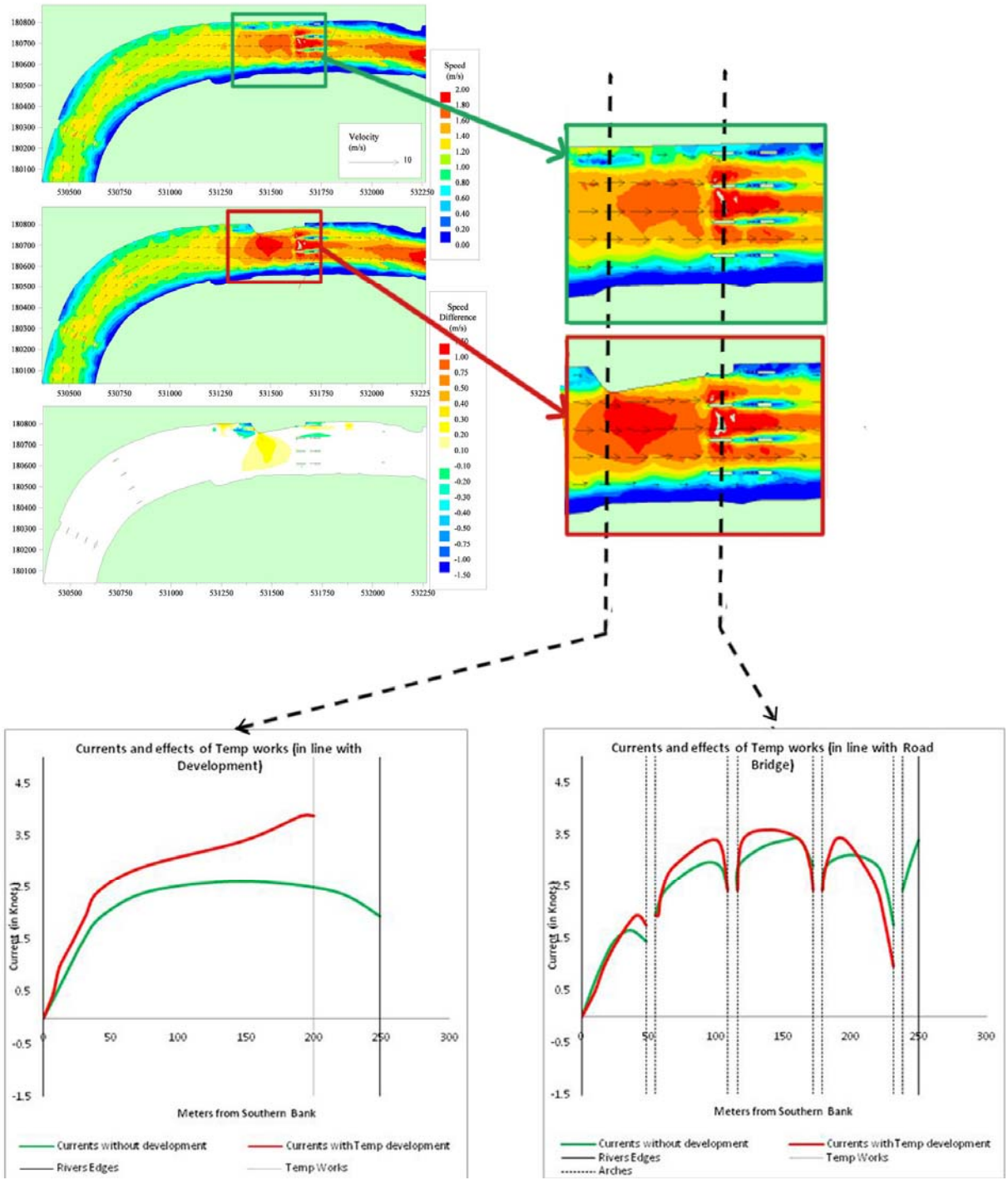


B.3.10 Temporary Works - Peak Ebb currents - spring tide, 800 m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.7 knots. The increase in maximum flow would be 1.2 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.1 knots. The increase in maximum flow would be 0.4 knots.

**Figure B.5 Temporary works - peak ebb currents – spring tide, 800m$^3$/s river flow**

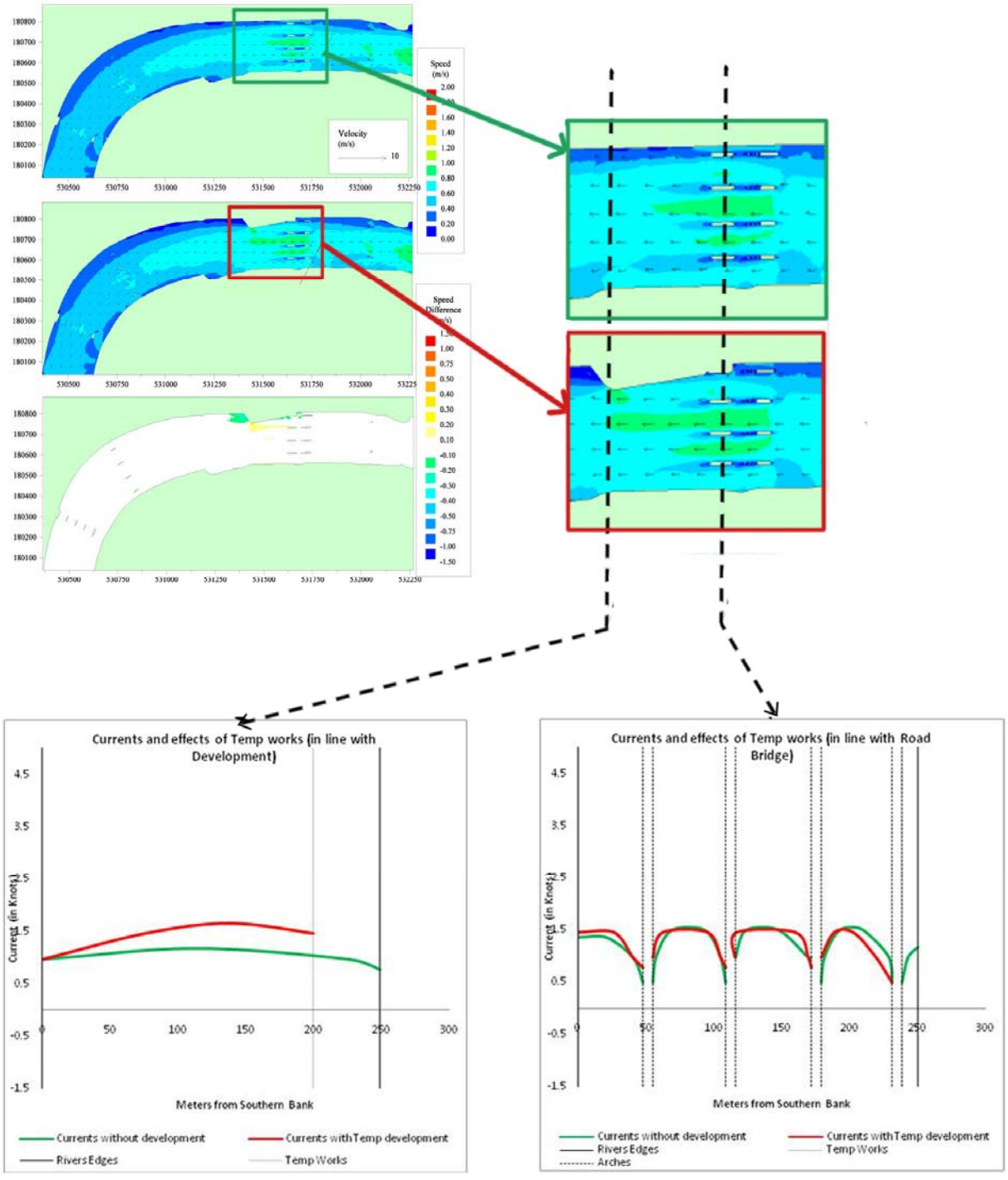


B.3.11 Temporary Works - Peak Flood currents - spring tide, 800 m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.4 knots. The increase in maximum flow would be 0.5 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.0 knots. The increase in maximum flow would be 0.1 knots.

**Figure B.6 Temporary works - peak flood currents – spring tide, 800m$^3$/s flow**

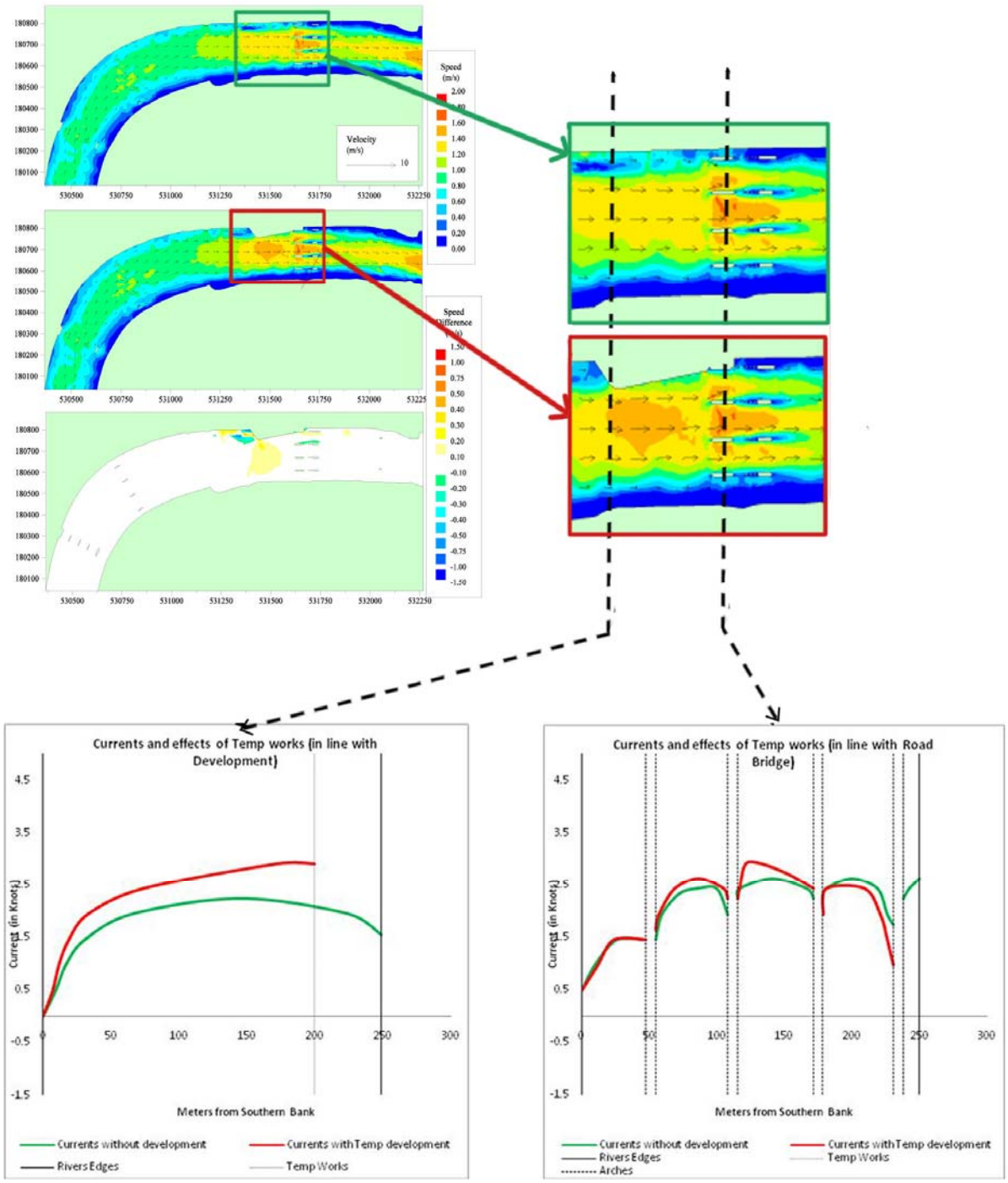


B.3.12 Temporary Works - Peak Ebb currents - large flood tide rise with 65m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.5 knots. The increase in maximum flow would be 0.7 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.0 knots. The increase in maximum flow would be 0.4 knots.

**Figure B.7 Temporary works - peak ebb currents – large flood tide rise with 65m$^3$/s flow**

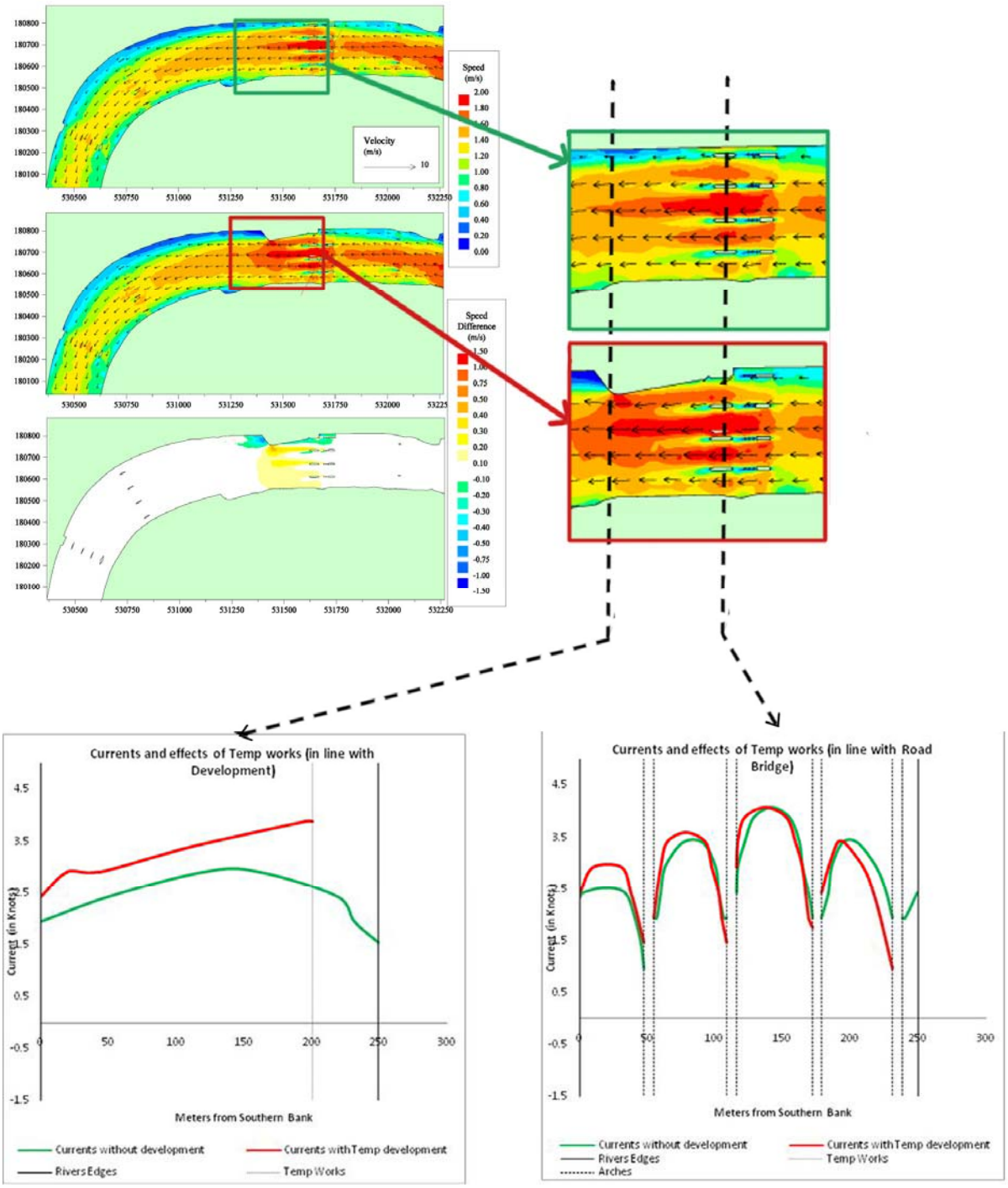


B.3.13 Temporary Works - Peak Flood currents - large flood tide rise with 65m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.8 knots. The increase in maximum flow would be 0.8 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.1 knots. The increase in maximum flow would be 0.4 knots.

**Figure B.8 Temporary works - peak flood currents – large flood tide rise, 65m$^3$/s river flow**

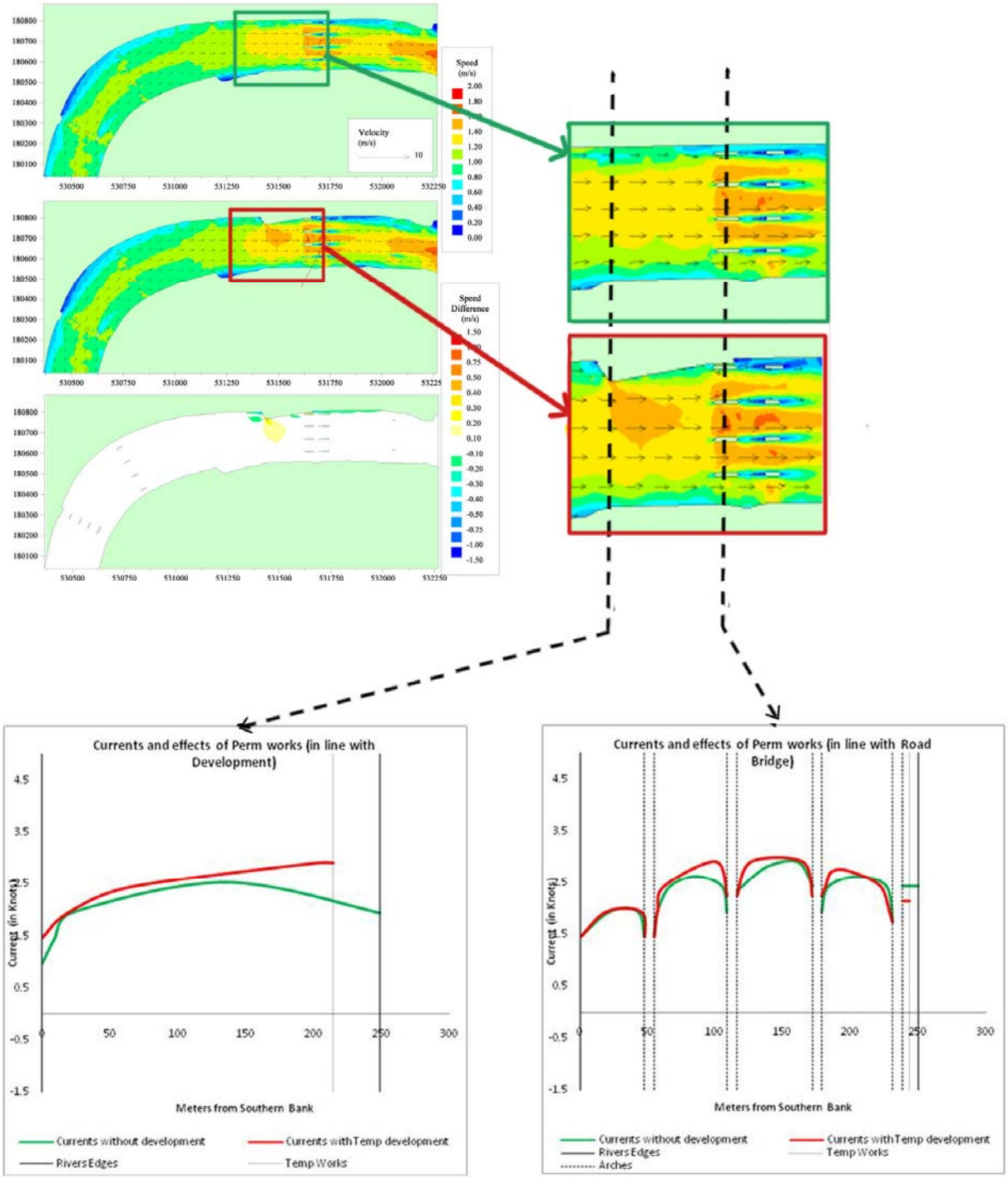


B.3.14 Permanent Works - Peak Ebb currents - Spring tide, 65m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.3 knots. The increase in maximum flow would be 0.5 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.1 knots. The increase in maximum flow would be 0.3 knots.

**Figure B.9 Permanent works – peak ebb currents – spring tide, 65m$^3$/s flow**

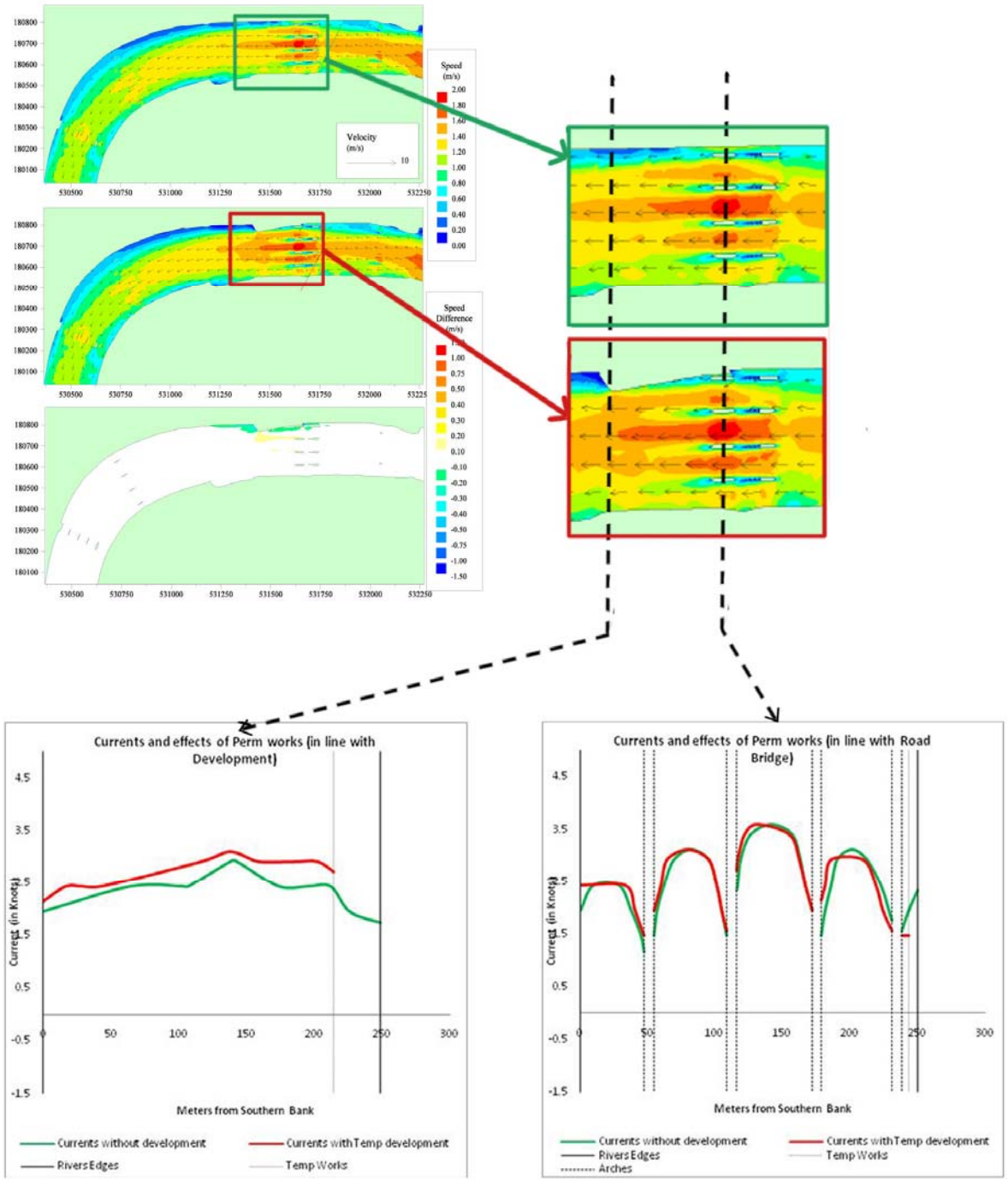


B.3.15 Permanent Works - Peak Flood currents - spring tide, 65 m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.4 knots. The increase in maximum flow would be 0.2 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.1 knots. The increase in maximum flow would be 0.1 knots.

**Figure B.10 Permanent works – peak flood currents – spring tide, 65m$^3$/s river flow**

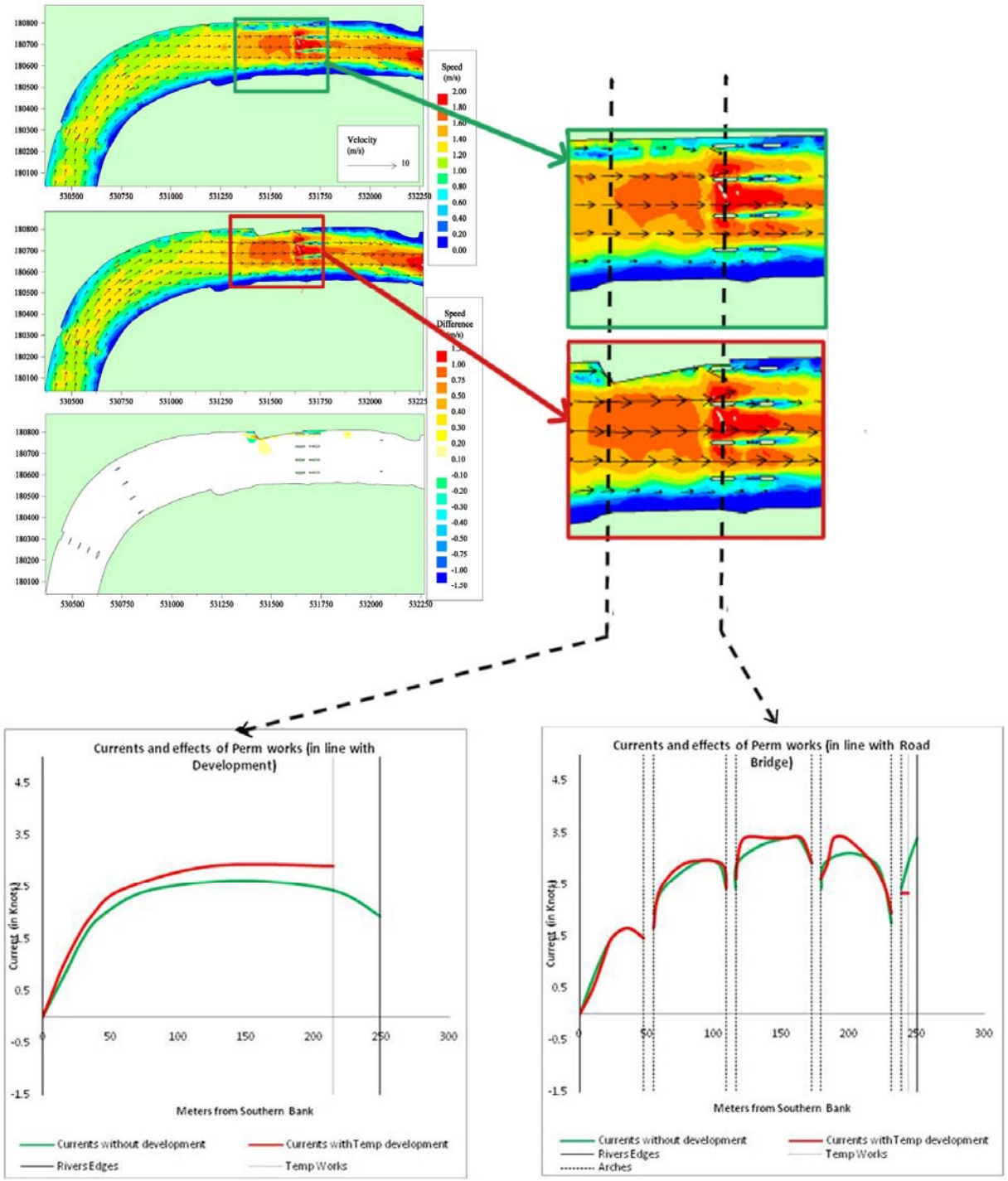


B.3.16 Permanent Works - Peak Ebb currents - spring tide, 800 m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.3 knots. The increase in maximum flow would be 0.3 knots.

b. There would be no average increase in flow (in line with Road Bridge). The increase in maximum flow would be 0.3 knots.

**Figure B.11 Permanent works – peak ebb currents – spring tide, 800m$^3$/s river flow**

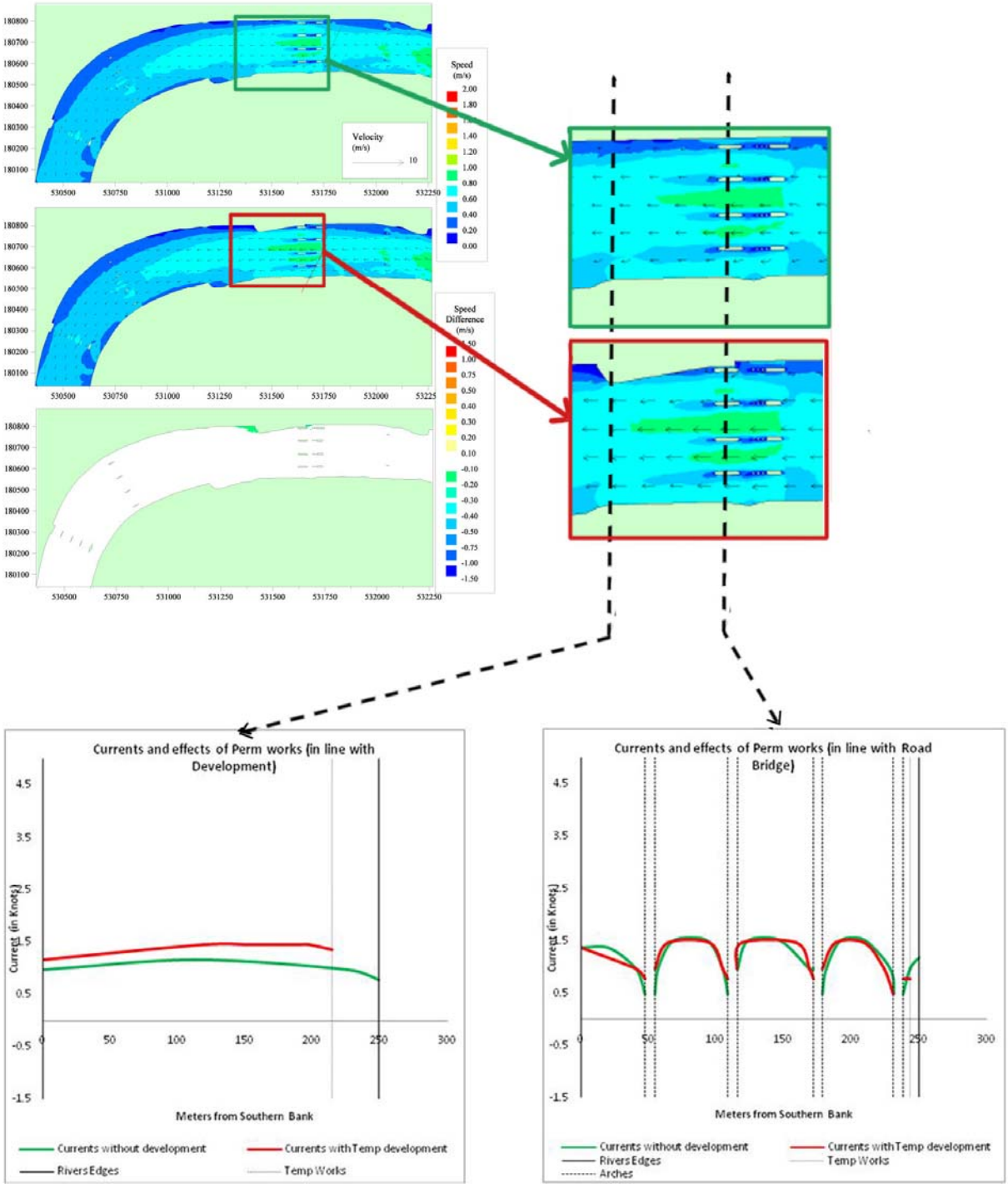


B.3.17 Permanent Works - Peak Flood currents - spring tide, 800 m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.3 knots. The increase in maximum flow would be 0.3 knots.

b. There would be no average or maximum increase in flow (in line with Road Bridge).

**Figure B.12 Permanent works – peak flood currents – spring tide, 800m$^3$/s river flow**

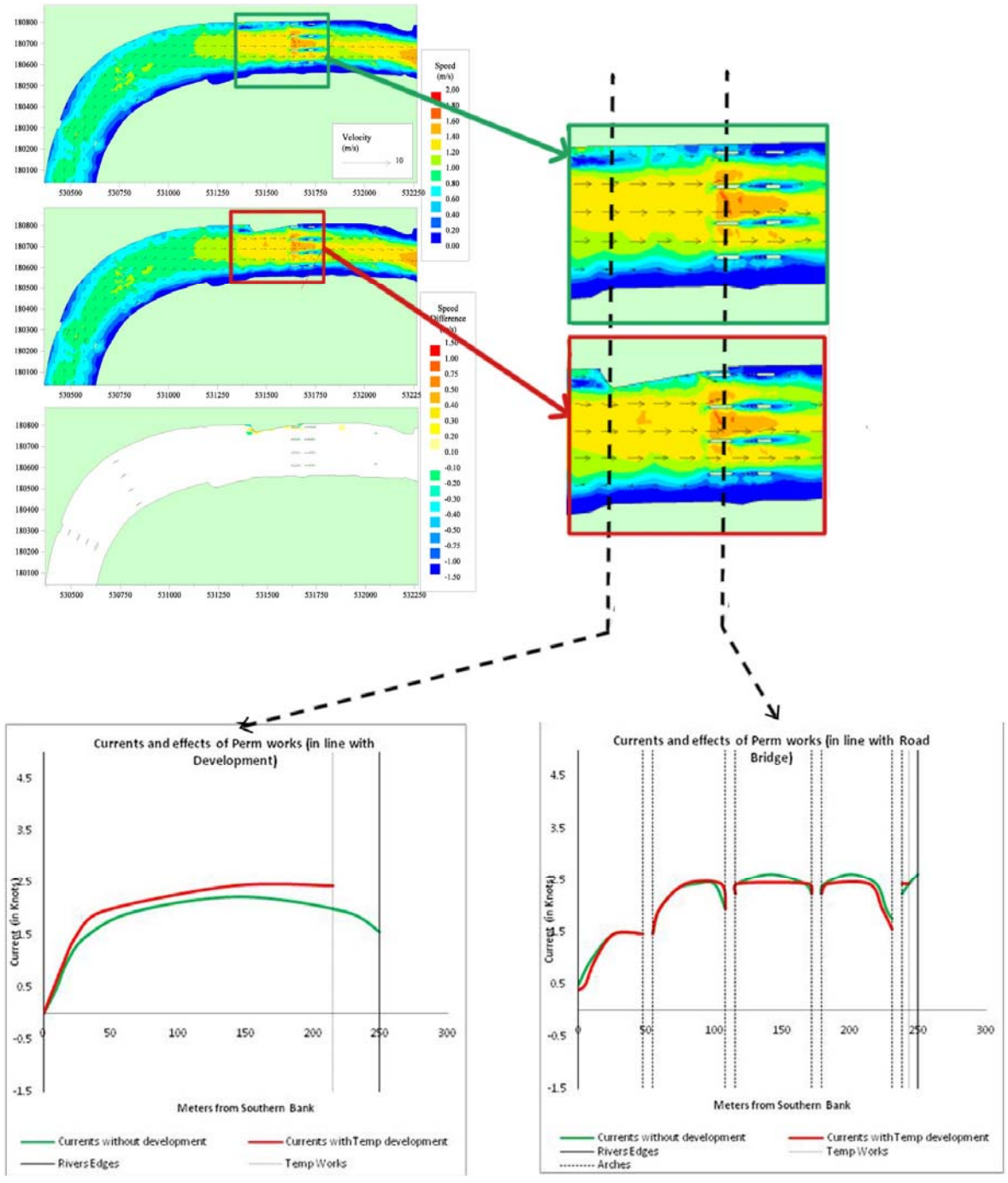


B.3.18 Permanent Works - Peak Ebb currents - large flood tide rise with 65m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.2 knots. The increase in maximum flow would be 0.3 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately -0.1 knots. The increase in maximum flow would be 0.2 knots.

**Figure B.13 Permanent works – Peak ebb currents – large flood tide rise with 65m$^3$/s river flow**

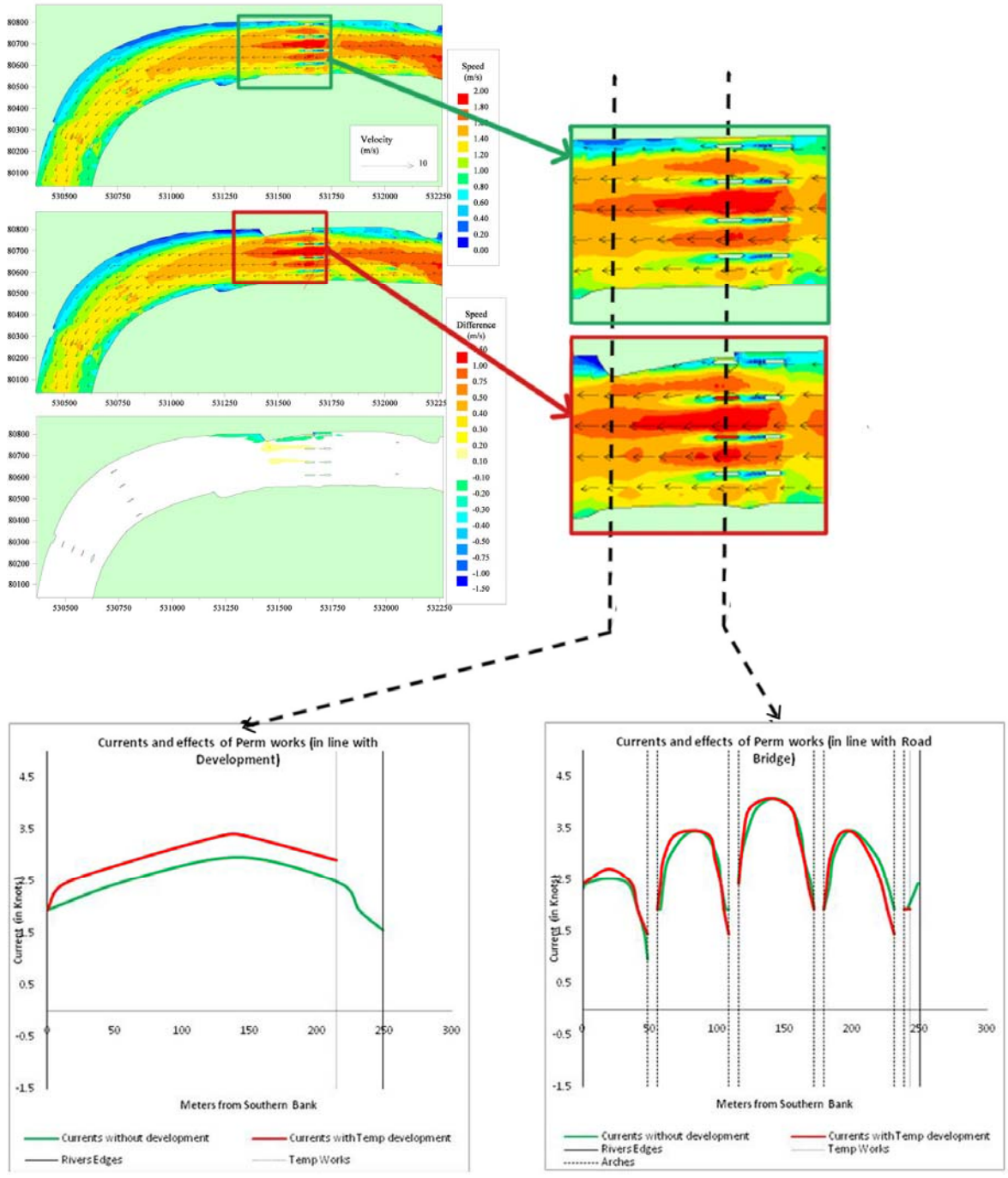


B.3.19 Permanent Works - Peak Flood currents - large flood tide rise with 65m3/s river flow:

a. The average increase in flow (in line with development) would be approximately 0.5 knots. The increase in maximum flow would be 0.4 knots.

b. The average increase in flow (in line with Road Bridge) would be approximately 0.1 knots. The increase in maximum flow would be 0.2 knots.

**Figure B.14 Permanent works – peak flood currents – large flood tide rise with 65m$^3$/s**



**Thames Tideway Tunnel**
Thames Water Utilities Limited

# Application for Development Consent

Application Reference Number: WWO10001

# Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.02**

## Blackfriars Bridge Foreshore

### Appendix C

APFP Regulations 2009: Regulation **5(2)(q)**

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# Appendix C: Freight tracks and AIS analysis

## C.1 Introduction

C.1.1 The in-river structure at Blackfriars Bridge Foreshore would be necessary because the embankment contains existing sewers that prevent building the shaft into the embankment. To minimise the impact that the in-river structure would have on existing river traffic the proposed final location of the shaft would be set back as far as is reasonably possible from the authorised navigation channel.

C.1.2 The in-river structure would protrude into the river beyond the line of the existing Blackfriars Pier and the vessel President and could have an impact on the less manoeuvrable in-bound vessels passing through Blackfriars Bridge arch No2.

C.1.3 A review was undertaken of the tracks of barges being towed in-bound through arch No2.

## C.2 Summary of results

C.2.1 An inbound passage that takes any vessel through arch No2 at Blackfriars with a view of continuing the trip through the corresponding arches at both Waterloo and Charing Cross Bridges would need to be mindful of the stronger tide set on that side of the river and to steer and maintain a course to remain clear of the permanent moorings along the Victoria Embankment. The results show that the majority of the vessel tracks would clear the permanent structure by 10m or more. This is true despite the pre-existing structure (Blackfriars Millennium Pier) being significantly smaller then the proposed development.

C.2.2 Vessel tracks exist that would not only clear the permanent works, but also the larger temporary works by a significant margin (some tracks pass the temporary development by greater than 20 meters). This ability to transit past the site with sufficient clearance implies that vessel masters would have sufficient manoeuvrability to clear both the permanent works and the temporary works structures.

C.2.3 There is concern that in clearing the in-river structures vessels would move out too far towards down-river vessels. However, up-river tugs and tows normally pass through arch No3 of Waterloo Bridge and these vessels are able to move carefully and safely into the centre of the river channel without unduly affecting other downstream traffic.

### Inbound transit

C.2.4 Vessels transiting through the two bridges at Blackfriars (Inward bound) currently have two options to take, passing through either arch No2 or arch No3, with arch No3 designated as the working arch.

C.2.5 During temporary works construction (Phase A) and while the temporary works would be removed (Phase C), it is assumed that Arch No2 would be

closed to larger vessels. The project intends to liaise with TfL to ensure that planned bridge maintenance and inspection routines would be conducted prior to the construction of works at Blackfriars Bridge Foreshore commencing.

C.2.6 Should an unexpected incident (i.e. an accident) occur that necessitates the closing of arch No3, contingency arrangements would need to be made. Provided any jack up barges and associated project plant being used on the temporary works are removed, arch No2 could be reopened for use until issues with arch No3 are resolved, although restrictions would need to be in place.

## Outbound transit

C.2.7 Vessels on an outbound transit have the option to pass through arches No 3 and 4. All construction would be based on the north bank and should have no direct impact on downstream traffic.

## Other main river users

C.2.8 Thames Clippers represent the heaviest user of Blackfriars Millennium Pier, and Cory Environmental represent one of the most significant freight operators passing through the Blackfriars area. To reflect their respective importance in the area, impacts and routing for these two operators have been analysed separately in the following section.

C.2.9 The Thames Clipper tracks are for access to the existing pier and show the proposed location of the new pier. It is apparent that the new location would provide better visibility of in-bound vessels (the existing location visibility being constrained by the Blackfriars bridges).

## Cory Tug & Tow Upstream GPS tracks

C.2.10 Cory environmental supplied the project with a set of GPS data showing the movements of their tugs and barges. The data covered 14 days in November 2011, a total of 35 tug movements. This data was analysed and visualised to inform various sections of this report. Included below in Figure C.1 is a GIS output of all tracks overlaid over a chart of the Blackfriars area.

## C.3 Cory Environmental Ltd

**Table C.1 Cory Environmental Ltd - AIS Data Tracks - November 2011 single rank of barges**

| Date | Unit | | Tug | Barge types | |
|---|---|---|---|---|---|
| | Number | Colour | | Head rank port | Head rank stb'd |
| 07/11/11 | | Blue | Recovery | Cringle | Wangas |
| 07/11/11 | | Red | Resource | Cringle | Cringle |
| 07/11/11 | | Green | Recovery | Cringle | Wangas |
| 08/11/11 | | Blue | Regain | Cringle | Cringle |
| 09/11/11 | | Red | Resource | Cringle | Walbrook |
| 11/11/11 | | Blue | Recovery | Walbrook | Cringle |
| 14/11/11 | | Green | Regain | Wangas | Cringle |
| 14/11/11 | | Red | Resource | Wangas | Cringle |
| 14/11/11 | | Blue | Recovery | Walbrook | Cringle |
| 15/11/11 | | Blue | Redoubt | Wangas | Wangas |
| 15/11/11 | | Green | Reclaim | Cringle | Cringle |
| 16/11/11 | | Red | Redoubt | Walbrook | Cringle |
| 17/11/11 | | Blue | Reclaim | Wangas | Wangas |
| 18/11/11 | | Blue | Recovery | Cringle | Cringle |
| 22/11/11 | | Red | Regain | Wangas | Wangas |
| 22/11/11 | | Green | Reclaim | Cringle | Cringle |
| 23/11/11 | FOG | Red | Reclaim | Wangas | Wangas |
| 23/11/11 | FOG | Green | Regain | Transponder on tug | |
| 23/11/11 | FOG | Blue | Redoubt | Cringle | Walbrook |
| 24/11/11 | | Red | Resource | Wangas | Wangas |
| 25/11/11 | | Red | Resource | Walbrook | Cringle |
| 25/11/11 | | Blue | Recovery | Wangas | Wangas |

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**Figure C.1 All single rank tracks from November data set - Temporary and Permanent Works Site**

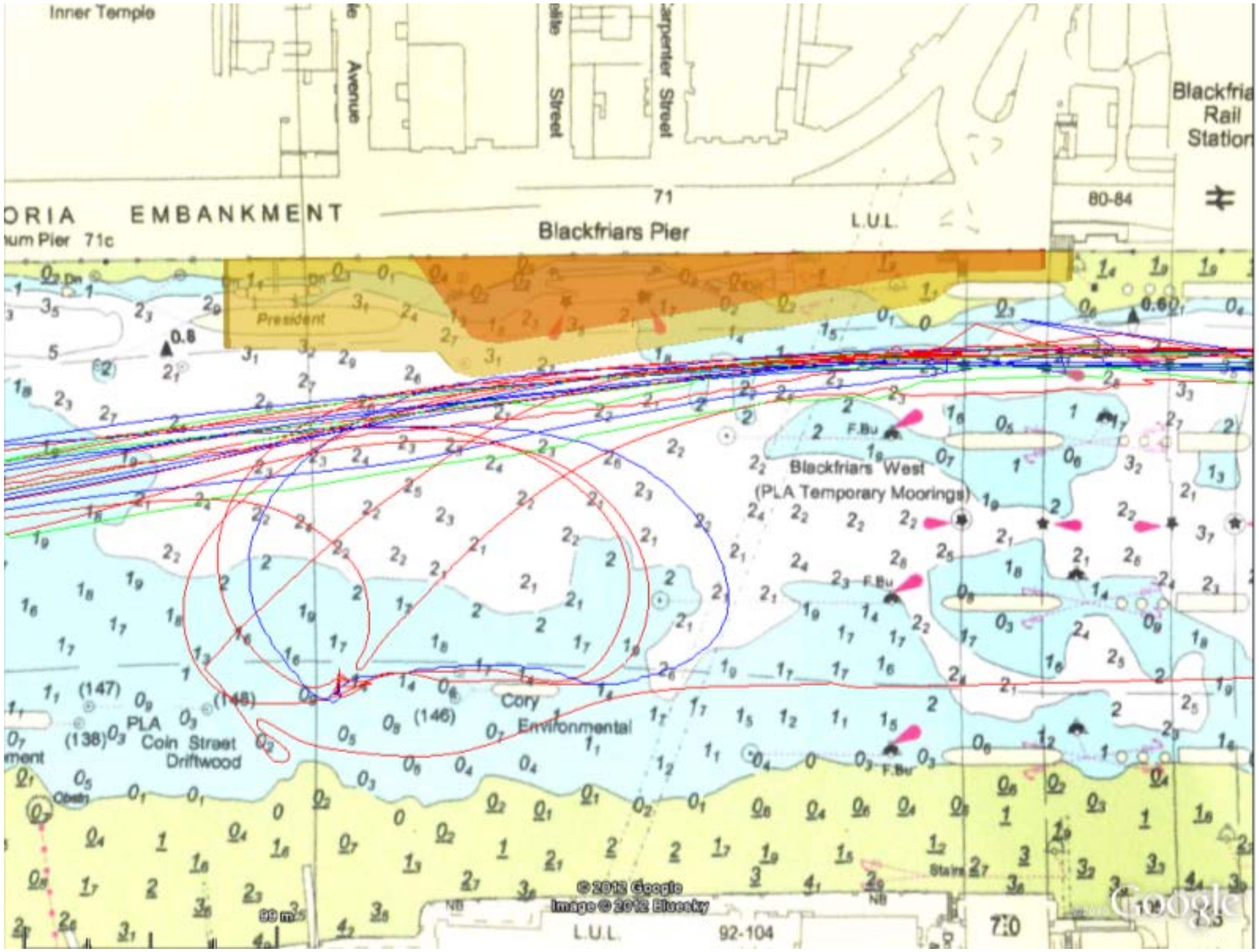
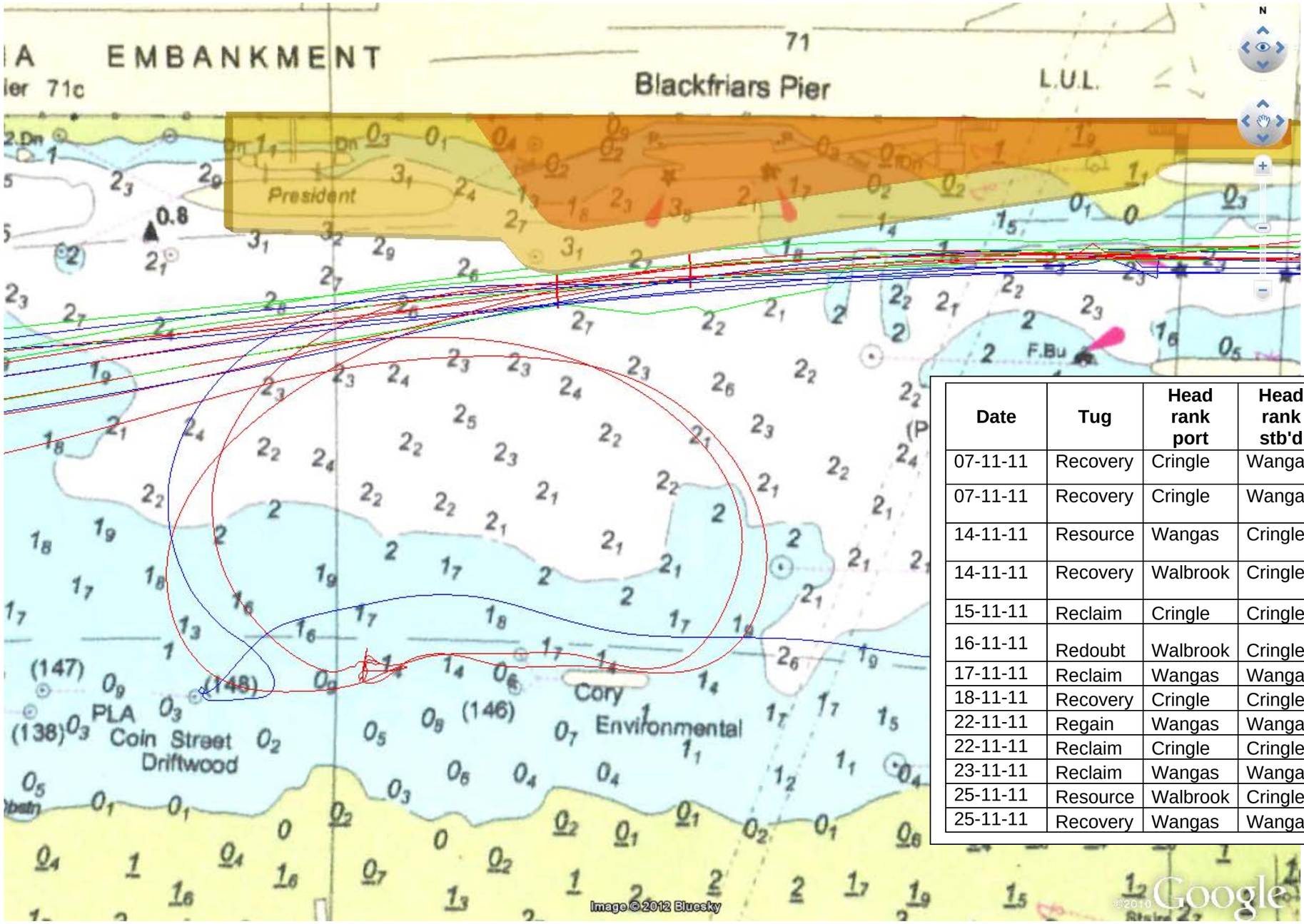


**Figure C.2 Single rank tracks within 10m of Temporary work structure**




| Date | Tug | Head rank port | Head rank stb'd |
|---|---|---|---|
| 07-11-11 | Recovery | Cringle | Wangas |
| 07-11-11 | Recovery | Cringle | Wangas |
| 14-11-11 | Resource | Wangas | Cringle |
| 14-11-11 | Recovery | Walbrook | Cringle |
| 15-11-11 | Reclaim | Cringle | Cringle |
| 16-11-11 | Redoubt | Walbrook | Cringle |
| 17-11-11 | Reclaim | Wangas | Wangas |
| 18-11-11 | Recovery | Cringle | Cringle |
| 22-11-11 | Regain | Wangas | Wangas |
| 22-11-11 | Reclaim | Cringle | Cringle |
| 23-11-11 | Reclaim | Wangas | Wangas |
| 25-11-11 | Resource | Walbrook | Cringle |
| 25-11-11 | Recovery | Wangas | Wangas |

**Figure C.3 All single rank tracks from November data set - Relocated Blackfriars Millennium Pier Location**

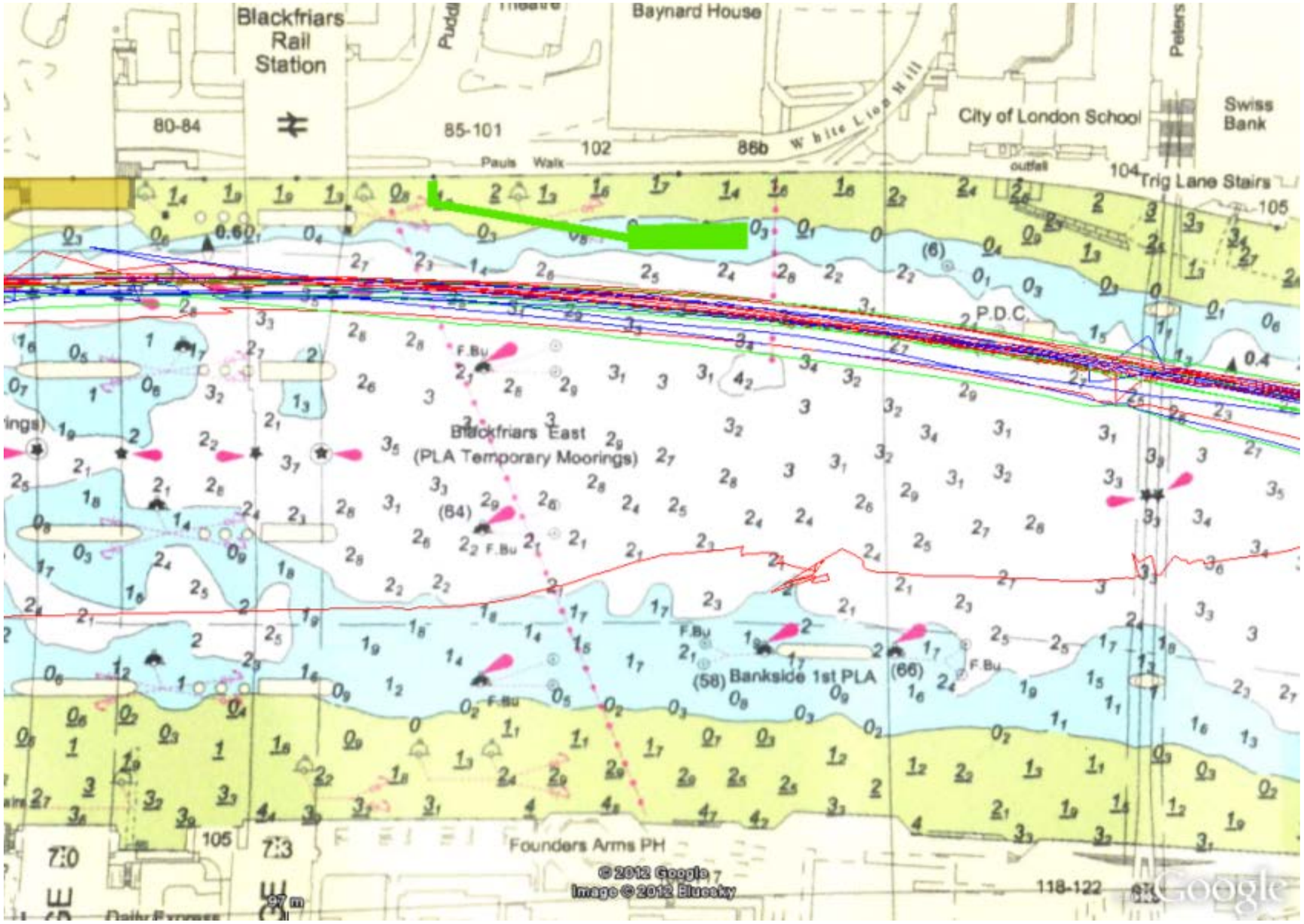
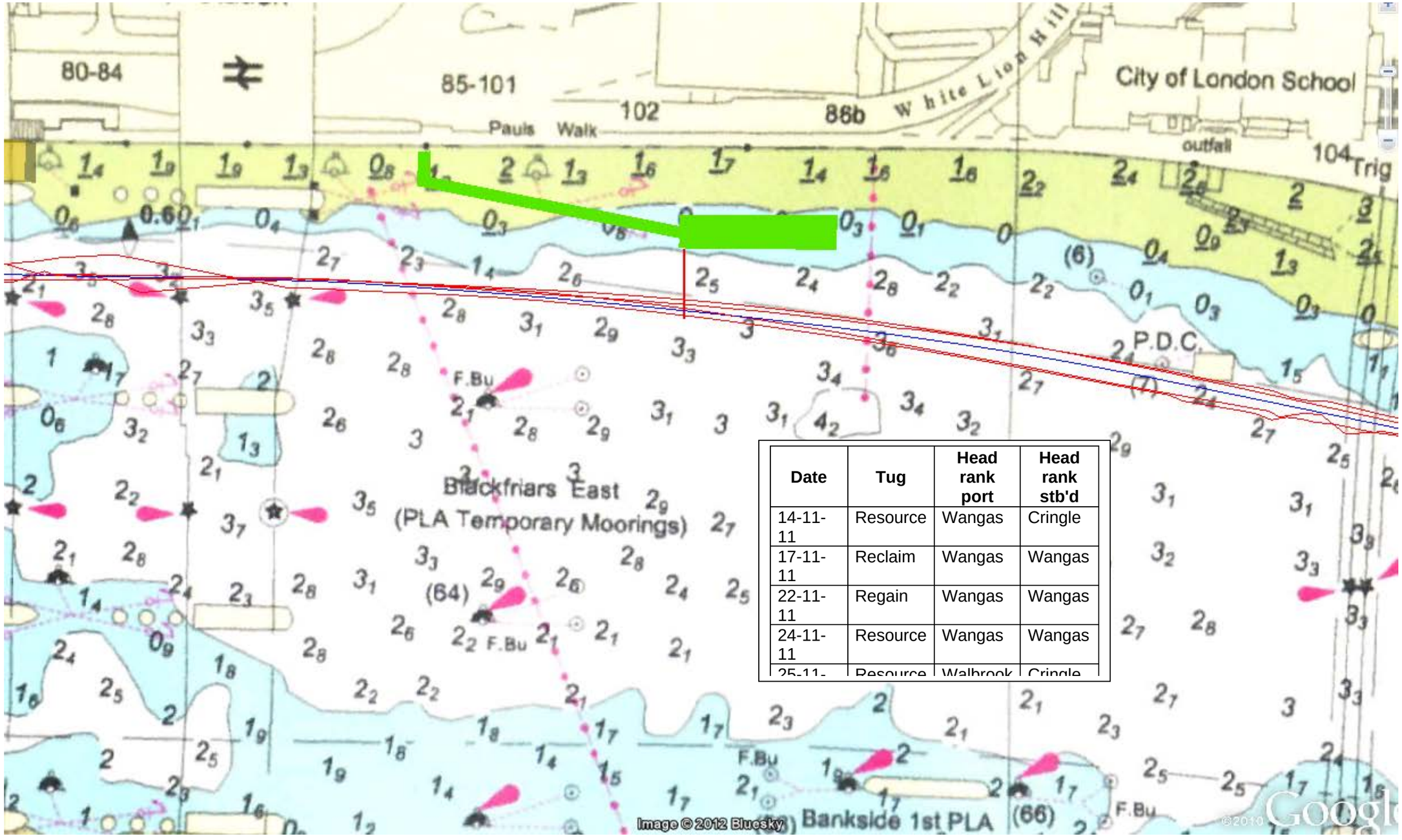


**Figure C.4 Single rank tracks within 20m of relocated pier position (closest = 15m from pier)**




| Date | Tug | Head rank port | Head rank stb'd |
|---|---|---|---|
| 14-11-11 | Resource | Wangas | Cringle |
| 17-11-11 | Reclaim | Wangas | Wangas |
| 22-11-11 | Regain | Wangas | Wangas |
| 24-11-11 | Resource | Wangas | Wangas |
| 25-11- | Resource | Walbrook | Cringle |

**Table C.2 Cory Environmental Ltd - AIS Data Tracks - November 2011 Double rank of barges**

| Date | Unit | | Tug | Barge types | | |
|---|---|---|---|---|---|---|
| | Number | Colour | | Head rank port | Head rank stb'd | Second rank |
| 07/11/11 | | Blue | Reclaim | Cringle | Cringle | Walbrook |
| 08/11/11 | | Green | Resource | Cringle | Cringle | Wangas |
| 08/11/11 | | Red | Reclaim | Cringle | Cringle | Cringle |
| 09/11/11 | | Blue | Recovery | Cringle | Wangas | Wangas |
| 09/11/11 | | Green | Redoubt | Cringle | Cringle | Wangas |
| 10/11/11 | | Blue | Regain | Cringle | Cringle | Wangas |
| 10/11/11 | | Red | Resource | Cringle | Cringle | Wangas |
| 11/11/11 | | Red | Reclaim | Cringle | Cringle | Wangas |
| 11/11/11 | | Green | Resource | Cringle | Cringle | Wangas |
| 16/11/11 | | Blue | Reclaim | Cringle | Cringle | Cringle |
| 16/11/11 | | Green | Recovery | Cringle | Wangas | Cringle |
| 17/11/11 | | Red | Redoubt | Cringle | Cringle | Cringle |
| 18/11/11 | | Red | Regain | Cringle | Wangas | Cringle |
| 22/11/11 | | Blue | Recovery | Cringle | Cringle | Cringle |
| 24/11/11 | | Blue | Reclaim | Cringle | Cringle | Cringle |
| 24/11/11 | | Green | Recovery | Cringle | Cringle | Cringle |
| 25/11/11 | | Green | Redoubt | Cringle | Cringle | Cringle |

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**Figure C.5 All double rank tracks from November data set**

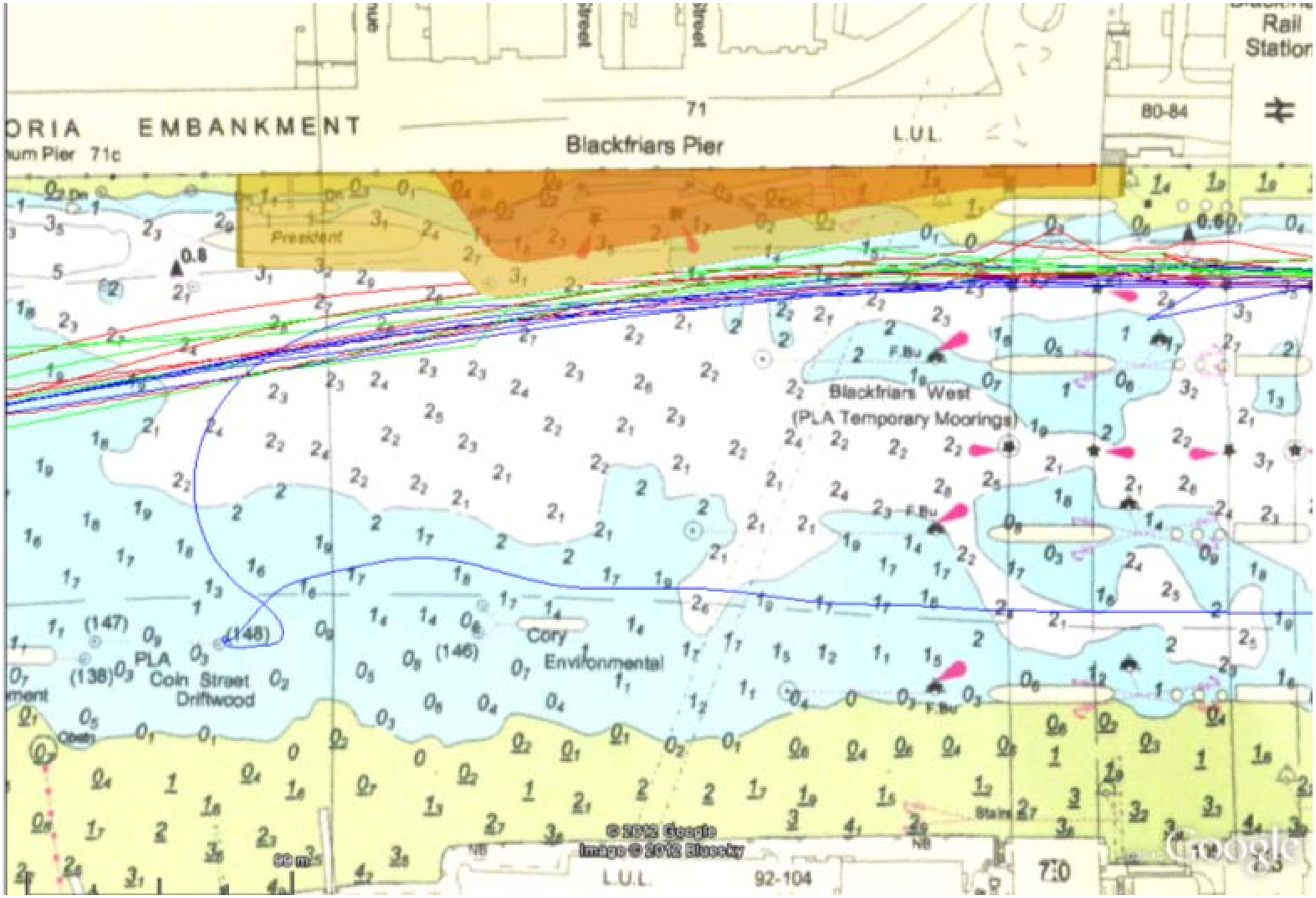
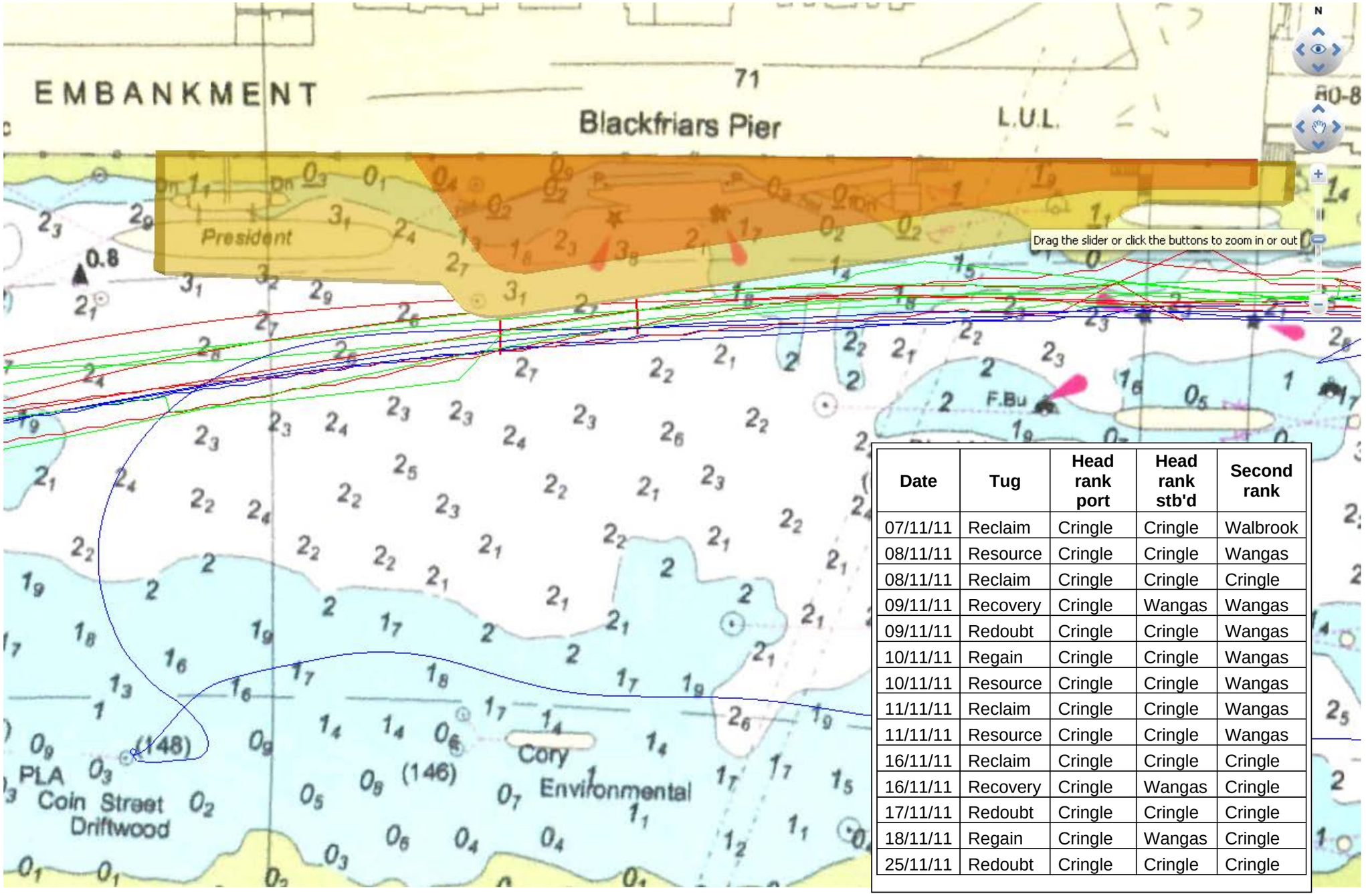


**Figure C.6 Single rank tracks within 10m of Temporary work structure**




| Date | Tug | Head rank port | Head rank stb'd | Second rank |
|---|---|---|---|---|
| 07/11/11 | Reclaim | Cringle | Cringle | Walbrook |
| 08/11/11 | Resource | Cringle | Cringle | Wangas |
| 08/11/11 | Reclaim | Cringle | Cringle | Cringle |
| 09/11/11 | Recovery | Cringle | Wangas | Wangas |
| 09/11/11 | Redoubt | Cringle | Cringle | Wangas |
| 10/11/11 | Regain | Cringle | Cringle | Wangas |
| 10/11/11 | Resource | Cringle | Cringle | Wangas |
| 11/11/11 | Reclaim | Cringle | Cringle | Wangas |
| 11/11/11 | Resource | Cringle | Cringle | Wangas |
| 16/11/11 | Reclaim | Cringle | Cringle | Cringle |
| 16/11/11 | Recovery | Cringle | Wangas | Cringle |
| 17/11/11 | Redoubt | Cringle | Cringle | Cringle |
| 18/11/11 | Regain | Cringle | Wangas | Cringle |
| 25/11/11 | Redoubt | Cringle | Cringle | Cringle |

**Figure C.7 All double rank tracks from November data set - Relocated Blackfriars Millennium Pier Location**

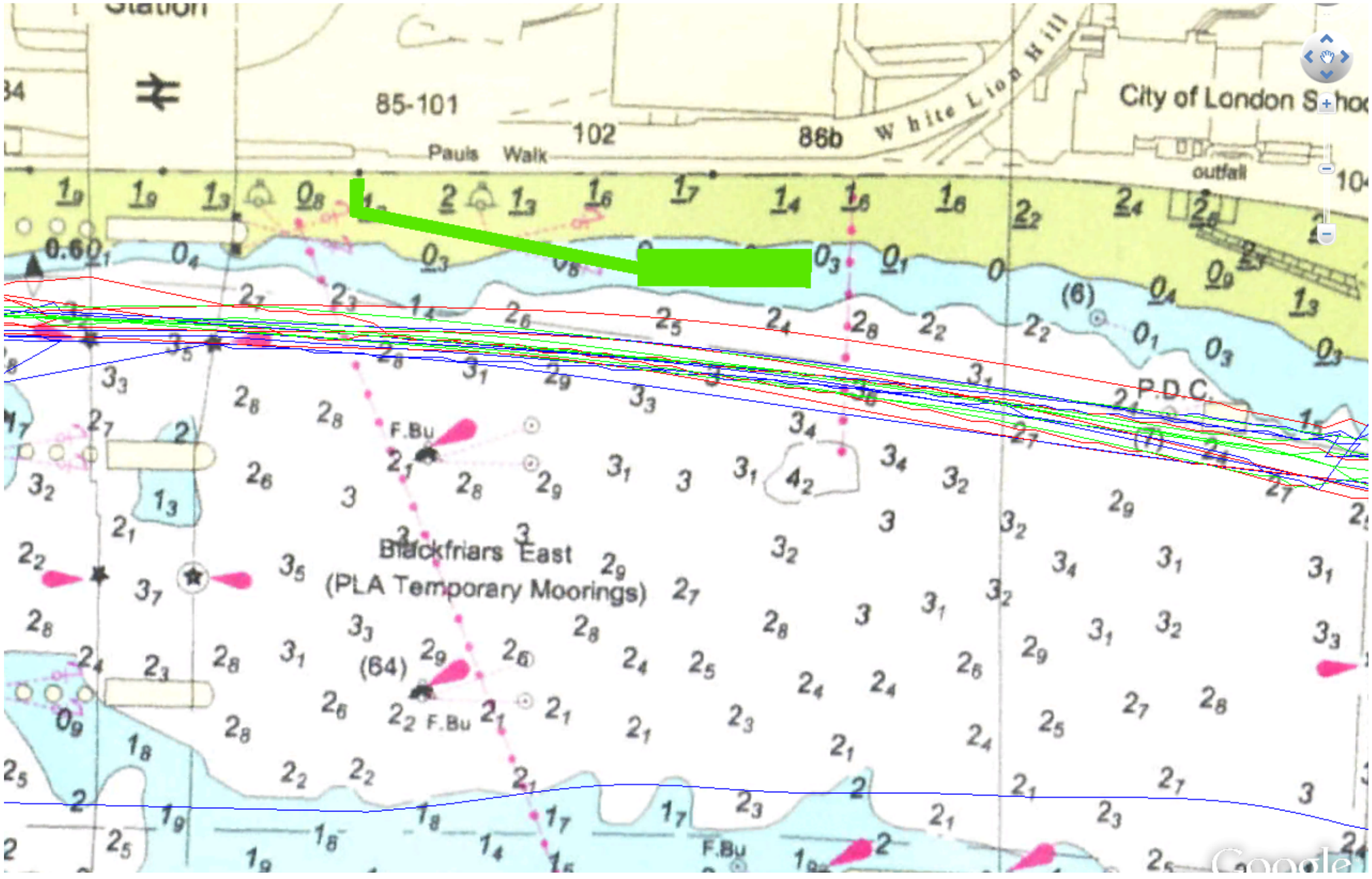
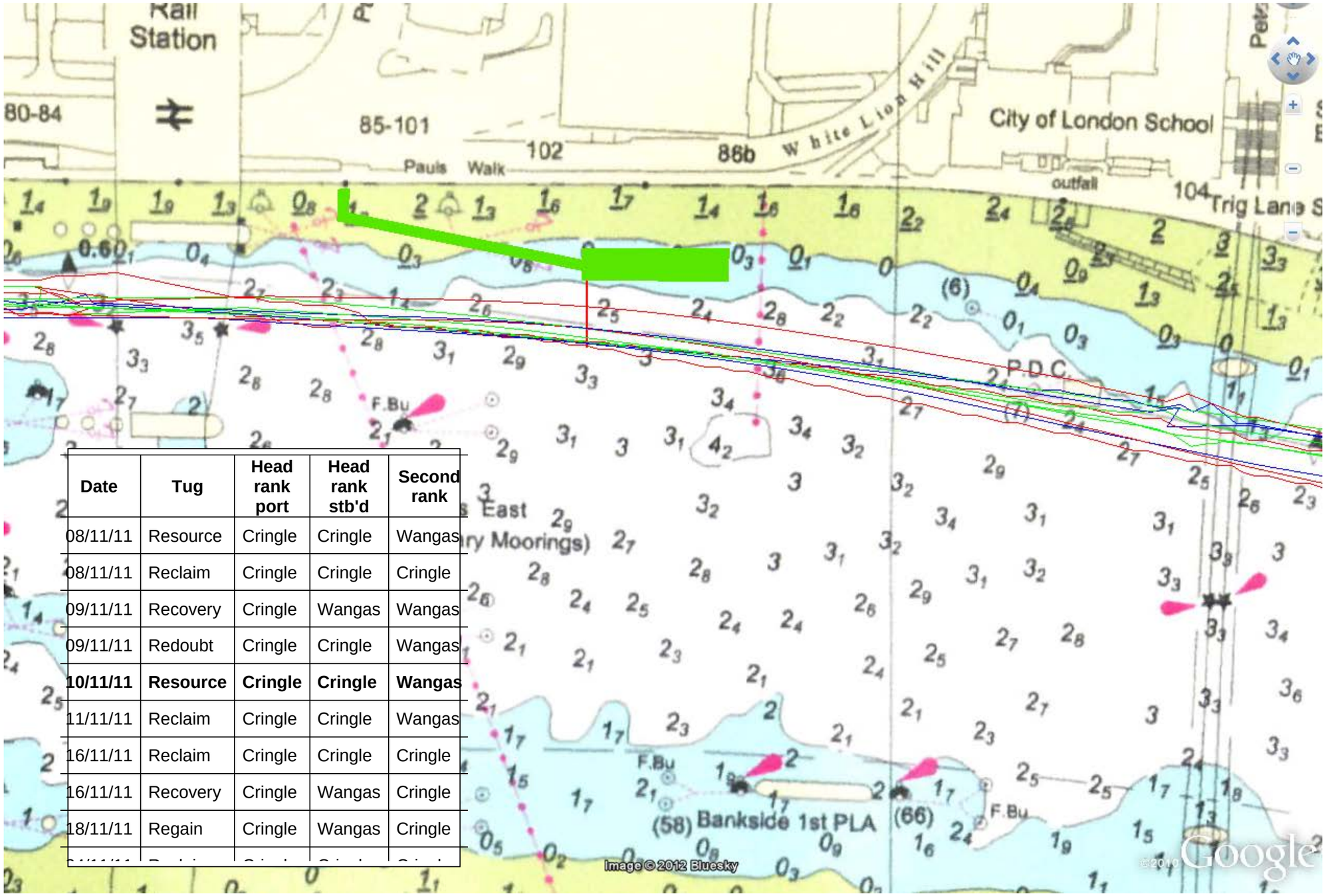


**Figure C.8 Double rank tracks within 20m of relocated pier position (closest = 8m from pier)**




| Date | Tug | Head rank port | Head rank stb'd | Second rank |
|---|---|---|---|---|
| 08/11/11 | Resource | Cringle | Cringle | Wangas |
| 08/11/11 | Reclaim | Cringle | Cringle | Cringle |
| 09/11/11 | Recovery | Cringle | Wangas | Wangas |
| 09/11/11 | Redoubt | Cringle | Cringle | Wangas |
| **10/11/11** | **Resource** | **Cringle** | **Cringle** | **Wangas** |
| 11/11/11 | Reclaim | Cringle | Cringle | Wangas |
| 16/11/11 | Reclaim | Cringle | Cringle | Cringle |
| 16/11/11 | Recovery | Cringle | Wangas | Cringle |
| 18/11/11 | Regain | Cringle | Wangas | Cringle |

**Figure C.9 2012 All Cory vessel tracks through the area**

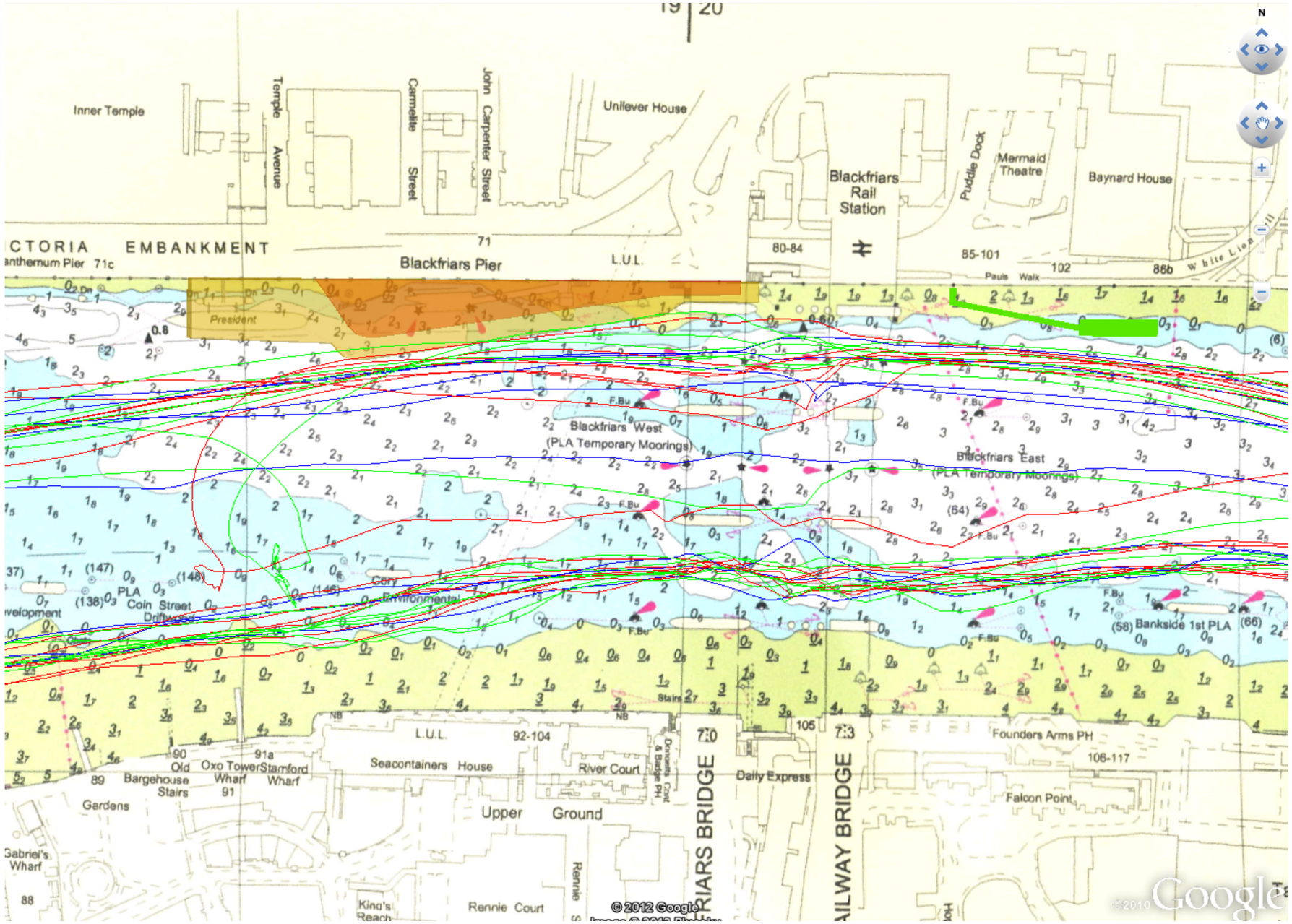


**Figure C.10 2012 All Cory vessel tracks past proposed relocated Pier with Clipper moored at downstream end**

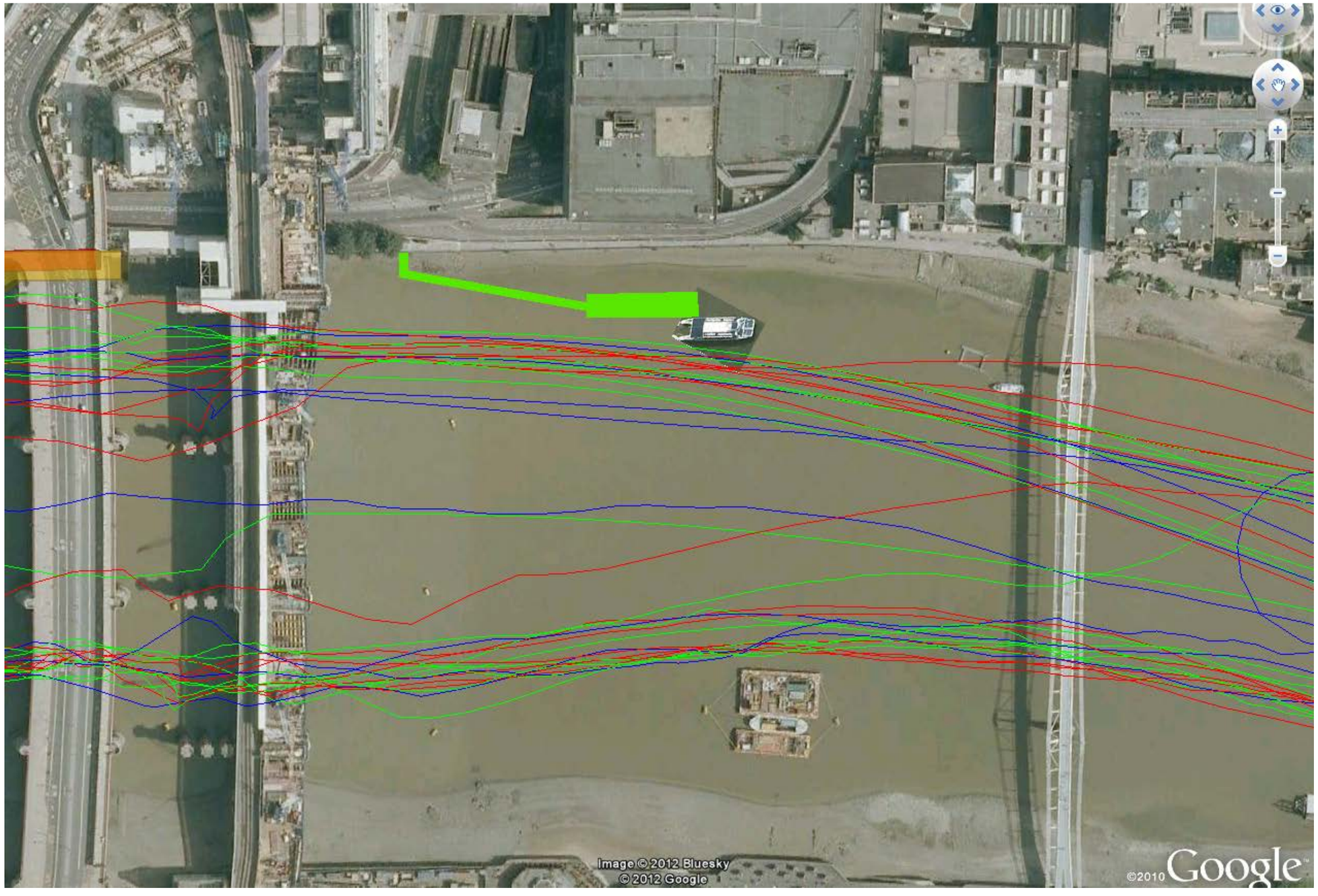
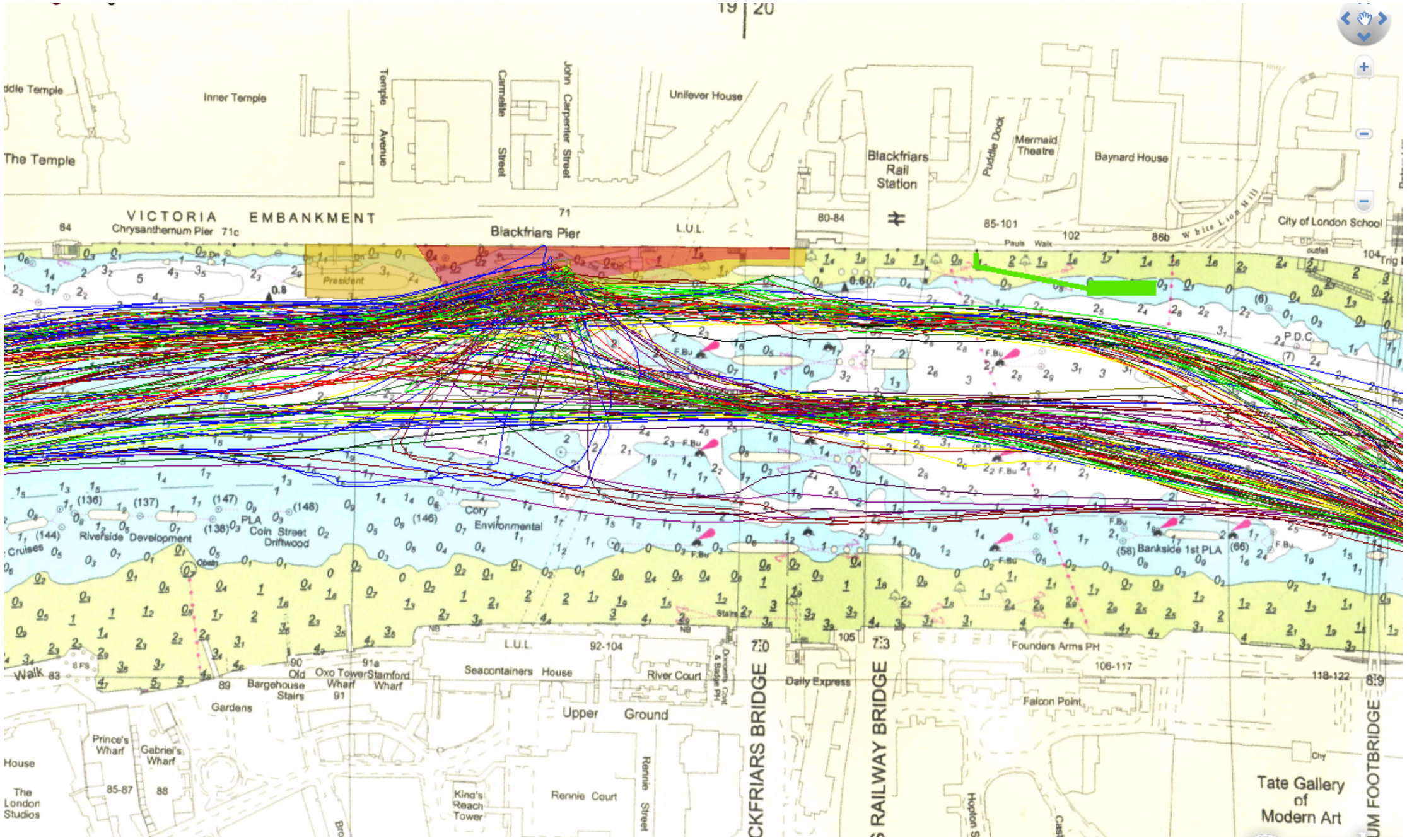


**Figure C.11 2012 All Thames Clipper vessel tracks past proposed structures (vessels calling at current Millenium Pier location)**



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**Thames Tideway Tunnel**
Thames Water Utilities Limited

# Application for Development Consent

Application Reference Number: WWO10001

# Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.02**

## Blackfriars Bridge Foreshore

### Appendix D

APFP Regulations 2009: Regulation **5(2)(q)**

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# Appendix D: Thames Tideway Tunnel vessel movements

D.1.1 Data for the barge movements associated with the Thames Tunnels project have been analysed to determine the maximum daily number of barges that will go to (or upriver of, and hence past) the Blackfriars Foreshore site.

D.1.2 The analysis indicates that a maximum of 24 barges associated with the Thames Tunnels will go to (or past) the Blackfriars Foreshore site per day. This daily maximum could be expected for duration of six weeks in July and August 2015. A breakdown of the maximum daily barge movements and their destinations for each year of the project is shown in Table D.1 to Table D.5.

**Figure D.1 Maximum daily TTT barge movements 2014 (June/July)**

| Site | Number of 350 Tonne Barges Per Day | Number of 1,000 Tonne Barges Per Day | Number of 1,500 Tonne Barges Per Day | Total Number of Barges Per Day |
|---|---|---|---|---|
| Albert Embankment | 3 | 0 | 0 | 3 |
| Barn Elms | 0 | 1 | 2 | 3 |
| **Grand Total** | **3** | **1** | **2** | **6** |

**Figure D.2 Maximum daily TTT barge movements 2015 (July/August)**

| Site | Number of 350 Tonne Barges Per Day | Number of 1,000 Tonne Barges Per Day | Number of 1,500 Tonne Barges Per Day | Total Number of Barges Per Day |
|---|---|---|---|---|
| Blackfriars Foreshore | 2 | 1 | 0 | 3 |
| Victoria Embankment | 3 | 0 | 0 | 3 |
| Albert Embankment | 2 | 0 | 0 | 2 |
| Kirtling Street | 4 | 0 | 0 | 4 |
| Putney | 5 | 0 | 0 | 5 |
| Barn Elms | 7 | 0 | 0 | 7 |
| **Grand Total** | **23** | **1** | **0** | **24** |

## Figure D.3 Maximum daily TTT barge movements 2016 (July/August)

| Site | Number of 350 Tonne Barges Per Day | Number of 1,000 Tonne Barges Per Day | Number of 1,500 Tonne Barges Per Day | Total Number of Barges Per Day |
|---|---|---|---|---|
| Albert Embankment | 2 | 3 | 0 | 5 |
| Cremorne Wharf | 2 | 1 | 0 | 3 |
| Putney | 3 | 0 | 0 | 3 |
| Barn Elms | 7 | 0 | 0 | 7 |
| **Grand Total** | **14** | **4** | **0** | **18** |

## Figure D.4 Maximum daily TTT barge movements 2017 (July/August)

| Site | Number of 350 Tonne Barges Per Day | Number of 1,000 Tonne Barges Per Day | Number of 1,500 Tonne Barges Per Day | Total Number of Barges Per Day |
|---|---|---|---|---|
| Blackfriars Foreshore | 3 | 0 | 0 | 3 |
| Kirtling Street | 2 | 2 | 0 | 4 |
| Chelsea Embankment | 1 | 1 | 0 | 2 |
| Carnwath Road | 1 | 0 | 0 | 1 |
| **Grand Total** | **7** | **3** | **0** | **10** |

## Figure D.5 Maximum daily TTT barge movements 2018 (April)

| Site | Number of 350 Tonne Barges Per Day | Number of 1,000 Tonne Barges Per Day | Number of 1,500 Tonne Barges Per Day | Total Number of Barges Per Day |
|---|---|---|---|---|
| Blackfriars Foreshore | 0 | 2 | 0 | 2 |
| Cremorne Wharf | 2 | 0 | 0 | 2 |
| Barn Elms | 1 | 0 | 0 | 1 |
| Grand Total | 3 | 2 | 0 | 5 |

**Thames Tideway Tunnel**
Thames Water Utilities Limited

# Application for Development Consent

Application Reference Number: WWO10001

# Navigational Issues and Preliminary Risk Assessment

Doc Ref: **7.20.02**

## Blackfriars Bridge Foreshore

### Appendix E

APFP Regulations 2009: Regulation **5(2)(q)**

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# Appendix E: Tide set

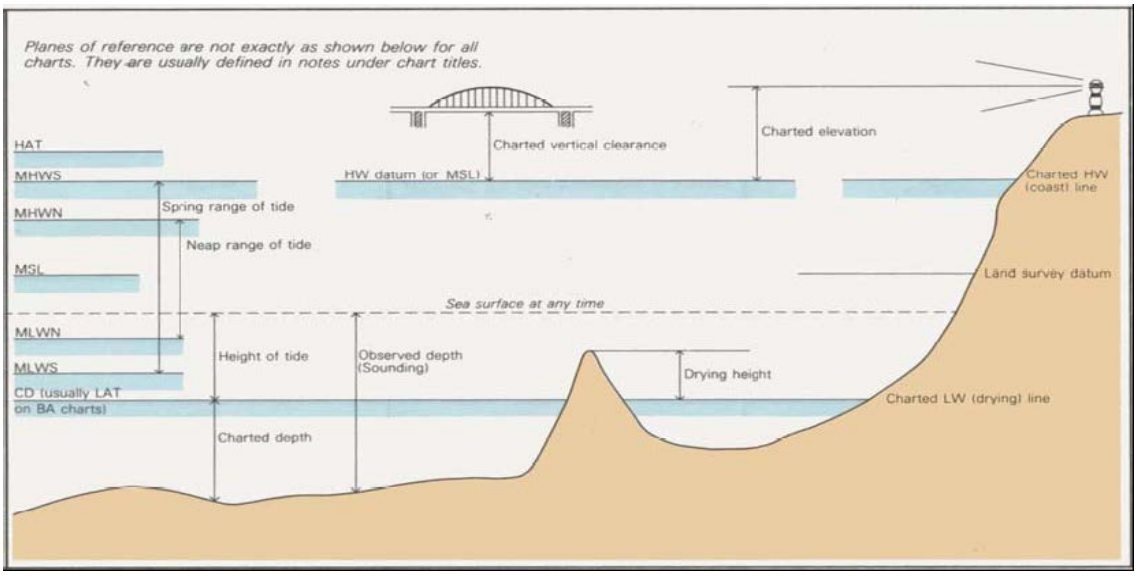
## E.1 Introduction

E.1.1 The term ‘Tide Set ’is used to describe the movement of water in a tideway into the bight or outside edge of a bend. In a tidal river like the Thames, which in the central area is embanked, it also leads to an increase in velocity.

E.1.2 This Appendix provides an explanation of the expected Tide Sets in the area known as Kings Reach, covered by PLA Chart No 317.

E.1.3 Figure E.1 and Figure E.2 provide an illustrative overview of the expected tide sets.

**Figure E.1 Tide definition**




i Neap Tide - A tide that occurs when the difference between high and low water is least. Neap tide comes twice a month, in the first and third quarters of the moon.

ii Spring Tide - A tide that occurs when the difference between high and low water is at its greatest. Spring tides usually occur during full or new moons. Spring tide is a term that implies a *welling up* of the water and bears no relationship to the season of the year.

iii MHW - Mean High Water - The average height of all high waters recorded at a given place over a 19 year period.

iv MHWS - Mean High Water Spring - Highest level to which the spring tide reaches (as an average) over a period of time.

v MHWN - Mean High Water Neap - The average height of the high water of neap tides.

vi MLWS - Mean Low Water Spring - The average height of the low waters of spring tides.

vii MLWP - Mean Low Water Neap - The average height of the low water at neap tides.

## E.2 Flood Tide

### Inbound transit

E.2.1 From the Millennium Footbridge, the set of tide begins to move slightly towards the north bank. For larger vessels and tugs with tows, a course that enables a passage through the centre arch of both Blackfriars Rail and Road bridges is the preferred route, passing directly beneath or a fraction to the south of the amber lights that mark the highest part of the span. Making use of the number two arch, one will experience a stronger set to the north and face almost a meter less headroom in the span of the road bridge.

E.2.2 Once clear of the Blackfriars Bridges, the sweep of the bend begins to take on more definition and the set of tide gradually becomes more pronounced. It is crucial that larger vessels begin to take a position to the south side of the channel as close to the floating moorings so as not to impede the passage of outbound traffic. This is to ensure their safe transit through Waterloo Bridge, where a strong set to the north exists.

E.2.3 An inbound passage that takes any vessel through the number two arches at Blackfriars with a view of continuing the trip through the two arches at both Waterloo and Charing Cross would need to be mindful of the stronger set on that side of the river and to steer and maintain a course to remain clear of the permanent moorings along the Victoria Embankment.

## E.3 Ebb Tide

### Outbound transit

E.3.1 From the Millennium Footbridge, the set of tide begins to move slightly towards the north bank. For larger vessels and tugs with tows, a course that enables a passage through the centre arch of both Blackfriars Rail and Road bridges is the preferred route, passing directly beneath or a fraction to the south of the amber lights that mark the highest part of the span. Making use of the number two arch, one will experience a stronger set to the north and face almost a meter less headroom in the span of the road bridge.

**Figure E.2 Blackfriars tide set**

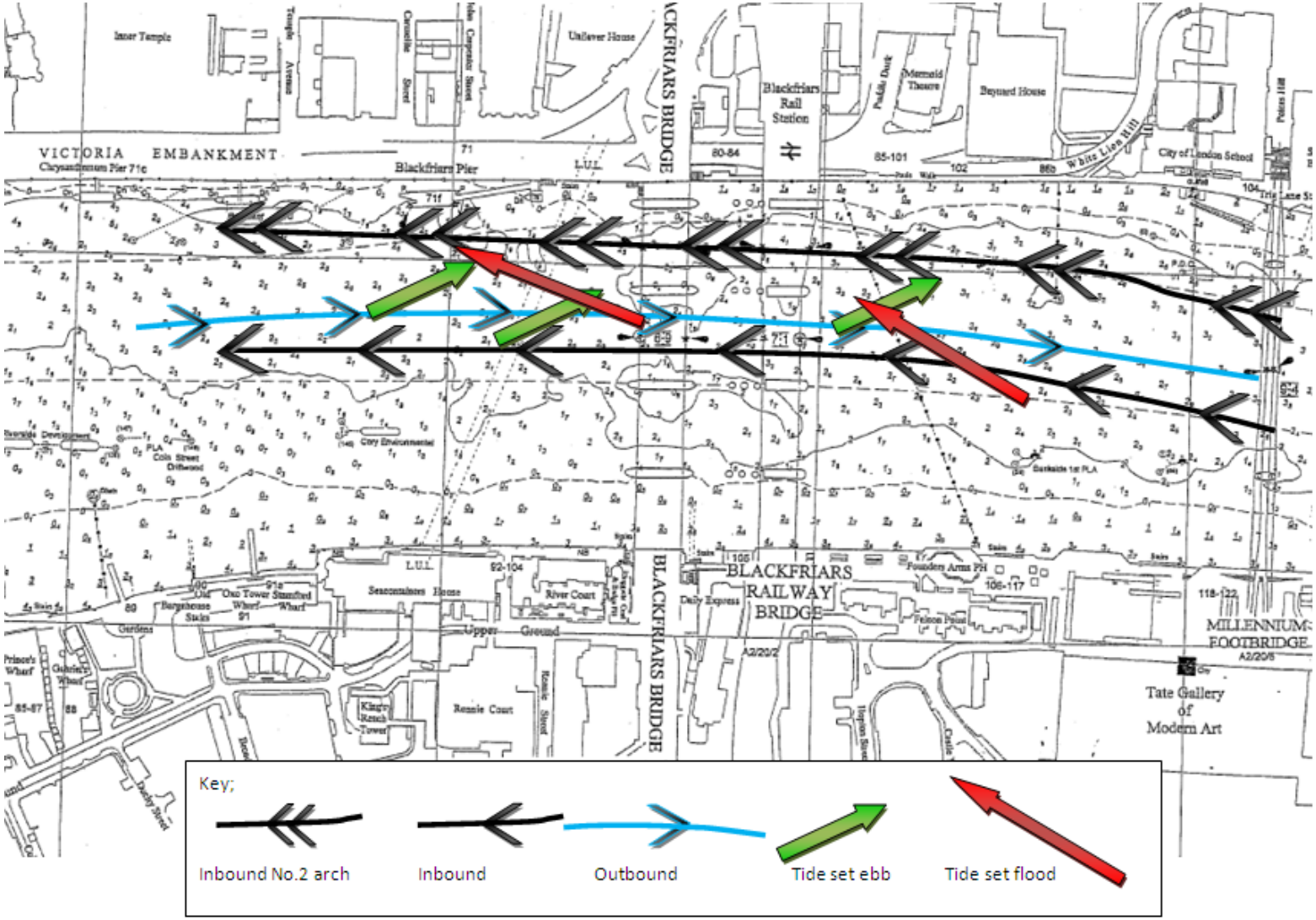
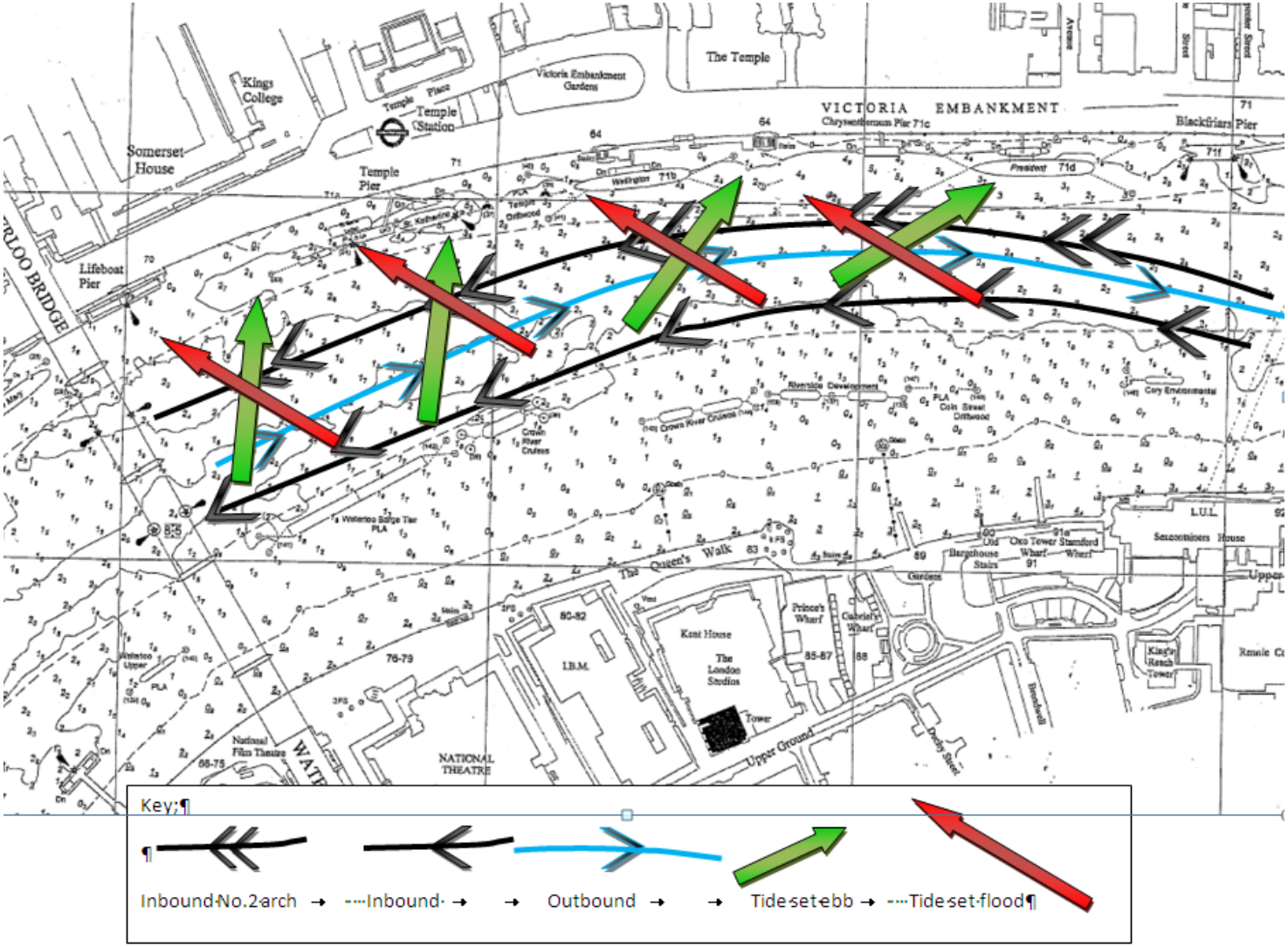


**Figure E.3 Waterloo Bridge tide set**



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