



Nine Elms - Pimlico bridge Feasibility study summary report

Final version

December 2013 (minor revisions November 2014)

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Executive Summary

This report summarises the results of feasibility work undertaken on the proposed Pimlico – Nine Elms pedestrian and cycle bridge. This feasibility work was carried out in three stages, covering location and landing concepts, demand and key planning/environmental issues, and the engineering requirements and business case.

A number of alignment options have been considered, however at this stage there is no clear consensus amongst key stakeholders about which option should be pursued. Regardless of which option is pursued, careful consideration will need to be given to environmental, planning and heritage issues associated with the main bridge span and landings on both banks of the river.

Results of the studies indicate that a bridge in this stretch of the Thames appears feasible in engineering and construction terms. The large distance between existing bridges in this location (relative to others in central London), combined with new demand generated by the development of the Vauxhall Nine Elms Battersea Opportunity Area, means that there is a high potential demand for the crossing.

Nonetheless there are some significant issues to be resolved around bridge location and landings. Potential demand will be significantly tempered by the bridge design and the likely need for stairs and lifts, which are required to provide the navigational clearance necessary to provide safe clearance for river traffic. Initial work suggests that achieving ramps on both banks is likely to be difficult due to the height of the bridge structure.

Construction cost estimates suggest that the cost of a bridge serving the centre of the Opportunity Area could be in the region of £40 million (current prices), based on either a tied arch or cable stayed structure accessed at both ends via stairs and lifts. These costs are based on concept designs and there may be scope to design a lower cost structure once more information about the location is known.

Next steps could include public consultation and the launch of a design competition in order to identify the optimum design for a bridge structure in this location.

1. Introduction

Transport for London (TfL) has undertaken a feasibility study into the potential for a new pedestrian and cycle bridge across the River Thames between Chelsea and Vauxhall bridges, working in conjunction with the London Boroughs of Wandsworth and Lambeth, Westminster City Council, the Nine Elms Delivery Team, the GLA and key developers. This report summarises the feasibility study.

The bridge would link the established residential area of Pimlico on the north bank with Nine Elms on the south bank, an area currently undergoing significant transformation.



Figure 1: Location plan

The feasibility study was completed between September 2012 and December 2013. A working group has been established to guide and inform the feasibility work, comprising representatives from the organisations listed above. This group has met at key stages in the study’s development and has been instrumental in gaining a good understanding of the issues associated with a scheme of this type and within this location.

Should a decision be made to progress with the bridge scheme, the feasibility study will represent a foundation on which further, more detailed planning work can be based.

2. Background

The concept of a pedestrian and cycle bridge in this location was first identified in the Cross River Partnership Vauxhall Battersea Development Framework (2003) as a way to improve cross-river connectivity, and again in 2009 in a transport study completed to inform the Vauxhall Nine Elms Battersea (VNEB) Opportunity Area Planning Framework (OAPF).

In 2012, the proposal was adopted as a key part of the VNEB OAPF. The incumbent Mayor of London made also made a manifesto pledge to:

‘examine whether there is demand for a new pedestrian river crossing, potentially between Vauxhall and Chelsea bridges as part of the Vauxhall Nine Elms development at Battersea, financed out of private funds.’

The OAPF and the Mayor’s manifesto pledge have been key drivers in this feasibility work.

2.1. Vision for Nine Elms

The OAPF envisages the delivery of a high density mixed use development comprising 16,000 new homes and up to 25,000 jobs. Development will be phased over a number of years, with construction underway and completion due in the early 2030s.

The bridge is identified within the OAPF as one of a number of transport schemes necessary to support this high level of growth, alongside such schemes as an extension of the Northern line to Battersea with two new Tube stations, enhanced bus services, improvements to National Rail stations, new passenger piers at Vauxhall and Battersea Power Station, pedestrian and cycle walkways, and new Barclays Cycle Hire docking stations.

The bridge therefore represents one of a package of measures to support the redevelopment of the Opportunity Area and enable a significant increase in population and employment to be realised. A brochure produced in summer 2013 providing an update on development plans for the area and how the bridge could contribute to these is attached as **Appendix A**.

2.2. Objectives of the scheme

The primary objective of a new bridge is to improve connectivity to and from the VNEB Opportunity Area, improving access to jobs, homes, leisure opportunities and transport links in this part of the Central Activities Zone. It will improve access by foot and cycle for residents living north of the river to the jobs and leisure opportunities generated in the Opportunity Area (OA).

Further objectives of the scheme are as follows:

- Increased mode shift from motorised modes of transport to walking and cycling, by reducing journey times and providing a new link
- Underpin the growth and regeneration foreseen in the VNEB Opportunity Area by providing increased transport capacity and an ‘image boost’ which instils confidence that the area is developing in a progressive manner
- Provide a better journey experience to many pedestrians and cyclists who currently have to use either Chelsea or Vauxhall bridge (shared with motorised traffic)
- Make a positive contribution to the urban realm in the area by encouraging local area movement and legible, high quality public spaces

A new crossing in this location would contribute towards the delivery of a number of policies and proposals in the Mayor's Transport Strategy (MTS) and the London Plan including:

- MTS Challenge: Improving transport connectivity
- MTS Challenge: Improving accessibility
- MTS Proposal 60: Providing safe, comfortable and attractive environments for pedestrians
- London Plan Policy 6.4: Enhancing London's transport connectivity
- London Plan Policy 6.9: Improving conditions for cyclists
- London Plan Policy 6.10: Improving conditions for pedestrians

3. Approach to the feasibility study

In order to ascertain whether a new bridge between Nine Elms and Pimlico is achievable in engineering terms and support by sufficient demand, a certain level of feasibility work has been required. Building on the pre-feasibility study completed in June 2012, a pragmatic approach has been taken to completing this work, with the study split into three separate but related stages. These three stages are outlined below:

Stage 1 – Location and landing concepts

This stage considered a total of five alignment potential options between Pimlico on the north bank and Nine Elms on the south bank. Two preferred options were identified as being most feasible (Options 1 and 2), for which further consideration was given to landing arrangements. This stage comprises the following reports:

- Location and landing concepts study – Buro Happold and J&L Gibbons – January 2013

Stage 2 – Demand and key planning / environmental issues

The second stage focussed on the theoretical demand for a new crossing. Initial environmental and heritage assessments were also completed, focusing on the two preferred options identified in Stage 1. This stage comprises the following reports:

- Walk and cycle demand analysis – Steer Davies Gleave – June 2013 (updated November 2013)
- Initial planning and environmental assessment – TfL – April 2013
- Initial heritage assessment – TfL – December 2012
- Archaeological assessment – Mott MacDonald – April 2013
- Arboricultural assessment – Hyder – February 2013

Stage 3 – Engineering requirements and outline business case

Stage 3 considered the key engineering requirements and constraints that would need to be considered in the design of any new bridge, and a high level business case was produced based on demand outputs derived from Stage 2. Two bridge concept designs were developed to assist in identifying the constraints and parameters associated with the two preferred options, and to demonstrate how these could be addressed.

Further work was also undertaken on the merits of alignment Option 4, which would run adjacent to Grosvenor Railway Bridge. This stage comprises the following reports:

- Engineering requirements and constraints – Buro Happold – October 2013 (minor revisions to this report were made in November 2014)
- Outline business case – Parsons Brinckerhoff – November 2013
- Further consideration of Option 4 – TfL – November 2012

Within this summary report, where further information is available within the reports listed above this is clearly signposted in the following manner (example):

See Stage 3 Engineering requirements report, Inclusive Design section, for further information.

4. Location options considered

4.1. Initial options considered

See *Stage 1 Locations and landing concepts study* for further information.

Stage 1 of the study identified a total of five potential alignment options between Chelsea and Vauxhall bridges. These alignment options were identified principally based on the availability of bridge landing opportunities on the north and south banks of the river.

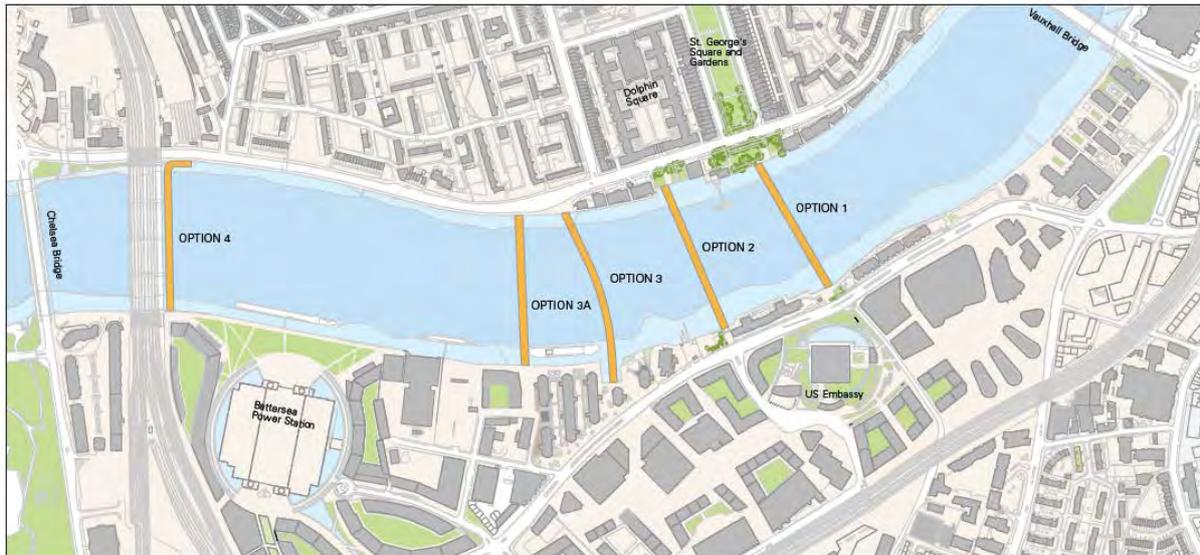


Figure 2: Alignment options

An initial options assessment was undertaken by the project team, and each option was scored against a range of key engineering and design aspects likely to affect the feasibility of constructing a new bridge in this location. These options are summarised below:

- Option 1 Nine Elms Riverside (US Embassy / Embassy Gardens) to Pimlico Gardens
Option 1 scored highest in the initial options assessment. Adequate space exists on both sides of the river for landing points and the alignment has the potential to link into both existing communities on the north and those emerging on the southern side.

- Option 2 Nine Elms Riverside to Pimlico Riverside (Dolphin Square)
This option scored second highest. Adequate space exists for landing sites and the alignment has potential to maximise connectivity for nearby communities.

- Options 3 & 3a Nine Elms Pier to Grosvenor Road / Churchill Gardens
Both options scored lowest in the initial options assessment, due primarily to insufficient landing space on both banks and were not progressed for further feasibility work.

- Option 4 Battersea Power Station to Grosvenor Road (Grosvenor Rail Bridge)
This option scored positively but was not initially progressed due to its location at the far west of the VNEB Opportunity Area. It was originally proposal that this structure be attached to the existing rail bridge, but Network Rail has indicated that any bridge would need to be structurally independent. Landing options are constrained by plans for nearby development and pre-existing buildings.

Options 1 and 2 were subsequently identified as the “most feasible”, and were progressed for further, more detailed feasibility work as the preferred options. Option 4 was identified as a cycle-only bridge, with the potential to be developed as a scheme in its own right at a later stage. However, this was considered as a complimentary measure rather than an alternative to the two preferred options.

4.2. Further options considered

Since the initial options assessment was undertaken, three further alignment options have been identified by stakeholders. These further options are summarised below:

- Option 4a Battersea Power Station to Grosvenor Road
In recognition of the constraints associated with the bridge landings for Option 4, an alignment approximately 50m to the east of Grosvenor Railway Bridge has been proposed. Such an option could potentially serve to reduce the numbers of bridge users routeing through the Pimlico area.

- Option 5 Nine Elms Riverside to Pimlico Gardens
This option utilises the southern landing site of Option 2, and the northern landing site of Option 1. Due to its greater length and span, the cost and technical difficulty associated with Option 5 is greater than for other proposed alignments.

- Option 6 Nine Elms Riverside to Grosvenor Road
Option 6 utilises the southern landing site of Option 2, but its northern landing lies further east on Grosvenor Road. The high cost and technical difficulties associated with the Option 5 bridge also apply to Option 6.

Options 5 and 6 are not deemed to be feasible, and have not been taken forward for further feasibility work. Option 4a has not been considered in detail but could potentially be feasible. This option may be worthy of further feasibility work going forward.

See **Appendix B** for further information on the advantages and disadvantages all of the alignment options considered, including the initial views of key stakeholders.

4.3. Focus of the feasibility study

Stages 2 and 3 of the feasibility study have focussed on Options 1 and 2, and the majority of feasibility work has been completed on these options. Following requests from stakeholders, further consideration has also been given to Option 4, however this has been considered in less detail. The following sections of this summary report are therefore focused on a bridge in alignment option 1, 2 or 4.

5. Potential demand

See Stage 2 Walk and Cycle Demand Analysis report for further information.

5.1. Walking and Cycling Demand

Demand analysis suggests that there is a high potential demand for a bridge in the Option 1 alignment. Due to the close proximity of Option 1 and Option 2 similar levels of demand are expected at either location.

Based on the results of this analysis, by 2031, when the development of the Opportunity Area is complete, the daily theoretical demand could be in the region of 9,000 pedestrians and 9,000 cyclists in total for both directions (i.e. both northbound and southbound trips). This is based on a number of assumptions, including that the new bridge will be at least as convenient to use as Chelsea and Vauxhall bridges, cyclists will be able to use the bridge without dismounting at either side, the Mayor's cycling targets will be met and the VNEB Opportunity Area will be developed in line with the plans outlined in the OAPF.

This level of demand, if it were to be realised, would make a bridge in this location the 8th highest used pedestrian crossing and the 6th highest used cyclist crossing in London all other things remaining equal.

This demand is expected to come mainly from trip diversion from Vauxhall and Chelsea bridges. In addition, there will be generation of new trips to and from the new jobs, homes and leisure opportunities that will be created in the Opportunity Area. The composition of demand is as follows:

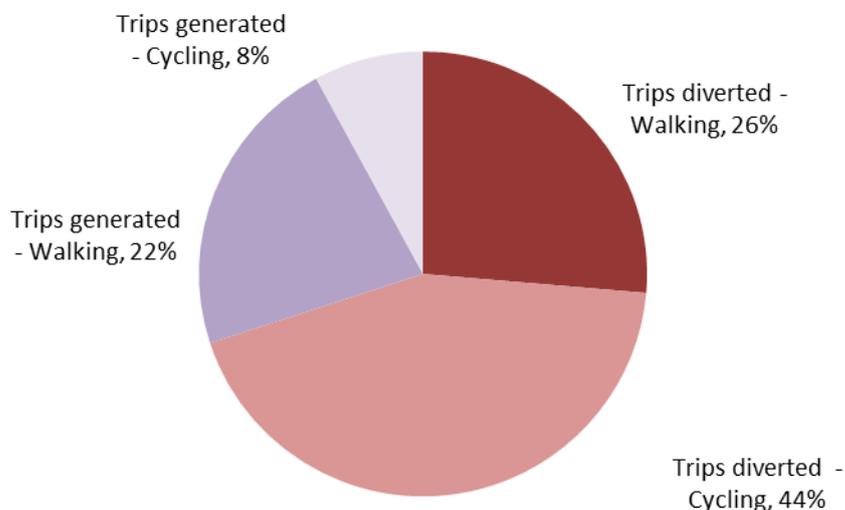


Figure 3: Expected composition of demand

Trip diversion is expected to make up around two thirds of total demand for the new bridge. This is partly a reflection of the large distance between Chelsea and Vauxhall bridges (1.8km) relative to other central London bridges (600m average). This is supported by surveys of walking and cycling trips across Vauxhall Bridge and Chelsea Bridge (carried out in late summer 2013), which suggest that a new bridge in the Option 1 alignment would be on the desire line of (and therefore potentially of

benefit to) a large number of existing users of Chelsea and Vauxhall bridges. The origin points of walking and cycling trips across these bridges, based on these surveys, can be seen in **Appendix C**.

It should be noted that in practice the number users is not expected to match the theoretical demand. Given recent work into the engineering constraints which indicate that stairs and ramps are likely to be required to access the bridge deck (see Section 7), the level of usage will be lower, particularly for cyclists. Once information about the design of any new bridge is known, further work will be required to determine the impact that this design could have on level of use and the provision that should be made for cyclists. Nonetheless the fact remains that there does appear to be a high level of theoretical demand for a new bridge in this part of London.

Demand for a bridge in the Option 4 alignment is likely to be significantly lower than Options 1 and 2 for walk and cycle trips. This is due to its position at the far western end of the VNEB OA and its greater distance from Vauxhall Bridge.

5.2. Accessibility

A bridge in the Option 1 and 2 alignment would improve walk and cycle access between a number of popular destinations. From the new US Embassy in Nine Elms (currently under construction), for instance, Victoria Station and Westminster Cathedral could be reached on foot in around 20 minutes compared to around 30 minutes currently.

The position of Option 4 at the western end of the Opportunity Area means that walk and cycle time to some destinations such as Pimlico station would be higher than in Options 1 and 2. However, an alignment in this location offers the opportunity to tie into future redevelopment of Victoria Railway Sidings, potentially benefitting from a direct link north through to Victoria Station in future.

5.3. Walk and Cycle Audit

Should the bridge be implemented, a number of new trips will be generated and levels of walking and cycling close to the landing points in Pimlico and Nine Elms will increase. To assess current provision for walking and cycling in Pimlico on the north bank, where the neighbourhood is already established, a walk and cycle audit was undertaken in the vicinity of the Option 1 and 2 landing points.

Across the area the great majority of links most likely be used by pedestrians and cyclists are considered to be adequate for accommodating increased use. Appropriate opportunities for improving conditions have been identified, including through the provision of wayfinding and Legible London signage.

6. Planning issues

6.1. Consents

See Stage 2 Initial Planning and Environment Assessment report for further information.

There are two planning consent routes available: the submission of two separate planning applications under the Town and Country Planning Act to Westminster City Council (WCC) and the London Borough of Wandsworth (LBW), or the submission of a Transport and Works Act Order (TWAO) to the Secretary of State for Transport. A TWAO would allow all necessary consents to be sought as part of the order, along with any necessary compulsory purchase powers, but the submission and decision process is likely to be longer and more costly than a planning application.

It is recommended that a Screening Opinion is sought to determine if the development would require a full Environmental Impact Assessment (EIA) or a comprehensive environmental report.

A number of documents are likely to be required to support any submission, including a Planning, Design and Access Statement; Navigational Impact and Risk Assessment, and Flood Risk Assessment. Further discussion with the local planning authorities and other agencies will be required to determine what further consents may be required, such as a Marine License (Marine Management Organisation), River Works License (PLA), Flood Defence Consent (EA) and Conservation Area Consent (Local Planning Authority).

6.2. Land Ownership

The land ownership on the north and south banks for Options 1, 2 and 4 has been identified as follows:

	North bank freehold	South bank freehold
Option 1	City of Westminster	London Borough of Wandsworth and Elm Quay Freehold Limited
Option 2	Friends Life Limited	London Borough of Wandsworth and Elm Quay Freehold Limited
Option 4	Network Rail and Peabody Trust	Battersea Project Land Company Limited

Table 1: Land ownership

6.3. Heritage

See Stage 2 Initial Heritage Assessment report for further information.

Option 1 was assessed as having the greatest potential to enhance the local heritage given its alignment with St George's Square on the north bank and far greater connectivity with Pimlico and Victoria than Option 2 which lands opposite the impenetrable Dolphin Square.

Although there are a number of heritage and design issues to be addressed in both locations, the heritage assessment concludes that a sensitively designed, slender bridge could be a positive addition to the riverscape, enhancing this stretch of the Thames and opening up views to historic landmarks such as the power station, Vauxhall Bridge, Dolphin Square, and the 19th century Pimlico townscape.

Potential heritage impacts have not been assessed for Option 4.

6.4. Archaeology

See Stage 2 Archaeological Assessment report for further information.

A desk based Archaeological Assessment concluded that there is potential for archaeological deposits to be present within both option sites, and recommends that investigation be undertaken to determine their presence (or otherwise). This would most likely be in the form of an archaeologist monitoring the geotechnical ground investigation works. If this shows the presence of - or a high potential for - archaeologically significant deposits, there may be a requirement for mitigation in the form of excavation prior to the start of construction or monitoring during groundworks.

6.5. Arboriculture

See Stage 2 Arboricultural Assessment report for further information.

A Tree Report and Impact Assessment found high value trees located in close proximity to both options. It concludes that Option 2 is the most favourable terms of impact on trees, and with appropriate design should have a negligible impact. Option 1 would require far greater planning, design and implementation measure to avoid negative impacts on high-value trees at its north landing site in Pimlico Gardens. Due to changes in bridge design since the initial tree report, it is recommended that further investigation be undertaken, including trial excavations at both locations to help confirm predicted impacts.

An arboricultural assessment was not carried out for Option 4.

6.6. Ecology and Biodiversity

See Stage 2 Initial Planning and Environmental Assessment report for further information.

The extent of in-river structures and the loss of inter-tidal habitats should be minimised under the proposed design, in keeping with other recent river crossing planning applications. Any loss of inter-tidal mudflats will have to be mitigated, either by like-for-like replacement or financial compensation, and this mitigation will need to be agreed with the EA, Natural England (NE), the PLA and the MMO.

It is recommended that further assessment is undertaken, including a desk based assessment and potentially marine and terrestrial surveys. Early discussions with the EA, MMO, PLA and NE are also recommended to help determine the extent of environmental assessment required.

7. Engineering issues

See *Stage 3 Engineering requirements report for further information.*

In order to fully understand the engineering issues associated with constructing a new bridge in this reach of the River Thames, including the key constraints and parameters that need to be taken into account, various discussions with stakeholders and surveys have been undertaken. Two bridge concepts were developed also for the Option 1 and 2 alignments, partly to demonstrate how these constraints and parameters could potentially be addressed. A bridge concept design has not been developed for Option 4. These concepts – an arch structure for Option 1 and a cable stayed structure for Option 2 – were also used as a basis for obtaining advice on construction methodologies and estimating costs.

7.1. Concept designs

Option 1: Arch Bridge

A single tied arch, 152m bearings to bearings with suspended deck. This option requires two piers to be constructed in the inter-tidal zone, approximately 15m from the riverbanks.

Option 2: Cable Stayed Bridge

Single large mast adjacent to South Bank with a cable supported deck. This option requires a single pier to be constructed in the river, approximately 60m from the south bank below mean low water spring level.

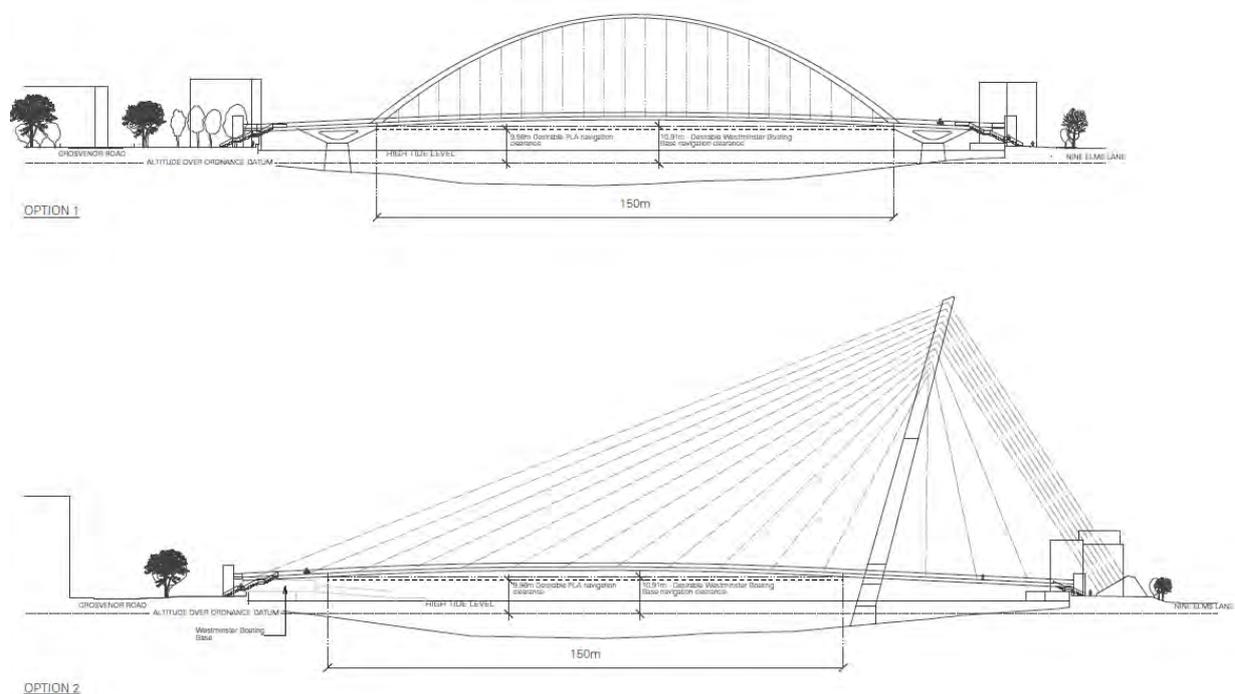


Figure 4: Designs for Option 1 (top) and Option 2 (bottom)

7.2. Stakeholder requirements

See Stage 3 Engineering requirements report, Stakeholders and Consultation section, for further information.

Port of London Authority

The PLA's desirable navigation zone is 150m wide and 12.4m above Chart Datum (9.96m above ordnance datum). Bridge piers are permitted to be located outside of this zone. Consultation with the PLA is ongoing, including on the scope to reduce the 150m navigation zone and/or shift the navigation zone laterally north or south. The construction programme for the bridge will also need to consider barge activity associated with the Northern line extension and Thames Tideway Tunnel (TTT).

Westminster Boating Base

In order to enable Westminster Boating Base (WBB) to sail boats underneath the bridge at high tide, a 7m navigational clearance above Mean High Water Springs (10.91m above ordnance datum) is required. In terms of location, WBB's first preference for Option 1 would be to move the pier south in line with the WBB pontoon and extend the pontoon to link with it, with a second preference to move the pier and extend the pontoon without physically linking them. Any linking of the pier and pontoon without moving the pier is felt not feasible. Both of these options require a reduction in the PLA's 150m navigation zone. WBB's third preference would be to extend the pontoon without relocating the pier. Relocating the buoys would be of no practical use to WBB.

The only solution for Option 2 that would not affect WBB's operations would be to have no intervention to the west of the base.

Further consultation would be required with Westminster Boating Base to determine potential impacts should Option 4 be chosen as the preferred bridge location.

Cory Environmental

Cory Environmental's fixed barges would need to be relocated to allow construction for Option 1. Further consultation will be required with Cory Environmental if the project moves forward

Thames Water

Construction of the TTT is scheduled to occur from 2016 - 2020, and will require a large amount of spoil transported by barges in the same reach of the Thames as the proposed bridge. Constructing a bridge foundation above the TTT would incur significant cost. It is assumed that the foundations are to be outside the limits of deviation of the tunnel. It is likely that the detailed design of any new bridge will need to be approved by Thames Water.

Environment Agency

The EA have expressed a preference for Option 4 due to its potentially lower impact on the river environment. However as long as a bridge at an alternative location did not unduly impact on the river environment, and appropriate environmental mitigation measures were included, it is likely that the EA be supportive overall given the sustainability benefits of walking and cycling.

7.3. Inclusive design

See Stage 3 Engineering requirements report, Inclusive Design section, for further information.

The bridge must place users at the heart of its design process, adhering to the highest standards of accessible and inclusive design, and it is recommended that consultation with disabled people be used to inform the planning and design process. Segregation of shared facilities may be used to increase the sense of safety, user confidence and user comfort. Where practical, different surface

textures should be used to aid visually impaired users on segregated footways. Surfaces should be firm, durable and slip resistant with consistent frictional characteristics. Visual contrast should be used to indicate level differences.

Gradients should be as shallow as possible, preferably less than 1:21, on the bridge deck itself no steeper than 1:20 and on ramps no steeper than 1 in 12. However, this means that flight lengths and traverse distances increase because of the added distance required.

Lifts should be provided in pairs to ensure resilience. Lift sizes should be determined by traffic flow, with an initial minimum of Type III (1400 x 2000mm) lifts recommended pending further work.

7.4. People and cycle movement

See Stage 3 Engineering requirements report, People and Cycle Movement section, for further information.

Bridge Width

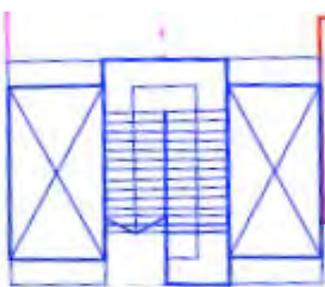
Based on the Stage 2 Demand Analysis bridge widths providing different levels of comfort have been considered. These widths exceed the minimum widths of shared paths as given in the Department for Transport Local Transport Note 2/86 'Shared Use by Cyclists and Pedestrians'.

Total width	Walkway	Cycle path	Level of Service	Description
5-7 m	2-4 m	3 m	C+	Environment becoming increasingly uncomfortable, with the majority of people experiencing conflict or closeness with others and bi-directional movement becoming difficult.
7-8 m	3-4 m	4 m	B	Good level of service. Enough space for normal speed with some conflicts.
9 m	4 m	5 m	A-	Environment is very comfortable with plenty of space for people to move at their chosen speed.

Table 2: Bridge widths considered

Bridge End Connections

Three possibilities for the connection of the bridge to the existing infrastructure were proposed.

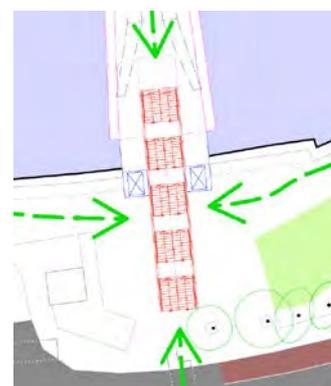


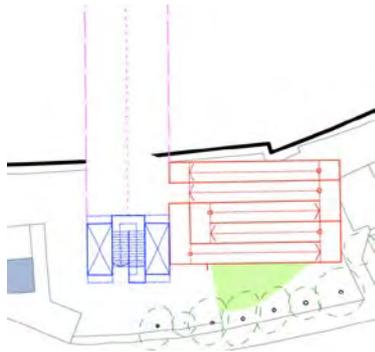
Connection 1 provides a staircase and two lifts. The lifts have doors at the front and back to allow easy through flow. The staircase is broken into flights which switch back onto themselves.

It is estimated that a large percentage of cyclists would choose to use other bridges if faced with this option, and this was not adopted by the engineering requirements report.

Connection 2 also provides a staircase supported by two lifts. In this scenario the staircase is linear, with wheeling ramps on each side running the full length of the stairs.

This connection may have a conflict at the top of the stairs should the cycle lanes be included in the middle of the bridge. This may need to be addressed with pavement marking/signage. This connection option was adopted by the engineering requirements report.





Connection 3 combines a staircase and lifts, with the opportunity of including a ramp. It is assumed the most pedestrians and some cyclists would use the lift or stairs, with the remaining cyclists using the ramp. This has a lot more user resilience than connections 1 or 2, but due to the requirement for space it was not adopted by the engineering requirements report.

Lift and Stair Capacity

The following table shows lift capacity and remaining demand using stairs/ramp, assuming that half of the lifts are used by pedestrians and the other half by cyclists. If the remaining demand was split equally between bridge ends this would give a cyclist headway of 3.5 seconds (feasible, although very congested) and a pedestrian headway of 12 seconds (a good level of comfort).

	Pedestrians	Cyclists
Total lift capacity per hour	990	300
% of peak demand	66%	13%
Remaining peak demand using stairs/ramp	600	2050

Table 3: Lift capacity and remaining demand

Further detailed analysis is required to confirm that the suggested capacities are adequate to meet demand. Further work could consider the predicted demand given different levels of comfort, the effect of wide stairs with large landings and the effect of escalators and mechanical wheeling ramps.

7.5. River & flood risk issues

See Stage 3 Engineering requirements report, River and Flood Risk Issues section, for further information.

Flood Risk Management

The EA expressed a preference for Option 4, as this would pose the least impact to flood risk. The EA's preference is for one hydraulic efficient pier located on the north inside bend perpendicular to river flow. Surface run-off from the bridge deck should be discharged directly to the river, and a full flood risk assessment should be carried out to support the bridge planning application.

The bridge should allow for raising the existing river wall flood defences in line with the EA's proposals under Thames Estuary 2100 (5.85m AOD by 2065, 6.35m AOD by 2100). It is recommended that the bridge pass over the flood defence wall at least 7.1m AOD for ease of future inspection and maintenance. The EA would support raising the height of the flood defences as part of the bridge works, and may propose a planning condition stipulating this.

Ecology & Environment

The EA prefer Option 4, as it would pose the least threat to environment and ecology. The EA have requested that any pier(s) is located in the tidal zone, as the intertidal zone is the most ecologically rich part of the river bed. The EA will require mitigation for any loss of habitat. The EA's favoured mitigation is the creation of tidal terraces, with timber fencing where tidal terracing is not appropriate. Light spill from the bridge should be limited and spill onto the river should be avoided.

Piling and dredging works during construction are likely to be carefully controlled and conditioned by the EA.

Consents, Licences & Approvals

The following table summarises the approval requirements for river works:

Stakeholder	Title	Determination	Comments
EA	Flood Defence Consent	8 weeks	FDC is required for all works within, above and below 16m of the flood defence line. FDC is required for all temporary and permanent works. It should be assumed that FDC application should be made to both North Thames and South Thames EA offices.
PLA	River Works License	3 – 4 months	Required for all permanent and temporary works within river channel.
	Notice to Mariners	4 weeks	It should be assumed that Notice is required for all temporary and permanent works within the river channel regardless of whether they are outside of the prescribed 150m navigation corridor.
	Capital Dredge Consent	3 – 4 months	Required for all dredging works. ¹
MMO	Marine License	No prescribed consenting period	A marine licence is required for any activities involving a deposit or removal of a substance or object below the mean high water springs mark or in any tidal river to the extent of the tidal influence.

Table 4: Approvals required for river works

This is not an exhaustive list and should continue to be reviewed. In addition to specific consents, licences and approvals for river works, there will be other requirements as part of the planning works, including Flood Risk Assessment, Water Framework Directive and Environmental Impact Assessment.

7.6. Geoenvironmental and Geotechnical Considerations

See *Stage 3 Engineering requirements report, Geoenvironmental and Geotechnical Considerations section, for further information.*

The TTT will run under the southern side of the river with its tunnel crown at -35m OD. A services search must be commissioned that will confirm the location of all the services in the areas where foundation construction is to take place.

Based on a Preliminary Risk Assessment, it was deemed unlikely that the site could meet criteria for Contaminated Land under Part 2A of the Environmental Protection Act 1990. The risk of encountering an UXO is considered to be moderate, and it is recommended that health and safety measures are put in place for the ground investigation and during its implementation.

Geotechnical Assessment

The ground profile is typical for central London with the following notable differences:

- Foundations remaining from historical development along the river banks
- Fluctuating groundwater table in the river banks
- Scour, or drift filled hollow to the south east side of the site area
- Thames Tideway Tunnel

¹ Dredging works within the Thames are prohibited between 1st March and 31st October.

These could all have an effect on foundations for the bridge, and require focussed ground investigation and/or enabling groundworks.

Geoenvironmental Risk Assessment

Potential risks to construction and maintenance workers are assessed as Moderate / Low. Appropriate Health and Safety precautions and personal protective equipment would provide reasonable mitigation.

Potential risks to site users and off-site neighbours associated with the various contaminants are assessed as Moderate / Low. This reflects the nature of potential contaminant sources (Made Ground) and also the limited potential for exposure. This primarily relates to the accumulation of ground gas / vapours within enclosed spaces.

Potential risks to groundwater are assessed as Low. This reflects the nature of potential contaminant sources, the shallow depth to groundwater but also the sensitivity of this receptor (Secondary Aquifers are in hydraulic continuity with the site, no hydraulic continuity with local public water supply abstractions due to presence of London Clay).

Proposed Ground Investigation

Further ground investigation is recommended, with detailed recommendations given in the Stage 3 Engineering requirements report, Section 8.7.

7.7. Surveys

See Stage 3 Engineering requirements report, Surveys section, for further information.

A topographical survey was used to identify critical levels and constraints for Options 1 and 2. A utilities search was also carried out to check how utilities could affect the design and construction of the bridge. UK Power Network confirmed the location of a 132kV high voltage electricity tunnel under the Thames. This would form a potential constraint to the location of foundations at the south end of Option 2.

7.8. Parameters and constraints

See Stage 3 Engineering requirements report, Parameters and Constraints section, for further information.

The constraints and parameters identified are summarised in the following table.

Ref.	Description	Constraint/ Parameter	Origin	Further Information	Option 1 / Option 2	Contradictory Constraints	Contradiction Explanation
Navigation							
1.0	Navigation Height	12.4m Above Chart Datum. (9.96m AOD)	Port of London Authority	Clear over full navigation width	1 & 2	-	-
1.1	Navigation Width	150m.	Port of London Authority	Centre of zone TBC	1 & 2	3.6 & 5.1	See Below
1.2	Middle Wharf	No close proximity construction	Port of London Authority	Protected working Wharf	2 only	5.1	See Below
1.3	Navigation Height	7m above MHWS (10.91 AOD)	Westminster Boating Base	Clear over full navigation width	1 & 2	-	
User							
2.0	Bridge deck gradient	< 5%	Ch 5 Inclusive Design: Stage 3 Feasibility Report.		1 & 2	-	-
2.1	Feasible Bridge deck widths	4m cycle and 2 separate 2m pedestrian.	Ch 6 People and Cycle Movement: Stage 3 Feasibility Report.	The constraint shown is for a good level of comfort.	1 & 2	-	-
2.2	Feasible linear stair width	3m for pedestrian use only. 6m for combined used.	Ch 6 People and Cycle Movement: Stage 3 Feasibility Report.	This will cater for the predicted bridge demand.	1 & 2	-	-
2.3	Feasible lift size	33 person	Ch 5 Inclusive Design & Ch 6 People and Cycle Movement: Stage 3 Feasibility Report.		1 & 2	-	-
Environment							
3.0	Bridge Piers	Preference of one pier	Environment Agency		1 & 2	-	-
3.1	Bridge Piers	Single pier to be located on North side	Environment Agency		1 & 2	5.1	See below
3.2	Pier Alignment	Normal to river flow	Environment Agency		1 & 2	-	-
3.3	Pier Design	Hydraulic Efficient	Environment Agency		1 & 2	-	-
3.4	River Wall Height	6.35m AOD	Environment Agency	The walls will be increased to this height by 2100	1 & 2	-	-
3.5	Clearance above River Wall	Recommended 750mm	Environment Agency	Bridge soffit over wall is recommended 7.1m AOD	1 & 2	-	-
3.6	Pier Location	Intertidal Zone	Environment Agency	Zone below the low water line.	1 & 2	1.1	PLA require 150m navigation width

Ref.	Description	Constraint/ Parameter	Origin	Further Information	Option 1 / Option 2	Contradictory Constraints	Contradiction Explanation
3.7	Mature and Protected Trees	Location or bridge approaches	Borough Councils		1 & 2	-	-
3.8	Conservation Area	North Bank	City of Westminster		1 & 2	-	-
3.9	Pimlico Gardens	Option 1 north landing	Westminster City Council	Potential impact on public open space	1		
Utilities							
4.0	132 kV Tunnel	Impact on foundations	Ch 9 Surveys: Stage 3 Feasibility Report.	Further consultation required	1 & 2	N/A	N/A
4.1	Thames Tideway Tunnel	Foundations outside of the limit of deviation	Thames Water	Foundations above tunnel are possible with detailed coordinated design with Thames Water.	1 & 2	1.1	PLA required 150m navigation width. Option 2 requires foundations north of the TTT which shifts the centre of the 150m zone.
Stakeholders							
5.0	North Pier	Feasible for Option 1 only.	Westminster Boating Base.	Stops the WBB river activities	2 Only	3.1	EA prefer north pier locations.
5.1	North Pier	In line with the existing pontoon	Westminster Boating Base	Increases safety of WBB river activities.	1 Only	1.1	PLA required 150m navigation width
5.2	Residential Views	Maximise distance from properties	Consultation		1 & 2	N/A	N/A

Table 5: Parameters and constraints

Parameter and Constraints Contradictions

The following parameters and constraints are in conflict with each other:

- PLA's 150m navigation zone and EA's desire for no pier(s) in the inter-tidal zone
- WBB's preference for no pier on the north bank to the west of their buildings conflicts with EA's desire for pier(s) to be on the north bank where possible
- WBB's preference for no pier on the north bank to the west of their buildings combined with the southern location of the TTT make it difficult to provide PLA's requested 150m navigation zone without constructing a single span structure
- The future working nature of Middle Wharf restricts the construction of a pier in close proximity, which conflicts with WBB's preference for no pier on the north bank to the west of their buildings unless constructing a single span structure

Option 1 Constraints

The critical levels of adjoining topographical features are given in the following table:

Location Option 1	Average Height Above Ordnance Datum (m)
Top of the river wall on the north bank	5.82m to 5.83m
Top of the river wall on the south bank	5.88m
River bed level adjacent to the north river wall	0.00m
River bed level adjacent to the south river	1.00m
Ground level on the north bank	4.43m
Ground level on the south	4.70m

Table 6: Option 1 topographical constraints

Option 2 Constraints

The critical levels of adjoining topographical features are given in the following table:

Location Option 2	Average Height Above Ordnance Datum (m)
Top of the river wall on the north bank	5.82m to 5.83m
Top of the river wall on the south bank	5.61m
River bed level adjacent to the north river wall	2.04m
River bed level adjacent to the south river	2.20m
Ground level on the north bank	5.07m
Ground level on the south	4.17m

Table 7: Option 2 topographical constraints

7.9. Landing and access

See Stage 3 Engineering requirements report, Bridge Landing and Access Study section, for further information.

The need for a navigational 'box' of 150m x 10.91m AOD in order to meet PLA and WBB requirements results in a bridge deck approximately 6m above the adjacent ground level, given 1:21 ramping of the bridge deck ends. These constraints would result in long ramps, leading to increased pressure on lifts. Ramps would have a large footprint and considerable visual impact. For the Option 1 and 2 southern landing sites, as well as Option 2 northern landing site, this may have an unacceptable impact on adjacent buildings and their views.

Due to the height of the bridge deck, stairs of around 30 steps with a minimum width of 4m and a generous mid-level landing will be required. This represents a substantial structure. Cycle tracks integral to the stairs should be provided for cyclists, and cycle lifts or escalators could also be considered, subject to space requirements.

A minimum of two lifts would be required to ensure resilience, and large non-standard lifts may be required. It is expected that pressure on lift space will largely come from cyclists.

7.10. Connection to local transport network

See Stage 3 Engineering requirements report, Connection to Local Transport Network section, for further information.

North connection

Cycle Superhighway 8 runs along Grosvenor Road providing a cycle link from all northern landing sites. To access this route eastwards from Option 2 landing site a new pedestrian and cycle (toucan) crossing opposite Dolphin Square will be required, although care will be required to ensure vehicular access to Dolphin Square is retained. An Option 4 landing south of Grosvenor Road will require a new toucan crossing, or enhancement of the existing junction with Lupus Street, in order to improve eastbound land connectivity. A landing in Victoria railway sidings would provide the opportunity to link into a potential future direct route through to Victoria Station following redevelopment of the sidings. However, site redevelopment plans are not certain and would not be delivered until 2019 at the earliest.

There are a number of possible methods for improving connections between Pimlico Gardens (Option 1) and existing walking and cycling networks. These include upgrading the existing pedestrian crossing to the west to accommodate cycles, an upgraded pedestrian crossing to the east, and a marked route eastwards from the landing site. A combination of these measures will avoid skewing cycle traffic in one direction.

South connection

Established cycle lanes exist on both sides of Nine Elms Lane. The cycle lane on the north side of Nine Elms Lane follows the river bank for a length, which would allow it to connect directly with both the Option 1 and 2 landing sites. Full details of changes to cycling infrastructure as part of the ongoing OA development are not currently confirmed, but will be considered in any subsequent feasibility work.

The Option 1 landing requires a new toucan crossing directly opposite. This will connect to emerging development and to the proposed cycle routes around New Covent Garden Market. The existing pedestrian crossing at Option 2 requires upgrading to a cycle crossing. Option 4 would land on a pedestrianised riverfront walkway, with quick onward connections to the proposed new Northern Line Station at Battersea Power Station.

7.11. Construction methodology

See Stage 3 Engineering requirements report, Construction Methodology section, for further information.

This section of the study was developed in collaboration with Sir Robert McAlpine (SRM) and Severfield-Watson Structures Ltd (SWSL). Two principal design options for the bridge were considered. No construction methodology was developed for Option 4.

Materials

Materials for Option 1 could potentially be delivered to the riverbank and then lifted into position by crane. Materials for Option 2 could potentially be delivered by barge and lifted into position by a crawler crane in initial work stages and then by a tower crane located on a dedicated platform.

Construction Access

New road access will be created off Nine Elms Lane to the east of Elm Quay Court visitor car park, which can be used to access both southern landing sites. The contractor will be required to prevent vehicles obstructing the private entrance and Nine Elms Lane 'red route'.

On the northern bank, new site access would be created off Grosvenor Road. The westbound slow lane could be closed off to allow entry and exit without interrupting traffic flow.

Recommendation

Preliminary findings from SRM and SWSL conclude that from a construction perspective the cable stay design is preferred, as it involves less intervention in the river, it is technically simpler than the complex arched structure, there is a more manageable weight of steel involved and it will require less temporary works.

8. Business Case and Costs

The Outline Business Case compared the 'Do Something' scenario (a new pedestrian and cycle bridge is constructed) with a 'Do Minimum' scenario (a new bridge is not built but other developments in the VNEB area still come to fruition). This high-level business case attempts to document in a methodical way the expected benefits and costs of a new bridge, and is focused on the Option 1 alignment.

8.1. Costs

See *Stage 3 Engineering requirements report, Cost Model section, and Stage 3, Outline Business Case report, for further information.*

The construction and whole life costs for Options 1 and 2 were estimated by Gardiner & Theobald, an independent cost consultant. No cost estimates have been produced for Option 4. Due to the relatively limited amount of design and specification information available at this stage, it is suggested that a confidence level of +/- 20% can be given to the costs relating to the bridge structures and +/- 30% to the costs relating to the landing arrangements (i.e. stairs and lifts).

The estimated costs of the two options are similar (£38.4m and £40.5m respectively), and the costs for Option 1 have been used in the Outline Business Case. Note that whilst the Outline Business Case has not been updated to take into account the marginally different costs arising from the update of the Stage 3 Engineering requirements report in November 2014, the costs presented below in this summary report have been updated. The benefits considered would generally apply equally to Options 1 and 2, although there are differences between the two options in terms of costs and other feasibility / risk issues. The costs are in Q3 2013 prices, and are shown in the following table with and without an allowance for optimism bias:

	Q3 2013 prices, undiscounted, no optimism bias added (£m)	Q3 2013 prices, undiscounted, with optimism bias added to the capital costs (£m)	2013 prices, Present Value, including optimism bias (£m)
Capital costs	38.4	63.7	51.8
Maintenance and running costs	22.7	22.7	7.6
TOTAL	61.1	86.4	59.4

Table 8: Capital and operating costs

In undiscounted terms, the total costs are therefore £61.1m in 2013 prices. When the necessary adjustments have been made in order to make the costs suitable for inclusion within the economic appraisal, the total costs are £59.4m as a Present Value in 2013 prices.

In accordance with established guidance an allowance for optimism bias of 66% has been applied since this is a fixed link project where a single option is yet to be chosen. The capital costs exclude initial spares, land acquisition and demolition at life expiry. The maintenance costs are presented in full in the Outline Business Case Section 3.5.

8.2. Results of Quantified Analysis

See *Stage 3 Outline Business Case report* for further information.

In order to quantify the benefits of the new bridge, the 2031 trip diversion and trip generation rates from the Stage 2 Demand Assessment were used to estimate the profile of demand over time. For the purpose of the economic appraisal the bridge is assumed to open in 2020.

The following impacts of the bridge were quantified and valued:

- Journey time savings;
- Safety;
- Ambience;
- Health;
- Vehicle operating cost savings;
- Emissions.

Results over the 60-year appraisal period are presented in the table below. The key assumptions used to quantify these impacts are presented in the Stage 3 Outline Business Case Section 3.9.

Benefits	£m, 2013 prices and values, PV
Journey time savings	91.5
Safety	17.4
Ambience	1.1
Health	11.2
Vehicle operating cost savings	0.5
Emissions	0.1
Total benefits	121.8
Costs	
Capital	51.8
Maintenance	7.6
Total costs	59.4
Net Present Value	62.3
Benefit/Cost Ratio	2.05

Table 9: Benefits of the bridge over a 60 year appraisal period

The Benefit/Cost Ratio of 2.1:1 is above the TfL passmark of 1.5:1 and exceeds the 2.0:1 which Department for Transport WebTAG guidance suggests indicates of high value for money.

Limitations

As noted above the business case is based on the maximum theoretical level of demand as set out in Section 5.1 of this report, which is unlikely to be achieved in practice given the likely requirement for stairs and lifts. For this reason the quantified benefits are likely to be lower than those listed above; however initial sensitivity tests indicate that benefits would continue to outweigh costs even with conservative assumptions (eg. 50% scheme cost increase). Moreover, there are a number of significant benefits which have not been quantified at this stage such as the bridge's contribution to the image and regeneration of the VNEB Opportunity Area. It may be possible for some of these

additional benefits to be quantified once further information about the timescales and location etc are known.

Should further work on the scheme be undertaken, and a preferred option and design be agreed, there will be more certainty about the costs and it will be possible to reduce the allowance for optimism bias to reflect this, which is likely to improve the case for the scheme. It may also be possible to develop a more economical structure than the concept designs completed for this feasibility study.

One useful parallel is the proposed Diamond Jubilee footbridge, which would run adjacent to Battersea (Cremorne) Railway Bridge. This scheme has recently received planning consent. The forecast number of users is significantly lower than would likely be the case for a bridge in this location, yet the business case is still expected to be positive.

Measures of success

It was suggested that the number of trips, journey time savings and accident savings should be adopted as the key measures of success, since these are the most important aspects of the scheme in terms of quantified benefits.

9. Next Steps

The feasibility study represents a foundation on which further, more detailed planning work can be based. Possible next steps could include:

Public consultation

The undertaking of a public consultation would be a useful exercise for raising public awareness of the proposal and gauging opinion. It would allow interested stakeholders to express their views on the scheme which could inform various aspects of the scheme going forward. It may also assist in identifying a preferred location for the bridge.

Design competition

A design competition could encourage design innovation and produce a range of bridge designs, and ultimately help to identify the optimum design for a structure befitting of this part of London. The findings of the Stage 3 engineering requirements report in particular report could be used to inform the competition brief. A certain level of certainty on funding is likely to be required before a design competition can be launched.