TRANSPORT FOR LONDON

RIVER CROSSINGS: SILVERTOWN TUNNEL

SUPPORTING TECHNICAL DOCUMENTATION

SILVERTOWN TUNNEL: HIGHWAY INFRASTRUCTURE CONCEPTUAL DESIGN RECOMMENDATIONS

Atkins

April 2013

This report builds upon previous studies undertaken to investigate the highway connections between the proposed Silvertown Tunnel and the existing highway networks to the north and south of the River Thames, in order to identify the preferred options.

This report is part of a wider suite of documents which outline our approach to traffic, environmental, optioneering and engineering disciplines, amongst others. We would like to know if you have any comments on our approach to this work. To give us your views, please respond to our consultation at www.tfl.gov.uk/silvertown-tunnel

Please note that consultation on the Silvertown Tunnel is running from October – December 2014.

ATKINS

Silvertown Tunnel:

Highway Infrastructure Conceptual Design Recommendations

April, 2013

Plan Design Enable

Transport for London

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Executive Summary

Atkins and Mott McDonald have worked in collaboration to develop a conceptual design for the proposed Silvertown Tunnel and associated highway infrastructure. Atkins has focussed on the surface access, whilst Mott McDonald has focussed on the tunnel itself. This report identifies the preferred options for linking the tunnel to the local highway network and should be read in conjunction with Mott McDonald's complementary *Silvertown Tunnel Further Development of Tunnel Engineering* report.

The preferred highway alignment options are NORTH5C and SOUTH4A (see Appendix B for the relevant scheme plans). These alignments provide for:

- A grade separated, free flow link from the A102 south of Blackwall Tunnel to the Silvertown Tunnel south portal
- An at grade interchange with the Tidal Basin Roundabout providing a link from the Silvertown Tunnel north portal to the local road network with direct access to the Lower Lea Crossing
- Reconnection of Tunnel Avenue on the Greenwich Peninsula to improve local accessibility
- Public Transport and non-motorised user links to improve integration
- Considerations of emergency/contingency planning including impacts on the wider network

The designs have been developed using all available information based on the following data and constraints:

- Existing topography as derived from existing aerial survey data (LiDAR) which has been converted to a three-dimensional ground model
- Existing geotechnical information
- New utility searches made under the New Roads and Street Works Act
- Environmental conditions
- The safeguarded corridor
- Groundwater infiltration arising from hydraulic connections to the Thames

The total preliminary works cost estimate is **£463 million** of which approximately 15% is specific to the highways surface access infrastructure linking the tunnel to the local road network. This figure excludes an allowance for contingency, risk and Optimism Bias, which TfL will consider at the appropriate stage of the project.

An indicative construction programme has been developed, indicating a works period in the order of 260 weeks. This programme has been based on construction phases developed as part of this study to ensure that the works can be safely constructed whilst minimising disruption to the travelling public.

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Section A

Introduction & Scope

This study was commissioned by Transport for London (TfL) to build upon previous studies undertaken to investigate the highway connections between the proposed Silvertown Tunnel and the existing highway networks to the north and south of the River Thames, in order to identify the preferred options. The tunnel is to connect the Silvertown area to the north of the Thames to the Greenwich Peninsula to the south. Previous studies have been undertaken, which are described under the *Project Evolution* section below; however the scope for this study is to:

- Optimise the conceptual design of highway alignment options NORTH5A and NORTH5B, to form the hybrid option NORTH5C (the preferred option).
- Review the conceptual design of highway alignment option SOUTH4 to explore whether the alignment of the northbound approach to the Silvertown Tunnel from the A102 can be refined to provide a smoother alignment.
- Develop the civil & structural engineering aspects of highway alignment options NORTH5C and SOUTH4 to a conceptual stage, especially with regards to the highway bridge, retaining walls, earthworks and drainage.
- Investigate the compatibility of proposals NORTH5C and SOUTH4 with the requirements of localised free-flow/green-wave principles inherent in current tunnel life safety strategies.
- Secure an integrated view of both the highway design (being undertaken by Atkins) and the tunnel engineering study (being undertaken by Mott MacDonald), especially with regards to:
    - works phasing for both tunnelling and highway work looking at the stages in which the scheme can be constructed
    - road closures and strategic diversions and traffic management
    - contaminated land issues, whereby Atkins is to provide Mott MacDonald with information for the preliminary Site Waste Management Plan (SWMP) based on existing geotechnical site investigation data
    - the interface between the tunnel portal and the highway approach ramps with analysis of both deep cutting and retained slope solutions
- Review existing geotechnical site investigation data with resulting recommendations and engineering support to both the highway structure and drainage designs.
- Develop a strategic plan for dealing with the diversion of statutory undertakers' plant.
- Develop an outline works programme and preliminary works cost estimate for highway alignment options NORTH5C and SOUTH4.
- Consider environmental issues such as flooding, noise, landscaping, street furniture and sustainability.

Local Area Background

Southern Junction

The southern portal of the proposed Silvertown Tunnel will be situated in the Greenwich Peninsula (Royal Borough of Greenwich) in the immediate vicinity of the O_2 (Millennium Dome), which is the dominant feature on the Peninsula. The proposed portal location is just south of Edmund Halley Way and east of Millennium Way with a south-west facing alignment. Land use on the Greenwich Peninsula is predominantly commercial and retail to the east of the A102 (Blackwall Tunnel Approach) and light industrial to the west. The Peninsula is also home to other key structures and features such as the southern terminal of the Emirates Air Line Cable Car across the River Thames and a redundant gasometer. The gateway structure on the A102, before the northbound Blackwall Tunnel portal, is a listed building and will be retained.

The Blackwall Tunnel offers an existing crossing of the River Thames at the northern tip of the Peninsula via the A102, utilising two separate bores – one for northbound and one for southbound traffic. The A102 has a junction with the A2203 (Blackwall Lane), less than one mile south of the Blackwall Tunnel portals. It is this junction that currently provides access to the Greenwich Peninsula (via Millennium Way) as well as other destinations.

Northern Junction

The northern portal of the proposed Silvertown Tunnel will be situated in Silvertown (London Borough of Newham). Silvertown is an industrial district on the north bank of the Thames, which is dominated by the Tate & Lyle sugar refinery but is also undergoing significant residential development. The proposed tunnel is to tie-in to the roundabout where Lower Lea Crossing (A1020) and Silvertown Way (A1011) meet. Silvertown Way leads to Canning Town to the north and London City Airport and the local/strategic highway network to the south. Lower Lea Crossing goes west towards the A12 and the Isle of Dogs (Canary Wharf). The east-facing slip roads from the Canning Town roundabout on and off the A13 are now closed, so there is no direct access from Canning Town onto the eastbound A13, which reduces connectivity to the strategic road network from Silvertown Way. The Excel exhibition centre is east of Silvertown Way and attracts significant vehicle movements during events. Several Docklands Light Railway (DLR) routes are in the proximity of the proposed tunnel portal and junction.

The safeguarded corridor, which is the land that has been earmarked for the proposed tunnel and highway links, is shown on drawing MMD-298348-TUN-101 (Appendix A).

Project Evolution

This report references the following previous studies:

- **New Thames River Crossing: Greenwich to Silvertown - Highways (Alignment & Interfaces)** *(Mott MacDonald, December 2009)*
- **New Thames River Crossing: Network Development and Forecasting Report** *(Mott MacDonald, May 2010)*
- **Silvertown Crossing Study: Tunnel Engineering** *(Mott MacDonald, February 2012)*
- **TfL Silvertown Crossing: Highway Options & Feasibility Design (Volumes A to E)** *(Atkins, May 2012)*
- **TfL Silvertown Crossing: Highway Options & Feasibility Design (Volumes F & G)** *(Atkins, October 2012)*

The **New Thames River Crossing: Greenwich to Silvertown - Highways (Alignment & Interfaces)** report was commissioned by TfL in 2009 to investigate a link that was to connect the A102 on the Greenwich Peninsular to the Tidal Basin roundabout on the A1020 (Silvertown Way). Both a tunnel crossing and a lifting bridge crossing were to be investigated.

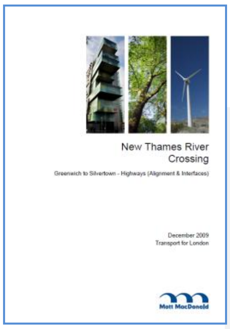
The **New Thames River Crossing: Network Development and Forecasting Report** in 2010 reported on some preliminary traffic modelling work to confirm the case for the development of a new river crossing connecting the Greenwich Peninsula and Silvertown. As part of this study, some early concepts for the alignments of the highway interfaces were developed.

This report was then followed up in 2012 with the **Silvertown Crossing Study: Tunnel Engineering** report, which looked specifically at the tunnel alignment and outline engineering principles, including the geotechnical aspects. Historical geotechnical investigation data from the cable car project was analysed and further geotechnical data was gathered in 2011 and 2012 to further inform the study.

In May 2012, the highway interfaces for the northern and southern tie-in points were subject to further study in the **TfL Silvertown Crossing: Highway Options & Feasibility Design** reports undertaken by Atkins. Volumes A to E looked at three options for the northern interface and one option for the southern, with a further two northern options considered in the subsequent volumes F and G in October 2012.

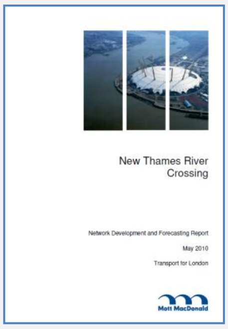
This report brings together the previous studies on highway infrastructure to offer recommendations for taking the project forward to the next stage of design, with an integrated approach to ensure that the highway and tunnelling work are fully integrated.

The Development of the Concept

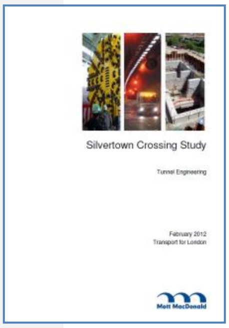


New Thames River Crossing
Greenwich to Silvertown - Highways (Alignment & Interfaces)
December 2009

Transport for London

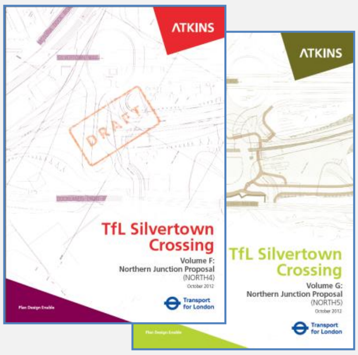


New Thames River Crossing
Network Development and Forecasting Report
May 2010



Silvertown Crossing Study
Tunnel Engineering
February 2012

TfL Silvertown Crossing
Highway Options & Feasibility Design (Volumes A to E)
May 2012



TfL Silvertown Crossing
Highway Options & Feasibility Design (Volumes F & G)
October 2012

Highway Concept Design April 2013

Tunnelling Concept Design April 2013

Silvertown Crossing Concept Design Report

April 2013

These two Concept Design documents are two volumes of the same study and are to be read in conjunction with each other.

Volumes A to G of the **TfL Silvertown Crossing: Highway Options & Feasibility Design (2012)** study are a comprehensive review of the interface options at both the northern and southern tie-in points of the proposed tunnel. The following briefly describes the highway options considered as well as their respective benefits.

Southern Junction

The parameters that defined the alignment for this junction included the need to:

- keep the scheme footprint within the safeguarded corridor (identified on MMD-298348-TUN-101 (Appendix A)
- retain the Grade II listed Tunnel House gateway on the approach to the Blackwall Tunnel
- retain the redundant gasometer to the east of the A102
- offer a free-flow solution, as at-grade signal controlled junctions or roundabouts are exceptionally unlikely to offer sufficient capacity and would introduce unacceptable user delays.

SOUTH1, SOUTH2 and SOUTH3

These were early considerations from the **New Thames River Crossing: Network Development and Forecasting Report (2010)**. It was found that these options either do not satisfy the above parameters or would require significant departures from design standards. All would necessitate the temporary closure of Tunnel Avenue in the vicinity of the new retaining walls that would require construction as part of the scheme, and would include a complex piled retaining wall in the close proximity of the listed 'Tunnel House' structure and the northbound carriageway of the A102. Further details regarding SOUTH1, SOUTH2 and SOUTH3 can be found in **Volume B** of the **TfL Silvertown Crossing: Highway Options & Feasibility Design (2012)** report. SOUTH4 is the successive iteration which eliminated many of these problems and is described below.

SOUTH4

Drawing No.: 5110309/HW/GA/0103 (Appendix A)

This proposal involves the significant realignment of the southbound A102 in order to generate a gap between the northbound and southbound carriageways, thus improving constructability as well as facilitating appropriate longitudinal gradients for changes in level. A free-flowing slip road diverging from the off-side of the northbound A102 connects to the Silvertown Tunnel, passing under the southbound carriageway. The northbound carriageway is also realigned slightly east, thereby enabling the reconnection of the two parts of Tunnel Avenue. There is a bus link from Tunnel Avenue onto the northbound A102 and a design for a bus link from Millennium Way to the Silvertown Tunnel has been created, although this is not considered essential and may be omitted subject to funding constraints.

The footbridge across the A102 will need to be relocated. A previous iteration of this proposal included the realignment of the southbound A102 carriageway over the cut-and-cover section of the Silvertown Tunnel, thereby negating the need for a structure to cross the Silvertown Tunnel approach. This proposal was adjusted to its current incarnation, primarily in order to reduce the footprint size of the proposal.

Key Benefits: *Free-flow connection to Silvertown Tunnel with only one highway bridge to be constructed – the majority of the infrastructure can be constructed off-line.*
Reasons for Elimination: *N/A*

Northern Junction

NORTH1

Drawing No.: 5110309/HW/GA/0101 (Appendix A)
This proposal was based on one of the recommended options from the **New Thames River Crossing: Network Development and Forecasting Report** issued in May 2010. The layout offers the same connectivity as the existing layout with the additional link to the Silvertown Tunnel, which connects to an hourglass-shaped elongation of the existing Tidal Basin roundabout. This proposal would see Dock Road realigned to the south of the proposed Silvertown Tunnel approach and the eastbound carriageway of the Lower Lea Crossing would be realigned at its tie-in to the elongated roundabout.

Key Benefits: *Relatively low cost option with same connectivity as the existing layout.*
Reasons for Elimination: *Indirect route for southbound traffic approaching the tunnel from Lower Lea Crossing and likely low junction capacity.*

NORTH2

Drawing No.: 5110309/HW/GA/0102 (Appendix A)
This proposal was a variant of NORTH1, also utilising an elongated roundabout but with an added grade separated connection to Silvertown Way. The structure spanned the proposed roundabout and the Docklands Light Railway (DLR) before connecting to Silvertown Way via a signalised junction near its junction with Peto Street North. As with NORTH1, the eastbound carriageway of Lower Lea Crossing was realigned south to tie-in to the proposed elongated roundabout.

Key Benefits: *Grade separated free-flow connectivity to Silvertown Way whilst maintaining all other existing connections.*

Reasons for Elimination: *Very high cost option with limited traffic flow benefits due to no direct access onto the eastbound A13 from Silvertown Way at Canning Town.*

NORTH3

Drawing No.: 5110309/HW/GA/0108 (Appendix A)

This proposal provided the same connectivity as NORTH2 without the additional complexity with a reduced cost and smaller footprint. The link to Silvertown Way is via the Tidal Basin roundabout and a signalised junction. This option features the same hourglass-shape for the elongation of the roundabout as the NORTH1 and NORTH2.

Key Benefits: *Connectivity with Silvertown Way with a more direct link than Tidal Basin Road.*
Reasons for Elimination: *A high cost and complicated road layout with potential safety concerns due to the close proximity of the arms connecting onto the circulatory.*

NORTH4

Sketch included in Appendix A

This option explored the provision of a free-flow, grade separated connection between the Silvertown Tunnel portal and Lower Lea Crossing, whilst maintaining access to the Tidal Basin roundabout and Dock Road via a roundabout or other junction type over or under the free-flow link. The fixed parameters were essentially the tunnel portal position at the eastern extent and the structure over the Docklands Light Railway (DLR) at the western extent. These two constraints are approximately 410m apart. The conclusion of this study was that the option is not feasible from an engineering perspective (given the existing constraints) whilst complying with the relevant design standards.

Key Benefits: *Direct free-flow two-way connectivity between Lower Lea Crossing and the tunnel.*
Reasons for Elimination: *Given the constraints, this alignment will require significant departures from design standards and therefore be associated with safety concerns due to excessively tight radii and steep gradients.*

NORTH5A

Drawing No.: 5110309/HW/GA/0207 (Appendix A)

This proposal involves the elongation of the existing Tidal Basin roundabout to an hourglass-shape, much like NORTH1 but with the addition of a signalised 'hamburger link' for southbound Lower Lea Crossing traffic to enable direct access to the tunnel, thereby giving a shorter route and subsequent higher capacity. In the event of traffic signal failure, this configuration can more readily function as a standard roundabout.

Key Benefits: *A more direct route for southbound traffic from Lower Lea Crossing entering the tunnel, thereby also offering higher junction capacity. The layout is also capable of functioning as a standard roundabout in the event of traffic signal failure. The signalisation of this configuration also enables effective clearing of the tunnel in the event of an emergency, using 'green-wave' principles.*
Reasons for Elimination: *N/A*

NORTH5B

Drawing No.: 5110309/HW/GA/0208 (Appendix A)
Much like NORTH5A, this elongation of the existing Tidal Basin roundabout also provides a 'hamburger link' but with two-way provision. This configuration is likely to offer the highest capacity solution of all the at-grade proposals. The 'hamburger link' has been straightened out to give a continuous and direct alignment for north- and southbound traffic. Traffic signals will control the junction.

Key Benefits: *Direct traffic-signal controlled two-way connectivity between Lower Lea Crossing and the tunnel offering high capacity.*
Reasons for Elimination: *Not compatible with 'green-wave' principles for emergency evacuation of the northbound tunnel-bore due to conflict between right-turn and straight-ahead movements, leading to possible grid-locking.*

Having eliminated previous options and iterations, this report develops the preferred options for the northern and southern junctions, based on SOUTH4 and NORTH5A.

Section B

Current Proposals

Proposals, for both the northern and southern sites, have been developed and will be outlined in this section. The proposals have been developed using the design principles described in the Design Input Statement in **TfL Silvertown Crossing: Highway Options & Feasibility Design (Volumes A).**

Proposal NORTH5C

Proposal drawings associated with this layout are included in Appendix B and listed below:

- 5110309/HW/GA/0218 – Scheme Plan
- 5110309/HW/GA/0230 – Long Section 1 of 3
- 5110309/HW/GA/0231 – Long Section 2 of 3
- 5110309/HW/GA/0232 – Long Section 3 of 3
- 5110309/HW/GA/0233 – Cross Section
- 5110309/HW/GA/0234 – Scheme Footprint

The proposals Preliminary Works Cost Estimate and Designer's Risk Assessment can be found in Appendix G and H respectively.

Outline Description

Proposal NORTH5C is based on proposal NORTH5A. Drawing number 5110309/HW/GA/0218 (Appendix B) shows the general arrangement layout, with the other drawings providing additional technical detail for information and completeness. The proposal is to elongate the existing Tidal Basin roundabout and to provide a 'hamburger' cut-through for southbound traffic approaching the tunnel from Lower Lea Crossing, giving a direct route through the signalised roundabout. This configuration will ensure that full access is maintained at the junction, with all traffic navigating the signalised roundabout conventionally, apart from the aforementioned traffic flow, which will cut-through the centre.

The principal benefits that proposal NORTH5C offers are:

- maintaining all existing connections at the Tidal Basin roundabout with additional connectivity to the proposed Silvertown Tunnel;
- a direct connection into the tunnel for traffic approaching from Lower Lea Crossing, without needing to navigate the full circulatory, thereby increasing capacity;

- compatibility with free-flow/green-wave principles, allowing a clear path to be provided for traffic exiting the tunnel in the event of an emergency;
- the proposal sits wholly within the safeguarded corridor; and
- good pedestrian access and routes around the junction due to the signalised nature of the roundabout.

The outline alignment has been designed vertically as well as horizontally using Ordnance Survey mapping and a digital ground model prepared using LiDAR level data. This ground model information is accurate to +/-100mm and therefore represents a good level of accuracy for a project at the feasibility stage. London Underground's Jubilee Line passes near the proposed extension of the Tidal Basin Roundabout. The precise location of the Jubilee Line infrastructure and the possible impacts and mitigation in relation to the proposed roundabout construction will need to be considered and verified at the next stage of the project.

Surface Water Drainage Principles

The catchment area for the surface water run-off that will need to be intercepted at the tunnel portal is estimated to be 3,007m^2 as shown in Table B1 below.

NORTH	Area (m^2)	Return Period/Storm Duration	Peak Flow (l/s)	Ave. Rainfall Intensity (mm/hr)	Total Volume (m^3)	Unconstrained Peak Flow (l/s)
	3007	1yr / 15min	46	39	25	52
	3007	1yr / 30min	39	25	32	39
	3007	1yr / 60min	26	15	39	26
	3007	5yr / 15min	67	64	41	86
	3007	5yr / 30min	58	41	52	64
	3007	5yr / 60min	42	25	62	42
	3007	10yr / 15min	74	75	48	100
	3007	10yr / 30min	65	47	60	75
	3007	10yr / 60min	48	29	73	49
	3007	50yr / 15min	84	115	73	142
	3007	50yr / 30min	83	74	93	115
	3007	50yr / 60min	70	45	114	76
	3007	100yr / 15min	87	134	85	161
	3007	100yr / 30min	86	86	109	132
	3007	100yr / 60min	80	53	133	90

Table B1 – Surface Water Drainage Parameters

A drainage sump at the tunnel portal will provide an intercept and storage for surface water run-off, as well as a reception chamber for water being pumped back from the low-point in the tunnel. Surface run-off will be collected via gullies or a combined drainage kerb system and collected in the sump, from where it will be pumped to an elevation from where it can be gravity drained to an outfall.

It is assumed that in addition to the drainage sump at the portal, an attenuation system will be required in the form of oversized carrier drains adjacent to the carriageway for the catchment area falling towards the portal. A flow-control device will control the outfall rate into the portal sump. A second attenuation system will be provided to store surface water from the remaining catchment area.

Structural Elements

The cutting from the tunnel portal to the tie-in at Tidal Basin roundabout will be retained using either secant piles or diaphragm walls, the impermeability of which will prevent ground water penetration. The two retaining walls either side of the carriageway will be connected by a reinforced concrete slab under the carriageway, which will prevent upward seepage of ground water. Together, the retaining walls and the slab will form a groundwater exclusion zone, which substantially reduces the volumes of water to be managed at the portal and therefore the risk of flooding in the tunnel. A typical section is shown on drawing 5110309/HW/GA/0233 (Appendix B). More details about this proposal can be found in Mott MacDonald’s report, *Silvertown Tunnel: Further development of Tunnel Engineering*.

Consideration was given to the use of sloped embankments in the place of the retaining walls. The principal benefits to this would be the reduced capital cost of the slope and the improved aesthetics. However, a slope would also:

- significantly increase the volume of (potentially contaminated) ground water that would need to be managed and pumped, which an impermeable retaining wall would prevent from entering the drainage network
- introduce additional risks associated with the draw-down of the water table around the portal as this will in the long term create clay shrinkage and/or heave issues
- increase the volume of material to be excavated and disposed of, including contaminants which have a high cost associated with their disposal
- reduce the available land for development

For the reasons identified above, the concept of slopes on the approach to the portal has been abandoned and the recommendation is to proceed with a retained solution.

Earthworks and Contaminated Land

As part of this study, the following work has been undertaken related to earthworks and ground contamination:

- **Silvertown Tunnel Crossing: Re-Use Potential and Waste Characterisation of Arisings** study (see Appendix D)
- **Geotechnical Conceptual Design Report** (see Appendix C)

The **Silvertown Tunnel Crossing: Re-Use Potential and Waste Characterisation of Arisings** desk-study analysed available borehole information. Whilst boreholes were previously undertaken within the footprint of the proposed scheme, chemical analysis data is only available from boreholes between 50m and 100m from the site. The available chemical analysis data does however flag that at least one contaminant soil screening value (SSV) is exceeded within 14 of the 31 samples of made ground. If a SSV for a contaminant is exceeded, it indicates the potential for a material to present a risk to human health if re-used. The full study, including the source of borehole information, is included in Appendix D.

The **Geotechnical Investigation Review and Analysis** (Section D and Appendix C) desk-study analysed available ground investigation information. This analysis has been used to make assumptions for retaining wall design and carriageway pavement construction. See Section D and Appendix C for full details of the geotechnical analysis, however, a summary of the borehole logs has been included in Figure B1 below.

The vertical alignment design, when overlaid onto the digital ground model, shows that approximately 49,911m^3 of material will be excavated between the tunnel portal and the tie-in to Tidal Basin roundabout. The average depth of made ground has been calculated to be 2.7m using the borehole information included within the *Geotechnical Investigation Review and Analysis* study (an extracted illustration is included below). Due to the insufficient chemical analysis data available, an assumption has been made that all excavated made ground will be classified as hazardous waste. The preliminary works cost estimate reflects this assumption in the cost of disposal. Table B2 shows the quantities of earthworks generated from the portal onwards and does not include the volumes generated as a result of tunnelling works including the cut-and-cover section of the tunnel.

Table B2: Earthworks Volumes

Total Volume of Excavated Material:	**49,911 m^3**
Volume of Acceptable Material for Re-Use On-Site:	**4,695 m^3**
Volume of Contaminated Material for Disposal Off-Site:	**33,077 m^3**
Volume of Unacceptable Material for Disposal Off-Site:	**12,139 m^3**
Total Volume of Material for Disposal Off-Site:	**45,216 m^3**

A preliminary Site Waste Management Plan has been prepared and is included in Mott MacDonald's *Silvertown Tunnel: Further development of Tunnel Engineering* report. Highway work generated material for disposal (both contaminated and unacceptable) is included within this.

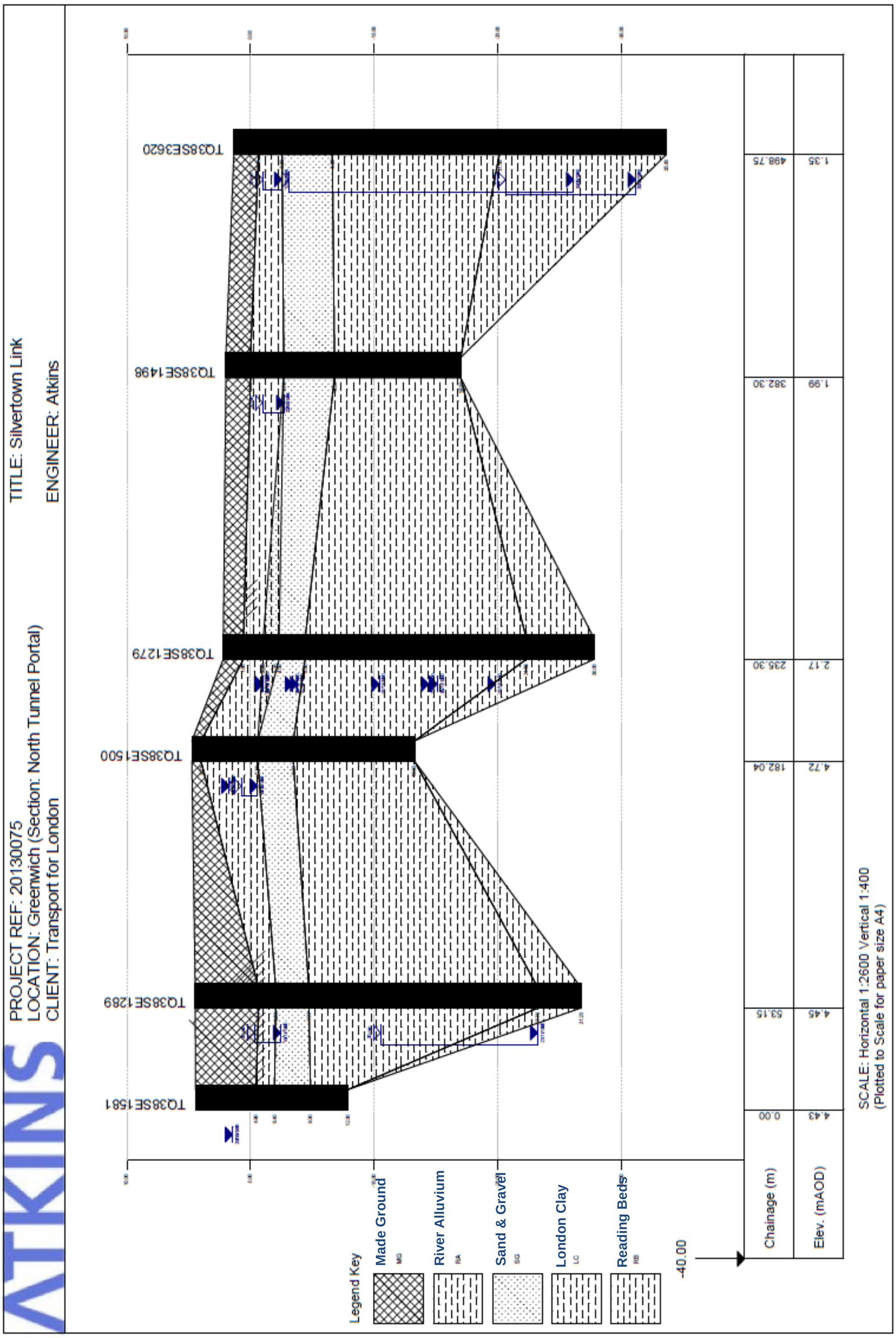


Figure B1 – Borehole Log Summary
(Section D and Appendix C)

Proposal SOUTH4A

Proposal drawings associated with this layout are included in Appendix B and listed below. These drawings give various details of the proposal and are provided for information only.

- 5110309/HW/GA/0219 – Scheme Plan
- 5110309/HW/GA/0223 – Long Section 1 of 4
- 5110309/HW/GA/0224 – Long Section 2 of 4
- 5110309/HW/GA/0225 – Long Section 3 of 4
- 5110309/HW/GA/0226 – Long Section 4 of 4
- 5110309/HW/GA/0227 – Cross Section 1 of 2
- 5110309/HW/GA/0228 – Cross Section 2 of 2
- 5110309/HW/GA/0229 – Scheme Footprint
- 5110309/ST/GA/0235 – Highway Bridge Option 1
- 5110309/ST/GA/0236 – Highway Bridge Option 2

The proposals Preliminary Works Cost Estimate and Designer's Risk Assessment can be found in Appendix G and H respectively.

Outline Description

Proposal SOUTH4A is based on proposal SOUTH4. Drawing number 5110309/HW/GA/0219 (Appendix B) shows the general arrangement layout. The concept of the design is to create a free-flow connection between the proposed tunnel and the A102 to and from the south only. This will be achieved by realigning the southbound carriageway of the A102 to the east and constructing a new bridge under which a link from the northbound A102 to the Silvertown Tunnel will be constructed. The northbound carriageway will also be realigned slightly to provide a better approach alignment. The southbound exit from the Silvertown Tunnel will join the A102 as a lane gain, with a short weaving length before the nearside lane drops to the Greenwich Peninsula.

A bus link will also be integrated, giving access from Millennium Way to the northbound carriageway of the Silvertown Tunnel, via a priority junction. Extensive retaining walls will be utilised to accommodate stark level differences throughout the proposed scheme.

The principal benefits that proposal SOUTH4A offers are:

- a direct free-flow connection to the proposed Silvertown Tunnel to and from the A102, which will maximise capacity

- a direct link from Millennium Way to the Silvertown Tunnel for the extensive bus routes that serve the Peninsula, which will help minimise bus journey times and therefore make public transport a more attractive option
- the reconnection of Tunnel Avenue's northern and southern sections, thereby giving access to the development and industrial land to the west of Tunnel Avenue without routing along Millennium Way

The outline alignment has been designed vertically as well as horizontally using Ordnance Survey mapping and a digital ground model prepared using LiDAR level data. This ground model information is accurate to +/-100mm and therefore represents a good level of accuracy for a project at the feasibility stage.

Surface Water Drainage Principles

The catchment area for the surface water run-off that will need to be intercepted at the tunnel portal is estimated to be 7,660m^2 as shown in Table B3 below.

SOUTH	Area (m^2)	Return Period/Storm Duration	Peak Flow (l/s)	Ave. Rainfall Intensity (mm/hr)	Total Volume (m^3)	Unconstrained Peak Flow (l/s)
	7660	1yr / 15min	115	39	63	131
	7660	1yr / 30min	95	25	80	101
	7660	1yr / 60min	65	15	99	67
	7660	5yr / 15min	191	64	104	216
	7660	5yr / 30min	155	41	131	166
	7660	5yr / 60min	104	25	159	108
	7660	10yr / 15min	222	75	121	253
	7660	10yr / 30min	181	47	153	195
	7660	10yr / 60min	122	29	186	126
	7660	50yr / 15min	331	115	185	371
	7660	50yr / 30min	275	74	237	295
	7660	50yr / 60min	190	45	290	197
	7660	100yr / 15min	376	134	215	423
	7660	100yr / 30min	320	86	277	340
	7660	100yr / 60min	223	53	339	230

Table B3 – Surface Water Drainage Parameters

A drainage sump at the tunnel portal will provide an intercept and storage for surface water run-off, as well as a reception chamber for water being pumped back from the low-point in the tunnel. Surface run-off will be collected via gullies or a combined drainage kerb system and collected in the sump, from where it will be pumped to an elevation from where it can be gravity drained to an outfall.

It is assumed that in addition to the drainage sump at the portal, an attenuation system will be required in the form of oversized carrier drains adjacent to the carriageway for the catchment area falling towards the portal. A flow-control device will control the outfall rate into the portal sump. A second attenuation system will be provided to store surface water from the remaining catchment area.

Structural Elements

The cutting from the tunnel portal to the tie-in at the A102 will be retained using either secant piles or diaphragm walls, the impermeability of which will prevent ground water penetration. The retaining walls either side of the carriageway will be connected by a reinforced concrete slab under the carriageway, which will prevent upward seepage of ground water. Together, the retaining walls and the slab will form a groundwater exclusion zone, which substantially reduces the volumes of water to be managed at the portal and therefore the risk of flooding in the tunnel. A flexible construction is likely to be susceptible to deformation because of heave due to hydrostatic effects, hence the concrete slab is deemed necessary. A typical section is shown on drawings 5110309/HW/GA/0227 and 5110309/HW/GA/0228. More details about this proposal can be found in Mott MacDonald's *Silvertown Tunnel: Further development of Tunnel Engineering* report.

Consideration was given to the use of sloped embankments in the place of the retaining walls. The principal benefits to this would be the reduced capital cost of the slope and the improved aesthetics. However, a slope would also:

- significantly increase the volume of (potentially contaminated) ground water that would need to be managed and pumped, which an impermeable retaining wall would prevent from entering the drainage network
- introduce additional risks associated with the draw-down of the water table around the portal as this will in the long term create clay shrinkage and/or heave issues
- increase the volume of material to be excavated and disposed of, including contaminants which have a high cost associated with their disposal
- reduce the available land for development

For the reasons identified above, the concept of slopes on the approach to the portal has been abandoned and the recommendation is to proceed with a retained solution. See Section C for details of the Highways Bridge proposed for SOUTH4A (Drawing 5110309-ST-GA-0235 – 0236 Appendix B.

Earthworks and Contaminated Land

As part of this study, the following work has been undertaken related to earthworks and ground contamination:

- **Silvertown Tunnel Crossing: Re-Use Potential and Waste Characterisation of Arisings** study (see Appendix D)
- **Geotechnical Conceptual Design Report** (see Appendix C)

The **Silvertown Tunnel Crossing: Re-Use Potential and Waste Characterisation of Arisings** desk-study analysed available borehole information. Whilst boreholes were previously undertaken within the footprint of the proposed scheme, chemical analysis data is not available within reasonable proximity. The full study, including the source of borehole information, is included in Appendix D.

The **Geotechnical Investigation Review and Analysis** desk-study analysed available ground investigation information. This analysis has been used to make assumptions for retaining wall design and carriageway pavement construction. See Section D and Appendix C for full details of the geotechnical analysis, however, a summary of the borehole logs has been included in Figure B2 below.

The vertical alignment design, when overlaid onto the digital ground model, shows that approximately 79,206m^3 of material will be excavated between the tunnel portal and the tie-in to the A102. The average depth of made ground has been calculated to be 2.1m using the borehole information included within the *Geotechnical Investigation Review and Analysis* study (an extracted illustration is included below). Due to the absence of chemical analysis data available, an assumption has been made that all excavated made ground will be classified as hazardous waste, which also follows the conclusions drawn for the northern site. The preliminary works cost estimate reflects this assumption in the cost of disposal. Table B4 shows the quantities of earthworks generated from the portal onwards and does not include the volumes generated as a result of tunnelling works including the cut-and-cover section of the tunnel.

Total Volume of Excavated Material:	**79,206 m^3**
Volume of Acceptable Material for Re-Use On-Site:	**7,120 m^3**
Volume of Contaminated Material for Disposal Off-Site:	**32,915 m^3**
Volume of Unacceptable Material for Disposal Off-Site:	**39,171 m^3**
Total Volume of Material for Disposal Off-Site:	**72,086 m^3**

Table B4: Earthworks Volumes

A preliminary Site Waste Management Plan has been prepared and is included in the Mott MacDonald's *Silvertown Tunnel: Further development of Tunnel Engineering* report. Highway work generated material for disposal (both contaminated and unacceptable) is included within this.

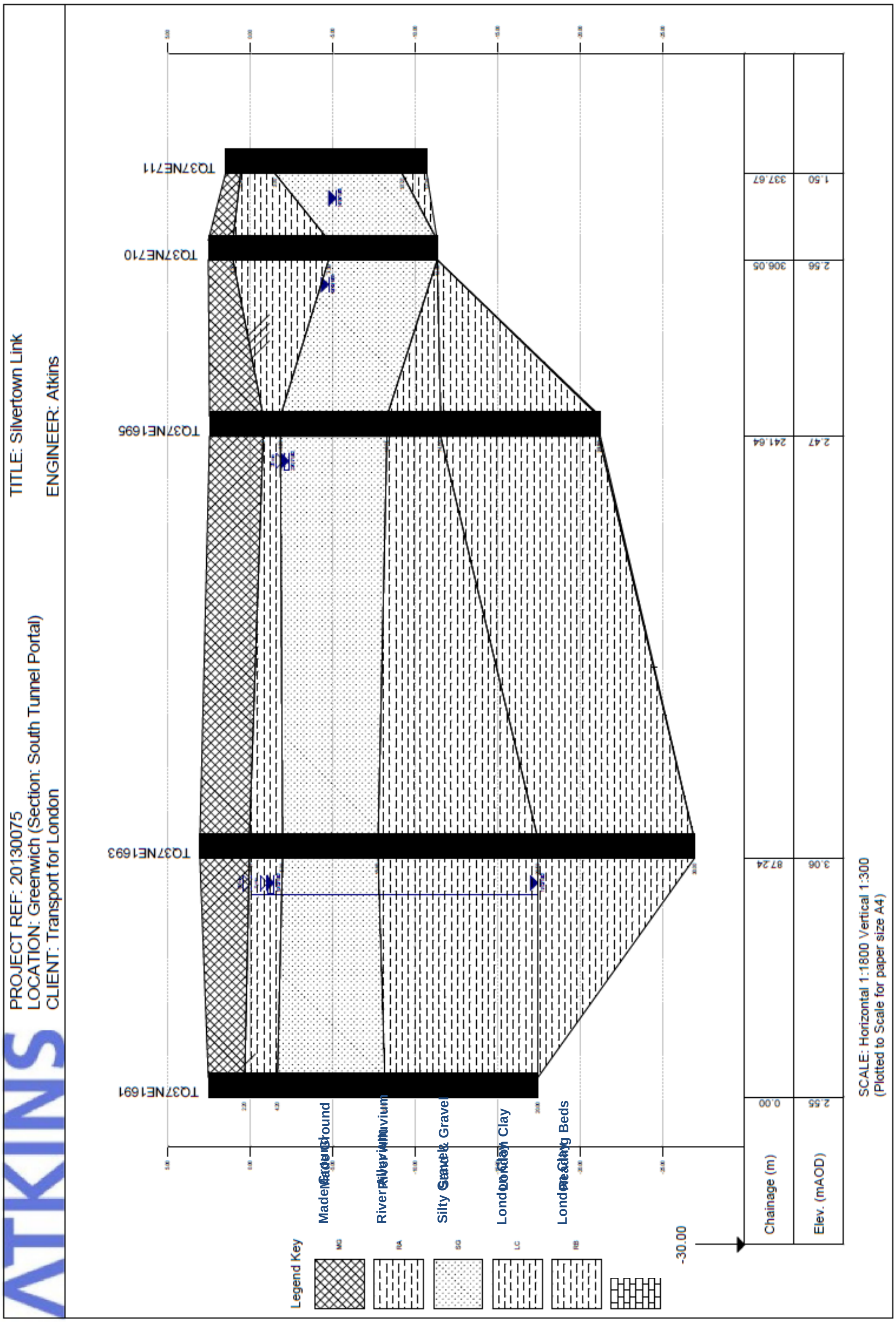


Figure B2 - Borehole Log Summary

(Section D and Appendix C)

Section C

Highway Bridge Details for SOUTH4A

Option SOUTH4A requires the construction of a new highway bridge, which takes the realigned southbound A102 over the top of the proposed northbound approach to the Silvertown Tunnel. This section outlines the preliminary design proposals and constraints associated with the bridge works.

Options for Structures

The vertical alignment of the existing road network and the proposed tunnel and its approach roads restricts the depth of construction of the bridge to achieve compliant headroom clearance for the proposed carriageway below.

Precast pre-stressed concrete girder option is discounted in view of the construction depth required for the required span. Post-tensioned voided concrete slab option is also discounted in view of the span length, the additional dead load and the complexity of the construction including future maintenance issues.

Based on the proposed horizontal alignment of the carriageway passing below the proposed bridge and the required visibility splay, without adjustments this would necessitate a deck skew of 45 degrees.

Normally, the cost of a longer non-skewed deck is greater than a shorter skewed deck. With this proposal however, there is a net cost saving for the installation of a straight deck, when taking into account the effects of the additional costs associated with longer lengths of skew abutments and foundations together with the complexities of the design and construction.

Current standards (BD 57/01) states that bridges with lengths not exceeding 60m and skews not exceeding 30 degrees shall be designed as integral bridges with abutments connected directly to the bridge deck without movement joints for expansion or contraction of the deck. Based on these guidelines, it is proposed to consider bridge structures with a maximum span length of 36m to 38m without any skew or 30m with 30 degrees skew. An integral form of construction is proposed for the bridge that eliminates a deck with skew greater than 30 degrees.

Option-1: Steel composite multi-girder

This comprises longitudinal fabricated steel plate girders connected by cross-bracing and acting compositely with a cast in-situ reinforced concrete deck slab above. It is more adaptable to phased construction than the half-through girder form, but has a greater construction depth. The steel girders will be lighter than those for the half through option and will be easier for lifting and launching.

Option-2: Half-through steel girder

This comprises a longitudinal steel girder along each edge of the deck with steel cross girders composite with a cast in-situ reinforced concrete deck slab. The girders could either be I beams or box beams fabricated from steel plate. Initial calculations indicated box beams are likely to offer the best solution, but it should be confirmed during the next stage of the design.

The girders will be positioned along the outer edges of the structure outside the verges and will result in the lowest practical deck construction depth below the carriageway and hence offers the best options in terms of headroom and vertical highway alignment. This option has the advantage of reducing the height of the approach earthwork offering savings in earthworks and associated retaining wall costs. However, it will require a wider deck in order to accommodate the steel girders and a rigid concrete barrier to protect it from traffic. This option is aesthetically less pleasing than conventional multi girder system and will render itself visually more obtrusive. This may be less important in a relatively industrial area.

Articulation

Bridges made integral between superstructure and abutments provide structural efficiencies and enable the elimination of bearings and expansion joints leading to improved durability of the bridge and reduction in whole life maintenance costs.

Fully integral or semi-integral construction may be adopted during the detailed design stage based on the capacity and type of foundations. A saw cut joint would be provided behind each abutment to accommodate the small movements and control reflective cracking. Run-on slabs are not considered to be necessary.

Figure C1 shows a "fully" integral connection between the bridge deck and abutment. This type of construction ensures a full moment connection between the bridge deck and abutment that reduces the bending moment in the span with possible savings in superstructure depth and capacity. Fixity or the moment connection is established by ensuring the bridge deck and beams are cast integrally with the abutment. Option-2 as described above is generally not suitable for this type of construction.

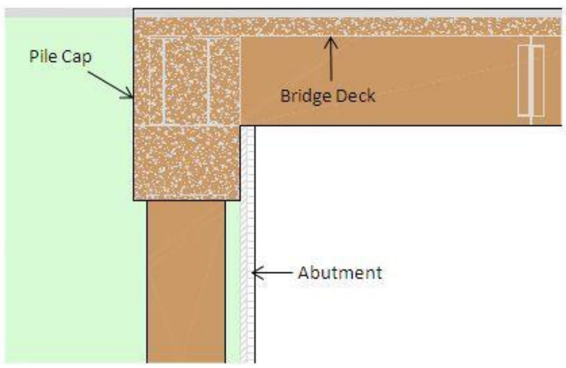


Figure C1 - Integral Abutment/Deck condition

Figure C2 shows a typical "semi-integral" bridge deck and abutment connection. In this form of construction, the flexure of the superstructure is not transferred to the abutment and bearings are installed between the bridge deck and the substructure to transfer vertical force but allow rotation of the deck relative to the abutment. So, for the semi-integral form of construction, there will be a maintenance activity associated with the use of bearings Hence, the semi-integral detail would be such that the bearings are in an enclosed environment that would not be subject to water ingress problems and accessible for inspection and maintenance. Both options 1 and 2 as described above are suitable for this type of construction.

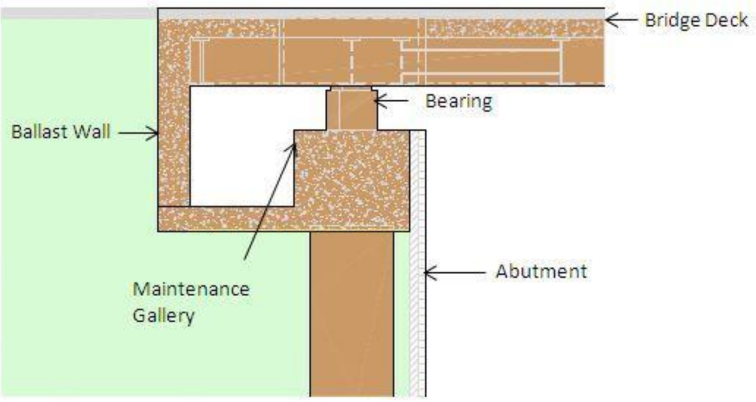


Figure C2 - Semi Integral Abutment/Deck Connection

Deck Materials

Steelwork

It is proposed to use either weathering or painted steel for the bridge deck beams and will depend on the final choice of the type of the structure.

Weathering steel is a low alloy steel that forms a protective oxide film or 'patina' that, in a suitable environment, seals the surface and reduces corrosion loss. Weathering steel does not require repainting, which obviates the need for road closure and provision of access. Hence, the use of uncoated weathering steel would be expected to give a lower whole life cost than the painted structural steelwork, because of reduced maintenance requirements. However, there are some concerns about aesthetics and long term durability.

In using weathering steel sections, allowance has to be made for the formation of rust and the resultant loss of structural section over the design life of the bridge, which would increase the steelwork tonnage relative to coated structural steelwork. However, previous experience indicates that the increased cost of the weathering steel is offset by cost savings resulting from elimination of initial painting costs.

There is a general perception that weathering steel may be less aesthetically acceptable than painted steel. However, use of weathering steel is becoming increasingly common in the UK and there has not been significant objection to its use by the public. It will be difficult and costly to properly maintain a paint system over a live carriageway and a poorly maintained painted option would be more aesthetically unpleasant during the design life of the structure.

However, the cost incurred in using weathering steel should be compared against the benefits to finalise the option of using weathering or painted steel. Therefore, both weathering steel and painted steel options should be taken forward for further consideration.

Weathering steel and painted steel options are both viable for Option-1. Weathering steel option is not proposed for Option-2 as the proposed bridge deck beams will be exposed directly to weathering action leading to rust staining.

Concrete

Concrete is proposed to be used to form the deck slab and the substructures.

The steel composite options as proposed for the bridge structure would require a reinforced concrete deck slab approximately 250 mm thick with precast concrete permanent formwork to the support the insitu concrete and any loads during construction. There are permanent formwork systems which are readily available that are considered to be participating formwork and therefore can be taken into account in the design of the deck slab accordingly.

The alternative forms for constructing the deck slab that can be considered are as follows:

- In situ concrete with traditional formwork supported either on the deck steel beams or from ground level. The formwork would need to be removed after the deck is cast. This form of construction may restrict the construction of the carriageway below and affect the overall programme.
- Glass reinforced plastic non-participating formwork – This option is considered to be more expensive than precast concrete participating formwork and does not contribute towards the strength of the deck slab.

Foundations

For reasons discussed in Section D, shallow spread footings have been discounted and contiguous piles or group piled foundations are considered appropriate.

Sustainability

Both concrete and steel are sustainable as they are durable and may be recycled as aggregate and scrap metal at the end of the life of the structure.

The depth of construction of the structure affects both land take and the quantity of materials required. However, the vertical alignment of the existing connectivity and the proposed tunnel restricts the depth of construction of the bridge to achieve compliant headroom clearance for the carriageway below.

Weathering steel options are considered more sustainable than the painted alternative due to the absence of the need to use paint chemicals during construction and future maintenance.

Section D

Ground Information

The following two studies were undertaken as part of this report:

- **Silvertown Tunnel Crossing: Re-Use Potential and Waste Characterisation of Arisings** study (see Appendix D)
- **Geotechnical Investigation Review and Analysis** study (see Appendix C)

The geotechnical report covers SOUTH4 (with and without bus links), SOUTH4A (preferred option), NORTH5A, NORTH5B, NORTH5C (preferred option). The full report is included in Appendix C. The Re-use Potential report is included in Appendix D. This section provides a summary of the key points identified in the two studies with relate specifically to SOUTH4A and NORTH5C (the preferred options).

Northern Site

General

The available historical exploratory boreholes recorded the presence of Made Ground, Alluvium, River Terrace Deposits and London Clay within the extents of the proposed earthworks. The Made Ground mainly comprised cohesive material that was described as soft to firm silty sandy Clay with some angular to sub-rounded gravel sized fragments of brick, chalk, concrete and flint. The maximum recorded depth of this material was 5.1m below existing ground level. Some of the exploratory holes recorded this material as Fill of ash, brick and gravel. The Alluvium was typically described as soft to firm silty Clay with occasional organic debris. The Alluvium deposits were recorded to underlay the Made Ground and extend typically between 3.8m and 6.5m below existing ground level with a thickness variation between 1.4m and 3.5m. The River Terrace Deposits were found to underlay the Alluvium and were typically described as loose to dense sub-angular to rounded sandy Gravel. This material was recorded to extend typically between 7m and 9.8m below existing ground level with a thickness variation between 2.3m and 4.3m. London Clay was found to underlay the layer of River Terrace Deposits and was typically described as stiff to very stiff fissured silty Clay. The thickness of this material was proven to vary between 13.5m and 18.5m with the base varying between 21.5m and 27.7m below existing ground level.

Groundwater levels vary between 1.8m and 4.8m below existing ground level, it should be noted that hydraulic continuity occurs between River Thames and the site through the River Terrace Deposits and therefore the groundwater level is expected to be influenced by the river level fluctuations.

Retaining Walls - The retaining walls proposed at the northern tunnel portal are to be developed by Mott MacDonald and are detailed in their complementary report "*Silvertown Tunnel: Further development of Tunnel Engineering (April 2013)*".

Contaminated Land – Whilst there is no relevant site data in the immediate vicinity of the north portal, two groups of exploratory holes have previously been excavated, located approximately 50m and 100m to the south east of the northern portal site.

The results of a screening exercise undertaken on recovered earthworks samples show that 14 out of the 31 samples within the Made Ground exceeded at least one of predetermined Soil Screening Values (SSVs) indicating that the material may present a risk to human health if re-used. In addition 17 of the Made Ground samples contained asbestos and therefore, may or may not pose a risk to human health depending on the percentage of asbestos and the manner in which it is re-used i.e. placed at a depth so that the pathway to human health is removed. Ten out of the 35 samples do not exceed the SSVs or contain asbestos indicating some of the Made Ground and the natural ground (Alluvium and River Terrace Deposits) material could be re-used.

A waste characterisation assessment was undertaken on samples that were identified as not suitable for re-use. The waste characterisation for the northern portal indicates that three out of the 14 samples would be classified as hazardous waste with the potential for an additional seven samples to be classified as hazardous as they contain asbestos. The remainder of the samples would be classified as non-hazardous.

Southern Site

General

The available historical exploratory boreholes recorded the presence of Made Ground, Alluvium, River Terrace Deposits and London Clay within the extents of the proposed earthworks.

The made ground is of granular consistency comprising either, clayey Sand with fragments of brick, concrete and flint or, as concrete, ash and sand. The cohesive portion of the Made Ground was described as soft to firm sandy Clay with gravel sized fragments of brick, concrete and flint. The maximum recorded depth of this material was 5m below existing ground level. The Alluvium layer comprises soft to firm Clay with occasional small pockets of peat and soft clayey Peat. The Alluvium deposits were recorded to underlay the Made Ground and extend typically between 4.2m and 6.5m below existing ground level with a thickness variation between 1m and 5m. The River Terrace Deposits were found to underlay the Alluvium and comprises medium dense to dense sandy Gravel. This material was recorded to extend typically between 10.7m and 11.7m below existing ground level with a thickness variation between 5.1m and 7.4m. London Clay was found to underlay the River

Terrace Deposits comprising very stiff fissured silty Clay. The thickness of this material varied between 3.3m and 13m, with the base varying between 14m and 25m below existing ground level.

Groundwater levels vary from 1.5m to 4.5m below ground level. Hydraulic continuity occurs between River Thames and the site through the River Terrace Deposits and therefore the groundwater level is expected to be influenced by the river level fluctuations.

Recommendations of Structural Elements

Curtain cut off wall - There are a number of significant risks associated with ground conditions throughout the site which include:

- High water table hydraulically connected to the River Thames
- High permeability materials which may lead to slope instability;
- Potentially contaminated groundwater.
- Heave risk within the London Clay due to unloading of overburden
- Water ingress through movement/expansion joints;
- Up-thrust from groundwater displaced by concrete slabs connected to retaining walls.
- To mitigate these risks it is proposed to construct:
- Water tight secant, diaphragm or part slurry barriers creating an overall curtain cut off wall.
- Sealed concrete slab road pavement connected to secant pile/diaphragm walls

Bridge foundations - These have been designed such that they can form part of the waterproof curtain wall arrangement as appropriate. The following conceptual design has been determined based on preliminary loadings derived for an integral bridge deck construction.

- South abutment: secant piles 1m diameter installed by Continuous Flight Augur (CFA) in a row of 10m width up to capping beam elevation integral with bridge. Total pile length = 18m (12m embedment length and 6m retained height).

- North abutment: secant piles 1m diameter installed by CFA in a row 10m width (12m embedded length with an additional 2.5m to the pile cap above design groundwater elevation. Total pile length = 14.5m. Sleeved piles are proposed supporting the integral bridge deck to be constructed above the secant pile cap inside a Reinforced Earth wall.

It is proposed that rectangular steel reinforcement cages are adopted to eliminate risk of the auger blade damaging the installed cages during construction of adjacent piles.

Retaining Walls - The retaining walls proposed at the southern tunnel portal are to be developed by Mott MacDonald and are detailed in their complementary report "*Silvertown Tunnel: Further development of Tunnel Engineering (April 2013)*".

A further retaining wall is proposed west of the Docklands Light Railway Bridge with a maximum retained height of 3m. The retaining wall is expected to be founded within the soft Alluvium material and the following retaining wall options were considered:

- Reinforced concrete wall or modular retaining wall system constructed on short piled (up to 2.5m long) foundation to transfer loads to the River Terrace Deposits. However it may be possible to achieve sufficient stability and minimise differential settlement issues by over excavating soft deposits and replace with high friction material.
- Over excavation and construction of geo-grid reinforced earth slope with a maximum slope angle of 70 degrees. As with the retaining wall option over-excavation of soft material and replacement with high frictional material may be required to ensure stability.

Provided that sufficient land take is available the most cost effective option will involve the construction of the steepened geo-grid reinforced earth slope that will utilise up to 4m long geogrid reinforcement at 0.5m vertical spacing.

Contaminated Land Issues – Previous ground investigations have provided no chemical data for soil samples within the areas of cut excavation, within 100m of the southern portal boundary It is therefore not possible to assess if the cut excavation material would be suitable for re-use. For the purposes of this study it has been assumed that all of the “made ground” is contaminated similar to the extent identified at the northern site.

Section E

Environmental Issues

A detailed environmental study is beyond the scope of this report, however the following section attempts to review the impacts and mitigation measures likely to arise specifically as a consequence of the proposed highways interface to the Silvertown Tunnel.

Existing Development Plans

The southern junction sits on the Greenwich Peninsula in the Royal Borough of Greenwich. The Peninsula Master Plan envisages the development of a new entertainment/sports complex to the west of the Blackwall Tunnel Approach with a mixed development of high quality commercial and residential properties throughout the peninsula. The A102 corridor is seen to divide the peninsula and a significant source of noise and air pollution.

The northern junction sits in the London Borough of Newham. The current development plans for the area seem to focus on the Silvertown Quays to the east of Silvertown Way for mixed residential and commercial development.

Archaeology

The flood prone nature of this area has left it largely undeveloped until the 19th century. Development was then largely industrial making use of the wharfage for imports and exports.

There are two significant buildings in the vicinity of the southern junction:-

- The Tunnel Gatehouse
- The Gasometer

The gatehouse was built in 1897 and is a Grade II listed building. Neither the Gatehouse or its immediate environment is affected by the current proposals. The gasometer to the east of the proposed junction is also unaffected, but is identified in the Masterplan as a structure to be maintained as an important historical impact. It is not considered that either of these buildings is adversely affected as a consequence of these proposals. There are no significant buildings in the vicinity of the north junction.

As a consequence of the above, it is not believed that the development of these junctions will have any archaeological significance.

Noise and Vibration

The primary impacts of noise and vibration arising as a consequence of the highway interfaces will result from:

- Construction plant and methods of construction.
- Temporary displacement of traffic during the construction phase.
- Increased traffic flow as a consequence of the Silvertown link.

There are no residential areas within 400 metres of the southern junction. At the northern junction there are residential properties within 200 metres of the site, however these are separated from the works area by the Silvertown link. Normal measures to limit construction noise and vibration such as noise and vibration suppressed equipment, working methods and controlled working hours will mitigate/eliminate this problem. It is likely that the removal of the pedestrian footbridge which spans the Blackwall Tunnel Approach on the Greenwich Peninsula will need to be undertaken overnight during road closures and will need careful consideration during the design and construction phase. Noise constraints should be discussed and agreed with the Environmental Health Department at the Royal Borough of Greenwich and Newham Councils at the detailed design stage.

Careful design of the highway interface will minimise the need for temporary traffic management and road closures, thus reducing the risk of displaced traffic causing disruption in the area. The necessary closure of Millennium Way to facilitate the construction of the Silvertown Tunnel will increase traffic using John Harrison Way to reach the O2 building and this may result in some limited disturbance to the adjacent flats. There is little disruption to existing traffic patterns during the construction of the north junction.

The future plans for mixed commercial and residential development on the Greenwich Peninsula will require careful consideration during noise modelling which is beyond the scope of this report. In qualitative terms, the links to the Silvertown Tunnel at the south junction will largely be constructed in troughs, to eliminate the risk of excessive groundwater ingress. This will have the added advantage of reducing noise pollution from these links which may be combined with further mitigation measures such as noise barriers or noise suppressant facings to the retaining structures. Further mitigation to reduce current noise levels arising from the existing traffic using the A102 such as the development of landscaped green swards may be possible, but have not been considered as part of this study and may be more appropriately dealt with in the master plan for the strategic development of the peninsula. Traffic flows will increase significantly on the Tidal Basin roundabout at the north junction and it may be possible to mitigate some of the resulting increase in noise by landscaping although the scope may be limited.

Air Quality

The Royal Borough of Greenwich has designated the entire borough as an Air Quality Management Area, with the Greenwich Peninsula being identified as an area where levels of Nitrogen Dioxide (NO2) and particulate matter with a mean aerodynamic diameter less than 10 µm (PM10) already exceed required standards. The council's Air Quality Action Plan specifically identifies the reduction of emissions of traffic using the A102 as an area for action in conjunction with TfL.

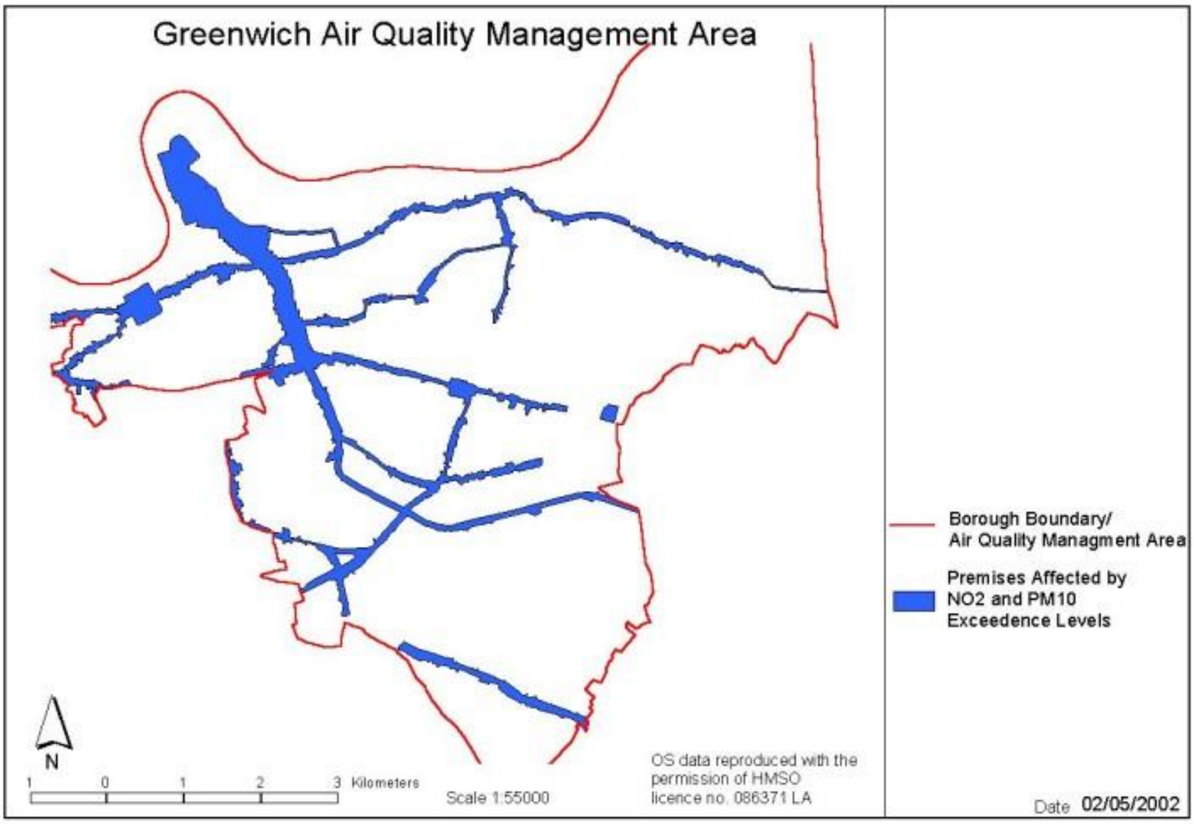


Figure E1 – Greenwich Air Quality Management Area

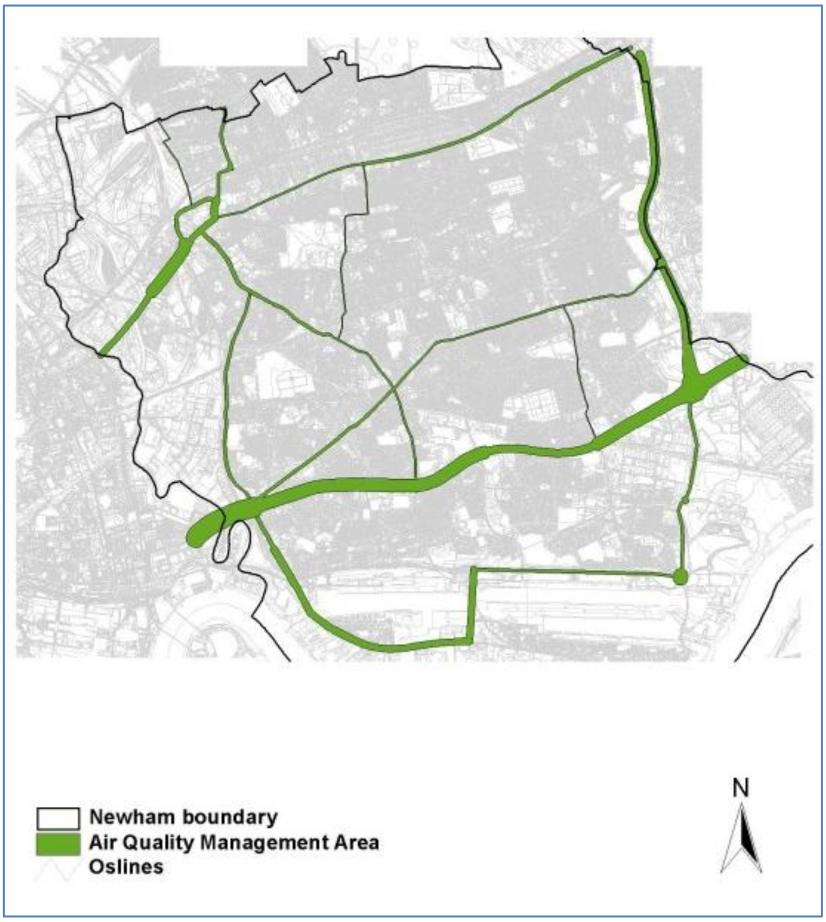


Figure E2 - Greenwich Air Quality Management Outlines

Improved traffic flows and reduced congestion resulting from the opening of the Silvertown Tunnel may help to improve the air quality on the Greenwich Peninsula but is likely to increase it in the vicinity of the Tidal Basin Roundabout and the Lower Lea crossing. The imposition of tolls on the Blackwall and Silvertown Tunnel may reduce demand and reduce displaced traffic from the Dartford River Crossing. An air quality assessment model should be developed. This assessment should be undertaken as part of the Environmental Impact Study.

It may also be possible to reduce the increase in NO_2 caused by increases in traffic volumes by the use of Photo-Catalytic coatings (such as Titanium Dioxide TiO_2) on the retaining structures on the approach to the Silvertown Tunnel portals, however further research and analysis would need to be undertaken to determine the cost effectiveness of this approach.

When TiO_2 is exposed to the ultraviolet light in sunlight, electron excitation occurs which releases hydroxyl radicals (OH) and the superoxide O_2^- from water and atmospheric oxygen in the following sequence of reactions.

- $H_2O \rightarrow H^+ + OH$ (hydroxyl radical) + e^-
- $O_2 + e^- \rightarrow O_2^-$ (a superoxide ion)

The overall reaction is therefore:

- $H_2O + O_2 \rightarrow H^+ + O_2^- + OH$

The hydroxyl radical can oxidize nitrogen dioxide to nitrate ions:

- $NO_2 + OH \rightarrow H^+ + NO_3^-$

The superoxide ion is also able to form nitrate ions from nitrogen monoxide:

- $NO + O_2- \rightarrow NO_3^-$

The nitrate ions are harmless and washed away. There are a number of products on the market such as Hanson's TioCem® which is a cement product containing Titanium Dioxide. This cement or similar products could be used in the upper layer of a concrete road pavement. On the retaining structures it may be more effective to apply a TiO_2 coating.

The price of Titanium Dioxide products has increased significantly over the last few years and therefore quotations should be obtained, if this is considered to be an option, nearer the time of its use. However current research suggests that its inclusion may increase pavement costs by around 10%.

Research into the effectiveness of TiO_2 in the field appears to be quite varied with ranges from 5% to 45% reduction in NO_2 levels depending on its application; however a full search of relevant research papers is beyond the current scope of this study.

Ecology

The tunnel portal and the link roads from the south junction obliterate an area of derelict land that appears to be heavily overgrown with a mixture of small trees and scrub. It is bound by paved areas including the Blackwall Tunnel Approach to the west, Millennium Way to the east, the Gasometer site to the south and an industrial site to the north. It is over 500m from the Greenwich Peninsula Ecology Park and an ecological walkover survey will be required to see and if there are any protected or notable flora or fauna in the area such that are known for inhabiting derelict areas in urban and industrial areas such as the Black Redstart. It is recommended that the site is cleared of trees and shrubs before the bird nesting season immediately prior to the construction of the works. The remainder of the south junction is being constructed within the corridor of the A102 Blackwall Tunnel Approach and is unlikely to be of ecological interest.

The north junction at tunnel approach roads impacts on a small area of derelict land that is entirely surrounded by the cement works and the embankments of the Docklands Light Railway. Again an ecological walkover survey will be required to see and if there is any protected or notable flora or fauna in the area.

None of these sites are identified on the Greenspace Information for Greater London plans. All derelict areas will need to be assessed for any invasive or injurious plant species on the site. A full ecological assessment has not been undertaken as part of this study.

Ground Conditions & Contamination

Geotechnical conditions and contamination issues are discussed in Section D of this report.

Drainage Strategy and Flood Risk

The Greenwich Peninsula has been identified as being in a flood risk area but is currently protected by river walls. The London Regional Flood Risk Assessment identifies that these walls may need to be raised beyond 2030. Both the Silvertown Tunnel and the Blackwall Tunnel will have a particular risk as their portals and ventilation shafts are within the tidal Thames flood risk zone.

In addition to the flood risk from the tidal Thames, the permeability of the flood plain alluvial layers makes ground water infiltration a possible risk. This will be mitigated by constructing all carriageways that are below the water table in concrete “troughs”, which comprise diaphragm walls and concrete ground slabs.

Surface water run-off from the new carriageway paved areas will be collected by a positive drainage system with storage capacity provided in the form of oversized pipes. At both junctions there will be two distinct surface waters systems. The higher level carriageways will be drained to an upper level storage system and connected into the existing highway drains with discharge limited to existing flow rates or less. Pollution control measures in the form of oil interceptors or other agreed facilities will be installed. Where the carriageways fall below the level of the existing drainage networks a second, lower level storage system will be provided, which will then discharge into the surface water sumps at the tunnel portals. The surface water storage will be designed to be sufficient to prevent the sump and tunnel pumps being overwhelmed on an agreed storm return period (1:100 years or greater).

Section F

Preliminary Works Programme & Construction Phasing

Preliminary Works Programme

A preliminary works programme (see Appendix E) has been prepared in conjunction with Mott MacDonald to identify the likely sequences and interdependencies between the tunnelling work and the highway infrastructure work. The programme has been built up using the main works phases identified in the following section. This report focuses on the highway infrastructure but the programme has been created holistically. The highway infrastructure work requires a shorter timeframe than the tunnelling work although the phasing is considerably more sensitive due to the highway interface.

Construction Phasing

The key parameters considered in the construction phasing of the Silvertown Tunnel and associated infrastructure works are:

- the site compound and construction areas necessary for the construction of the tunnel itself
- disruption to the strategic traffic route through the Blackwall Tunnel
- local connections, particularly, but not limited to, the access to the O2 Arena
- temporary works to facilitate construction, including ramps to accommodate level changes

Consideration of these parameters in relation to this stage of the design process has been limited to the main works phases, sufficient to ensure that the options are buildable and that the timetable for construction is realistic.

Southern Junction

The southern junction can be constructed in 4 overarching phases (See Appendix E and drawings 5110309/HW/UT/0119, 0120, 0121 and 022). Phases 1, 2 and 3 will see tunnelling and highway infrastructure work being undertaken concurrently. Phase 4 can only be completed once the muck-handling operations associated with the tunnel are finished.

Phase 1

Phase 1 comprises the construction of the realigned southbound carriageway from Blackwall Tunnel including the construction of the new bridge over the Blackwall Tunnel Approach to Silvertown Tunnel Link. This phase runs concurrently with the main tunnelling works and the primary features include:

- temporary road construction to provide an alternative route to the severed Millennium Way – this will need to be complete before the main tunnelling works get underway and has therefore been programmed as the very first activity;
- the construction of the bridge, which needs to span the Silvertown link with the minimum possible clearance to facilitate the tie in of the carriageway to the existing Blackwall Tunnel Approach. As a consequence two options have been considered for the bridge deck to provide a lower profile if required during the detailed design;
- the construction of the realigned southbound A102 carriageway, tying in to the existing A102 via the new bridge – some overnight lane closures may be required to facilitate the tie-in of the proposed to the existing carriageway using temporary ramping;
- the demolition of the existing footbridge which crosses the Blackwall Tunnel Approach in the vicinity of Boord Street. The footbridge comprises a reinforced concrete deck, with piers either side of the main carriageway. Its demolition will require it to be temporarily supported and cut into segments which can then be craned away. The design of the temporary works will need to ensure that sufficient clearance to the carriageway is maintained at all times. Some overnight road closures are inevitable as the bridge deck is removed;
- the installation of the diaphragm walls for the construction of the “troughs” to the east of the Blackwall Tunnel Approach that will contain the lower level carriageways and prevent the infiltration of ground water into the tunnel;
- the temporary diversion of buses heading southbound on the Blackwall Tunnel Approach wishing to exit into Boord Street, south to the A2203/Millennium Way Roundabout;
- the partial construction of the southern end of the Silvertown Tunnel southbound link road from the nosing of its merge with the Blackwall Tunnel Approach beyond its junction with Boord Street; and
- the partial construction of the bus link from Millennium Way to the tunnel portal.

On completion of this phase the southbound traffic from the Blackwall Tunnel will be moved onto the new southbound carriageway and the junction with Boord Street will be re-opened in its new configuration. A new footbridge will need to be constructed on an alignment which is yet to be determined and is dependent on the future development plans for the peninsula.

Phase 2

Phase 2 is a minor phase comprising works to the central reserve of the Blackwall Tunnel Approach in the vicinity of Boord Street and will run concurrently with tunnelling works.

The primary features of this phase include:

- the removal of the central reserve barriers, kerbs and concrete infill and its replacement with full depth pavement construction; and
- the installation of temporary safety barriers.

This phase is to enable northbound traffic to be moved away from the western edge of the Blackwall Tunnel approach to facilitate construction works reconnecting Tunnel Avenue and realignment of the northbound approach to Blackwall Tunnel.

Phase 3

During Phase 3, the north- and southbound traffic lanes are moved eastwards taking advantage of the Boord Street off-slip constructed in Phase 1 and the hardened central reserve constructed in Phase 2 to provide access for the construction of Tunnel Avenue and works to the northbound carriageway of the Blackwall Tunnel Approach.

The primary features of this phase include:

- northbound traffic being diverted onto the original southbound carriageway of the Blackwall Tunnel Approach, rejoining the northbound carriageway immediately before the northbound tunnel gateway structure. Facilities will have to be provided within the works area for dealing with prohibited vehicles;
- realignment of the northbound carriageway; and
- works to join up the two sections of Tunnel Avenue.

On completion of this phase the A102 (Blackwall Tunnel Approach) will be operating in its final configuration.

Phase 4

Phase 4 is the final major phase of the southern junction and comprises the construction of the link roads to the Silvertown Tunnel portal. The prerequisite to this phase is the completion of the major earthworks and civils work associated with the tunnel construction. The Primary features of this phase comprise:

- completion of the diaphragm walls to the west of the southbound carriageway of the A102;
- excavation of the bulk earthworks;
- construction of the reinforced concrete base slab to prevent the ingress of water into the lower level carriageway areas;

- reinstatement of Millennium Way and Edmund Halley Way over the top of the cut-and-cover section of the tunnel;
- construction of the A102 central reserve; and
- any other remaining finishes.

On completion of this phase the southern junction will be fully operational awaiting the formal opening of the tunnel.

Temporary Diversions

During the construction of the cut-and-cover section of the Silvertown Tunnel, Millennium Way will be severed south of Edmund Halley Way. To facilitate connection to the O2 Arena it is proposed to:

- Divert traffic at the A2203/Millennium Way Roundabout and then northeast along John Harrison Way and then north along West Parkside
- Construct a temporary 2 way single carriageway road abutting the northern perimeter of the tunnel construction compound, effectively realigning Edmund Halley Way to restore the connection to Millennium Way north of the severance
- Construct a turning facility at the severed end of Millennium Way
- Provide a new access to the car park adjacent to the O2
- Provide appropriate signage

This temporary arrangement will remain in place until the tunnel construction compound is removed and Millennium Way is reconnected.

Northern Junction

The northern junction can be constructed in 3 overarching phases (See Appendix E and drawings 5110309/HW/GA/0220, 0221 and 0222). Phases 1 and 2 will see tunnelling and highway infrastructure work being undertaken concurrently. Phase 3 can only be completed once the muck-handling operations associated with the tunnel are finished.

Phase 1

Phase 1 comprises the construction of the elongation of the Tidal Basin Roundabout. This phase runs concurrently with the main tunnelling works and the primary features include:

- traffic using the existing roundabout with no alterations to the existing configuration other than temporary arrangements to facilitate working areas at the carriageway tie-in points;

- construction of the elongated circulatory carriageway of the Tidal Basin Roundabout;
- construction of the Lower Lea Crossing realignment to the tidal basin roundabout; and
- construction of the link to Dock Road.

Following this phase traffic will be diverted onto the elongated roundabout and the new link to the westbound carriageway of the Lower Lea Crossing will be opened.

Phase 2

Phase 2 comprises the construction of the hamburger link on the Tidal Basin roundabout and its connection to the Lower lea Crossing. This phase runs concurrently with the main tunnelling works and the primary features include:

- the completion of the southbound link from the Lower Lea Crossing to the Hamburger Link at the Tidal Basin Roundabout;
- the construction of surface water storage facilities in the centre island of the Tidal Basin Roundabout; and
- the installation of the traffic signals, although the roundabout will not require signal control until Phase 3 of the works are complete and the tunnel is opened.

Phase 3

Phase 3 comprises the completion of the carriageway works joining the Tidal Basin Roundabout to the Silvertown Tunnel and the construction of the Dock Road Link. The prerequisite to this phase is the completion of the major earthworks and civils work associated with the tunnel construction. The primary features of this phase comprise:

- the removal of the redundant carriageway from the elongated Tidal Basin Roundabout circulatory carriageway;
- construction of the north and southbound carriageways linking the Tidal Basin Roundabout to the Silvertown Tunnel; and
- construction of the Dock Road link.

On completion of this phase the northern junction will be fully operational awaiting the formal opening of the tunnel, however after opening of the tunnel the signal controllers will need calibration to ensure that performance is optimised.

Temporary Diversions

During the construction of the tunnel, Dock Road is severed by the cut-and-cover tunnel section and the compound including conveyor systems linking the works to the Thames Wharf. This will also sever the only highway access to the Wharf and waterfront businesses. To facilitate connections it is proposed to:

- close Dock Road and provide a turnaround facility at the severed end adjacent to the tunnel site compound;
- divert traffic northbound along Silvertown Way to the Tidal Basin Roundabout; and
- construct a new temporary link through the Brewsters Waste Management Site to connect the wharf and waterfront businesses to the Dock Road spur (subject to agreement).

This temporary arrangement will remain in place until the tunnel construction compound is removed and Dock Road is re-connected.

Section G

Statutory Undertakers' Plant

There is an extensive network of underground statutory undertakers' plant within the vicinity of both the northern and southern sites of the Silvertown Tunnel. The diversion of the affected plant will require significant consideration and coordination. A Preliminary Enquiry (C2) has been made to statutory undertakers under the New Roads and Street Works Act (NRSWA) 1991. Appendix F of this document contains composite plans for both the northern and southern sites, showing the approximate positions of all declared utility plant.

The affected parties are likely to include those identified in the table below, although this may not be an exhaustive list:

Statutory Undertaker	Description	Affected?	
		Silvertown	Greenwich
BT	Telecommunications	YES	YES
Cable and Wireless	Telecommunications	YES	NO
Environment Agency	Water Authority	YES	YES
Envoy	Gas	NO	YES
Gas Transportation Company	Gas	YES	NO
Global Crossing/Interoute	Telecommunications	YES	NO
London Borough of Newham	Telecommunications	YES	NO
National Grid Gas	Gas	YES	YES
Network Rail	Telecommunications	YES	NO
Southern Gas Networks	Gas	NO	YES
TATA	Telecommunications	YES	NO
Thames Water	Sewerage and Water Main	YES	YES
Traffic Master	Telecommunications	NO	YES
Transport for London	Telecommunications	YES	YES
UK Power Network	Electricity (11kV & LV)	YES	YES
Virgin Media	Telecommunications	YES	YES

Table G1 – Statutory Undertakers

Drawings 5110309/HW/UT/0029 and 5110309/HW/UT/0028 (Appendix F) identify proposed corridors for the utility diversions for both the southern and northern sites. The principle of the corridor is to have all plant diverted along the same route in the same trench with the appropriate spacing. The layout of the utility corridor, especially in terms of spacing between differing plant, has been created using guidelines provided by the National Joint Utilities Group (*Volume 1 – Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus*) to avoid problems, including electromagnetic interference.

The route is indicative and consideration will need to be given to water pipes, sewers and other plant that have limited minimum radii. Local connections have been omitted. A cost estimate for the diversion work is included in Section H and is based on historical unit rates for different types of utility diversion works.

All diversionary work will need to take place ahead of the main works and a duration of up to 24 months should be allowed for site work.

Section H

Preliminary Works Cost Estimate

The preliminary works cost estimate for the Silvertown Crossing proposal, including the bored tunnels and highway proposals NORTH5C and SOUTH4A, totals **£462,941,962**. This figure excludes an allowance for contingency, risk and Optimism Bias, which TfL will consider at the appropriate stage of the project.

The estimate has been prepared in three parts as follows:

- **Highway Infrastructure Works** – developed by Atkins as part of this report
- **Tunnelling Works** – developed by Mott MacDonald in the *Silvertown Tunnel: Further development of Tunnel Engineering (April 2013)* report
- **Construction Preliminary Costs** – developed in collaboration between Atkins and Mott MacDonald to cover both elements of the scheme

The total scheme costs are tabulated in Appendix G, which is in the estimation format requested by TfL.

Highway Infrastructure Works

The rates used to compile the works cost estimate have been collated from previous works contracts (adjusted to 2013 equivalent rates) and using Spon's Civil Engineering and Highway Works Price Book (2013). The Highway Infrastructure Works cost estimate includes for the entire infrastructure associated with this scheme beyond the tunnel portals, with the exception of the diaphragm retaining walls, the reinforced concrete slab under the carriageway and the drainage sumps and pumping stations at the portals (see *Tunnelling Works*). Table H1 identifies the key elements, quantities and rates for the highway infrastructure.

Costs associated with providing free-flow tolling are not included in this estimate, nor are client costs associated with defining and promoting the scheme and obtaining approvals.

DESCRIPTION	COST* (2013)	COMMENTS	SECTION OF ESTIMATE
Preliminaries - Temporary Road Construction & Traffic Management	**£2,220,700**	*All other preliminary costs are included in the summary sheet but not separately identified*	
Site Clearance	**£615,135**	*Includes for the demolition of the footbridge*	*Tab A1 Series 200*
Safety Fencing & Guardrailing	**£293,640**		*Tab A1 Series 400*
Earthworks – Excavation	**£1,249,779**	*Includes excavation, deposition and compaction*	*Tab A1 Series 600, as described*
Earthworks – Disposal	**£10,997,640**	*Includes disposal of contaminated made ground*	*Tab A1 Series 600, as described*
Drainage & Service Ducts	**£1,674,160**	*Excludes the drainage sump and pumping station at the tunnel portal*	*Tab A2 Series 500*
Pavements	**£3,717,011**	*Includes the reinstatement of Millennium Way and Edmund Halley Way*	*Tab A2 Series 700*
Kerbing, Footways & Edgings	**£271,650**		*Tab A2 Series 1100*
Structure – Road Bridge	**£2,079,650**	*Includes structural elements only – other elements in the respective sections above*	*Tab B Under 'Two lane overbridge'*
Structure – Footbridge	**£2,500,000**	*Allowance rather than estimate as requirements for footbridge to be determined*	*Tab B Under 'Pedestrian footbridge'*
Structure – Gantries	**£1,765,760**	*Includes for five gantries in total*	*Tab B Series 1800*
Street Lighting, Signing & Landscaping	**£624,740**		*Tab E Series 1200, 1300 & 3000*
Statutory Undertakers' Allowance	**£9,018,000**	*Subject to significant change*	*Tab E Under 'Utility Diversion North & South'*
Accommodation & Facilitation Works	**£885,000**	*This allowance is included for minor works to existing infrastructure to facilitate the tunnel*	*Tab E*
** The costs do not include Optimism Bias, Contingency or Risk Allowance*			

Table H1: Highway Infrastructure Works Costs

Tunnelling Works

The tunnelling element has been developed by Mott MacDonald in the *Silvertown Tunnel: Further development of Tunnel Engineering (April 2013)* report, where further details can be found. The diaphragm retaining walls, the reinforced concrete carriageway slab, the drainage sump at the portals and pumping installations are included within this element of the preliminary works cost estimate. Appendix G contains a summary of the scheme costs as a whole.

Construction Preliminary Costs, Contingency and Optimism Bias

Atkins has worked with Mott MacDonald to identify and coordinate costs that affect both elements of the project. The preliminaries include the setup costs of the site compound and accommodation, which are substantial due to the extensive earthworks involved. These costs have been combined to ensure no duplication. The traffic management allowance and the temporary road construction cost have been identified separately within the Preliminaries. Contingency and Optimism Bias are not included in the identified costs at the request of TfL and will need to be considered at a later stage.

Risk Allowance

The following risks were identified during a Risk Workshop undertaken by Atkins and Mott MacDonald. These risks have been used to calculate a risk value using the @RISK software, a Monte Carlo simulation risk tool, which is currently excluded from the budget costs. For further details of the risk process, please see the Mott MacDonald *Silvertown Tunnel: Further development of Tunnel Engineering (April 2013)* report.

Table H2: Silvertown Tunnel Project Risks

Silvertown Crossings – Project Risks		
Category	**Risk description**	**Mitigation**
Planning & Consent	Failure to obtain powers and conflicting development requirements.	Engagement with all stakeholder parties High level or political influencing Design & Mitigation to reduce potential of objections
	Potential for buildings within safeguarded area on Silvertown side to become listed.	Block listing.
	Project delay giving rise to increased development immediately adjacent to tunnel route.	Establish a safeguarded zone. Expedite planning and construction.
	TfL may have to purchase additional land parcels	Allow additional costs (up to £10-12m) as part of client estimate.
Stakeholders	Compromise on safeguarded area and access requirements.	More detailed construction planning required.
	Additional measures required to avoid objections from the PLA (may need to interface with PLA on ground treatment above the tunnel)	Continued liaison with PLA.
	Additional measures required to avoid objections from the LFB. Minimum cross-passage spacing, fire suppression system. Other measures.	Agreement reached, residual risk captured in risk assessment.
	Additional measures required to deal with close proximity of LCC.	Parameters now known and incorporate in the design
	Additional measures required to deal with close proximity of DLR.	Ongoing interface with DLR residual risk captured in risk assessment
	HSE do not permit construction with safety exclusion zone from gas holder on Greenwich Peninsula	Early liaison with HSE
	Additional measures required to deal with close proximity of other stakeholders. E.g. to remove gas works structures.	Ongoing interface with Stakeholders residual risk captured in risk assessment
Environment	Additional measures required to avoid objections from the EA. Impact on marine life, river bed, contamination etc.	Continued liaison with EA. Allow additional cost.
	EA does not allow jet grouting beneath the riverbed to facilitate cross passage construction because of cement and mud pollution.	Early consultation with EA.

Silvertown Crossings – Project Risks		
	EA may object to piling through remediated land with ground membrane.	Allow additional cost and programme for alternative solution.
	Additional measures required to avoid objections from Nature England, Marine Management, Green organisations etc.	Continued liaison. Residual risk captured in risk assessment.
	Objections due to pollution, noise, dust, light, traffic management, 24 hour working etc.	Additional mitigation measures in the cost estimate, residual risk in risk model.
	Increase in amount of contaminated material.	Allowances made in the cost estimate based on recent surveys
	Thames River to be classified as Marine Conservation area resulting in more stringent controls and regulations.	Monitor, not believed to have a major impact
	Flooding of tunnel during construction and operation.	Consider flood prevention further during detail design.
	Thames flood defences are breached and tunnel is flooded.	Locate critical equipment above flood level e.g. tunnel standby generator
Design and Approvals	Design, scope creep due to conditions imposed by stakeholders, third parties, design development, scheme development, site Investigation works, procurement etc.	Ongoing liaison with stakeholders, residual risks captured in the risk assessment (e.g. Fire Suppression System and additional cross passages)
	ADR category E is changed which may increase fire life safety requirements and pumping requirements.	Risk of needing to provide additional ventilation, tunnel size, additional pumping etc allowed for in the risk model.
	Design for 100MW fire increased to 200MW fire.	Residual risk in needing Fire Suppression
	Change to legal requirements and standards or key design parameters.	Regarded as a small residual risk
	Green-wave cannot be achieved at exiting portals.	Not a problem with current design
	More stringent requirements for discharge of drainage water required.	Covered in base costs and estimating uncertainties, further surveys to be carried out at detailed design stage
	More elaborate launch chamber required to launch TBM on a curved alignment.	Current solution believed to be firm
	Blow out or failure due to low ground cover to bored tunnel crown.	Detailed Site Investigation and if shown necessary ground treatment. Provide protection at river bed.
	TBM failure during tunnel excavation.	Good TBM spec, TBM intervention at mid-point.
Construction	Hard layers in ground slowing TBM advance and excessive wear on cutters.	More SI, Good TBM spec, TBM intervention at mid-point.
	Encounter obstructions during TBM excavation.	Reasonable estimate allowed for in the base cost. Further surveys to be carried out.
	Encounter obstructions during piling and constructing diaphragm walls.	Reasonable estimate allowed for in the base cost. Further surveys to be carried out.
	Utility diversions required are greater than anticipated.	Further surveys needs to be undertaken in the next design phase.
	Unexploded ordnance encountered.	Carry out specialist survey and identify risky locations and clear them in advance of starting the works.
	Hard material may be encountered during dredging / piling	Further surveys needs to be undertaken in the next design phase.

Section I

Wider Transport Strategy (including Green Wave)

Normal Traffic control

The overall signal staging for the Tidal Basin Roundabout will be as shown below, but actual timings, and precise details of the Method of Control, including pedestrian facilities, will be developed during detailed design. The key driver for the signal timings will be to minimise the traffic queue in the northbound tunnel. The lack of signals on the approach to the northbound tunnel from Greenwich means that there is no facility to regulate the flow (unlike the approach to the southbound tunnel), making the Tidal Basin Roundabout the only control mechanism. As a consequence, traffic from Tidal Basin Road and the off slip from Silvertown Way could experience longer queues. It may be necessary for operational reasons to provide a “gate” facility on the approach to the northbound tunnel as there is for the Blackwall Tunnel.

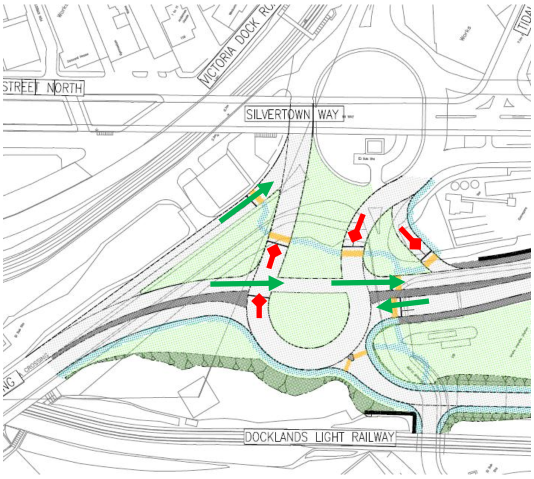


Figure I1 - Stage A

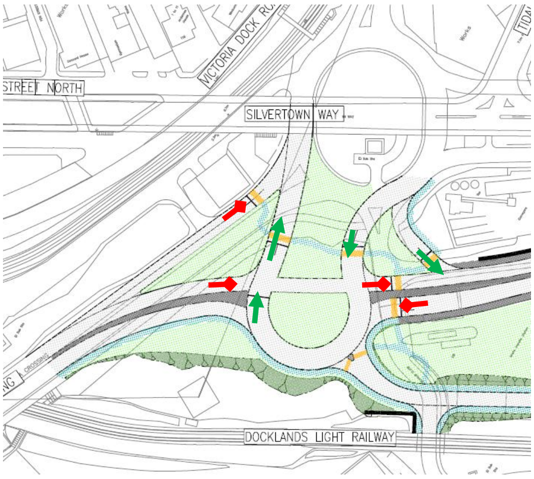


Figure I2 - Stage B

At the south end of the tunnels the egress from the Silvertown Tunnel at its junction with the Blackwall Tunnel Approach will be free flowing with grade separation.

There is an aspiration by London Buses, to use the Silvertown Tunnels for buses. The tunnel geometry accommodates two full sized lanes in each direction with no restrictions on height. An indicative access route from North Greenwich has been included to ensure that it can be accommodated, however further demonstration will be required of the operational robustness of the bus merge, given the geometry of the link between the bus access way and the main northbound carriageway to the tunnel.

There is one signal controlled junction downstream of the Silvertown Tunnel on the A102 South at Blackwall Lane. The green time allocated to the exit slip from the A102 will be adjusted to minimise the risk of queuing back onto the main road.

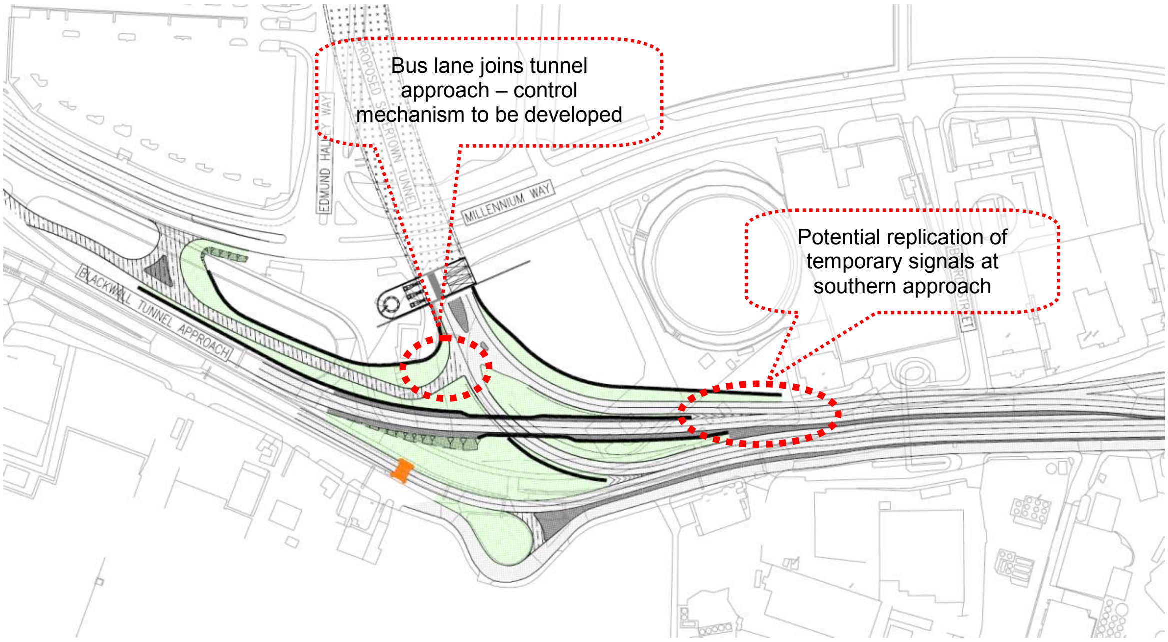


Figure I3 – Traffic Management Considerations

Nomenclature

The new tunnels will in effect be Blackwall tunnel bores 3 and 4, albeit that they emerge at different locations at the north end. For the purposes of both local and wider traffic management it would make sense to designate the combined four bores as a single entity - the "Blackwall Crossing" and to designate the four bores as Blackwall Tunnel Northbound, Blackwall Tunnel Southbound, Silvertown Tunnel Northbound and Silvertown Tunnel Southbound.

For destination signing on the strategic road network, it is envisaged that "Blackwall Crossing" would be used, (say south of the A2 and north of the A13) and the individual tunnel bore names would be reserved for tactical, operational use. This follows the convention at Dartford where the term Crossing is used strategically and Bridge and Tunnel used locally.

Emergencies

Given the choice of the cross passage strategy any emergency in either bore will require the closure of the other for escape and emergency access.

In the event of a significant incident the immediate requirement is to allow the traffic in both tunnels to clear and to manage the approach traffic to allow the emergency services to get to the scene. These simple objectives underpin the strategies needed to manage the outcomes of the incident including medical and other interventions required at the scene before the injured are evacuated.

The timeframes are thus:

- Short Term – Clearance of Traffic and Emergency Access
- Medium Term – Crisis Management
- Long Term – Recovery and Repair

In the short term strategy the northbound tunnel will be cleared by maximising Stage A at the Tidal Basin Roundabout and ensuring clear access from the west end of Lower Lea Crossing to Leamouth Road and Aspen Way.

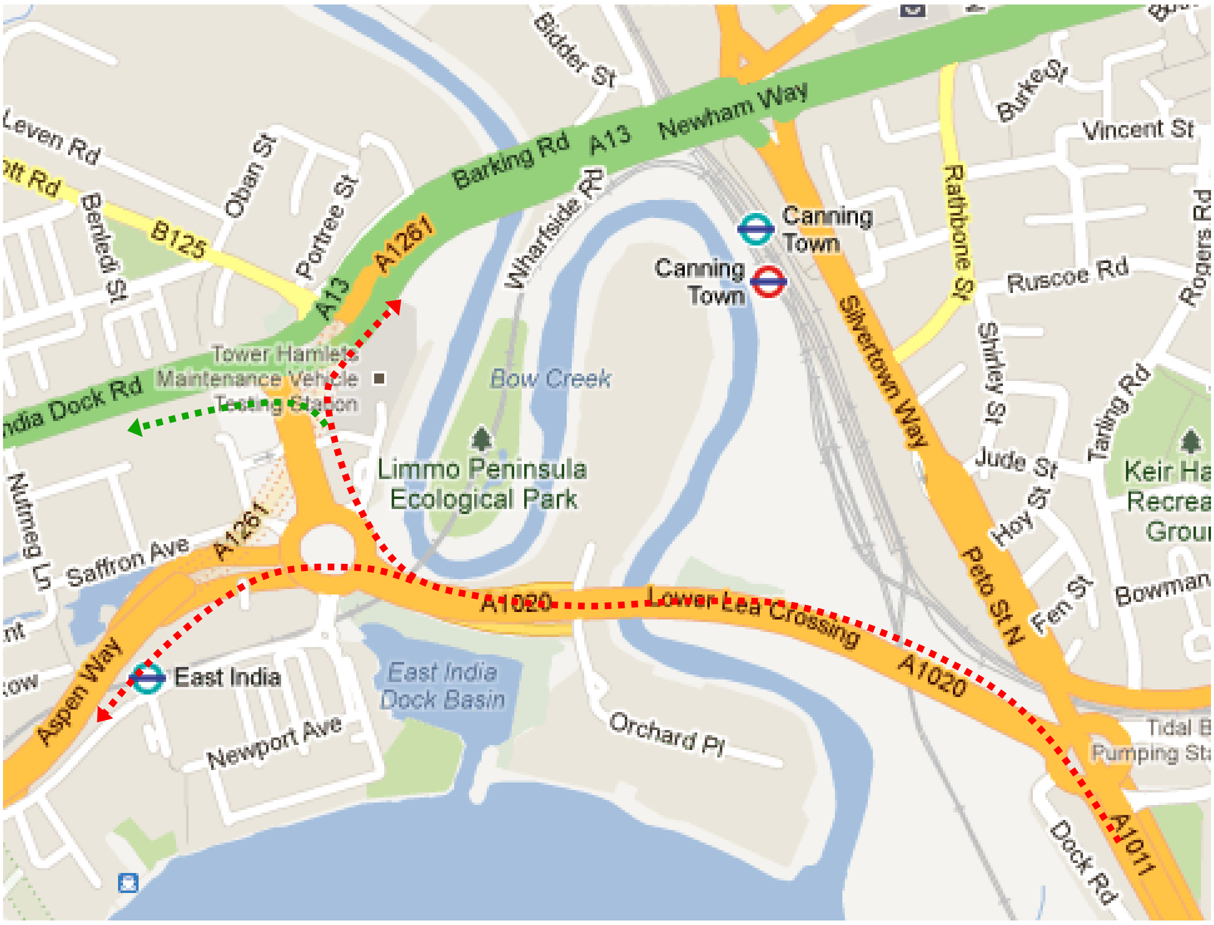


Figure I4 –Green Wave (North)

The southbound tunnel will be cleared by ensuring the A102 downstream is free flowing with reference to the Blackwall Lane signals and including the short term "gating" of the Blackwall Tunnel southbound approach north of the river.

Figure I5 –Green Wave (South)

The closest fire stations are at:

- Silvertown, Plaistow and East Ham in LB Newham (being considered for closure),
- Poplar, Milwall and Bow in LB Tower Hamlets and
- East Greenwich, Greenwich and Woolwich in RB Greenwich.

Access to the south end of the tunnels for emergency services can be facilitated by the bus ways on the Greenwich Peninsula with access gained from Peartree Way, thus avoiding any congestion on the northbound A102.

From the northern approach access from Poplar is protected by Bus Lanes and from East Ham and Plaistow, with access being gained via North Woolwich Road. Routes further north will need to cross the DLR and may be affected by traffic in Canning Town backing up from the incident.

Some preliminary discussions have been held with London Fire Brigade (Laurie Kenny) but given the timescale the wider access issues will need to be discussed as the design progresses. The emergency operation input to the tunnel accesses will come from:

- London Fire Brigade (currently Laurie Kenny)
- Metropolitan Police (currently Paul Coombes)
- London Ambulance – including air ambulance

Use of bus lanes and bus only routes by emergency services will need to be discussed with Bus Network Planning. John Barry or Bob Blitz are the principal points of contact in the first instance.

Consultation will be needed on the wider traffic measures with:

- The Highways Agency (M25, M11 and Trunk Roads outside London)
- Transport for London (TLRN and Bus Infrastructure)
- London Boroughs of Tower Hamlets and Newham (Local Roads north of the River)
- Royal Borough of Greenwich (Local Roads south of the River)

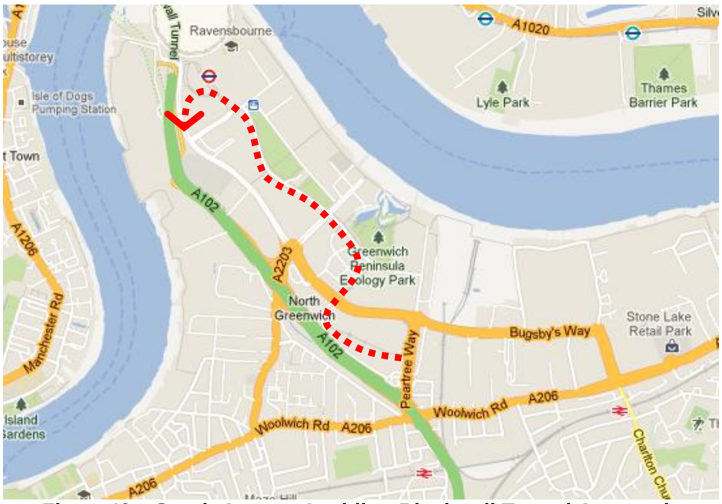


Figure I6 – South Access Avoiding Blackwall Tunnel Approach

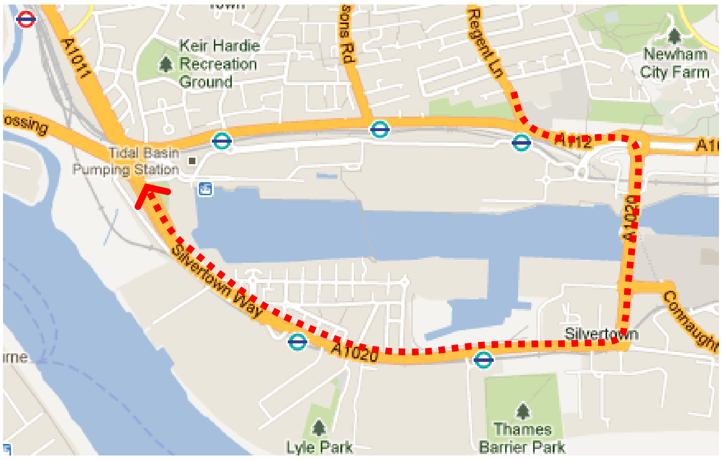


Figure I7 – North Access Avoiding Canning Town

Marshalling and Control Areas

At the north end of the tunnel the initial marshalling and control area will be at the roundabout or close to western end of Royal Victoria Dock.

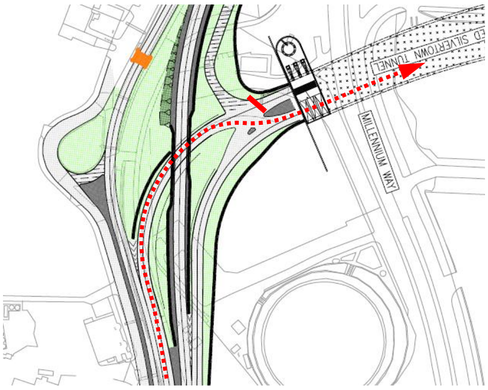
At the south end there is space close to the underground and bus stations, which are easily accessible via the bus link (emergency access) which will provide for onward transference of evacuees, via the Jubilee Line, the Emirates Airline or the bus network. Given that both tunnels will be closed, the southern end of the tunnels may be seen by the LFB as the most suitable for all their evacuation purposes.

Longer Term Changes

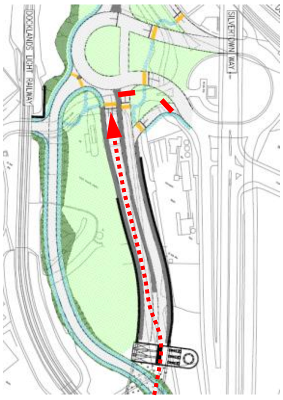
A longer term strategy is required in case of a closure, whether resulting from an emergency or for longer term maintenance.

In the case of closure of the northbound Silvertown Tunnel, TfL's tunnel managers have indicated that it will be preferable to switch to reversed running in the southbound Silvertown Tunnel rather than use the height restricted Blackwall Tunnel.

The reversed working in the southbound tunnel will be accommodated via the crossovers which will be installed in close proximity to each portal. Local TM, including speed restriction and specific signing, and physical barriers will be required.



Entry to Reversed working



Exit from Reversed Working

Figure I8 – Cross-Over South **Figure I9 – Cross-Over North**

Strategy for Closures

In the event of tunnel closures the following signing strategy could be implemented.

Blackwall Tunnel Northbound – Diversion Signage at the M25, between Dartford and Swanley, Warning Signage on A2, A20 and A205

Blackwall Tunnel Southbound – Diversion Signage at the M25 between Potters Bar and the A13, warning Signage on the A12, A13

Silvertown Tunnel Northbound – Reverse running in the Silvertown Southbound Tunnel; Diversion Signage at the M25, between Dartford and Swanley, Warning Signage on A2, A20 and A205

Silvertown Tunnel Southbound – Diversion Signage at the M25 between Potters Bar and the A13, warning Signage on the A12, A13.

NB: The signing strategy for closures refers exclusively to the operation of the tunnels and the closure of Blackwall Tunnel is not required as part of the Silvertown Tunnel construction works.

Southern Strategy

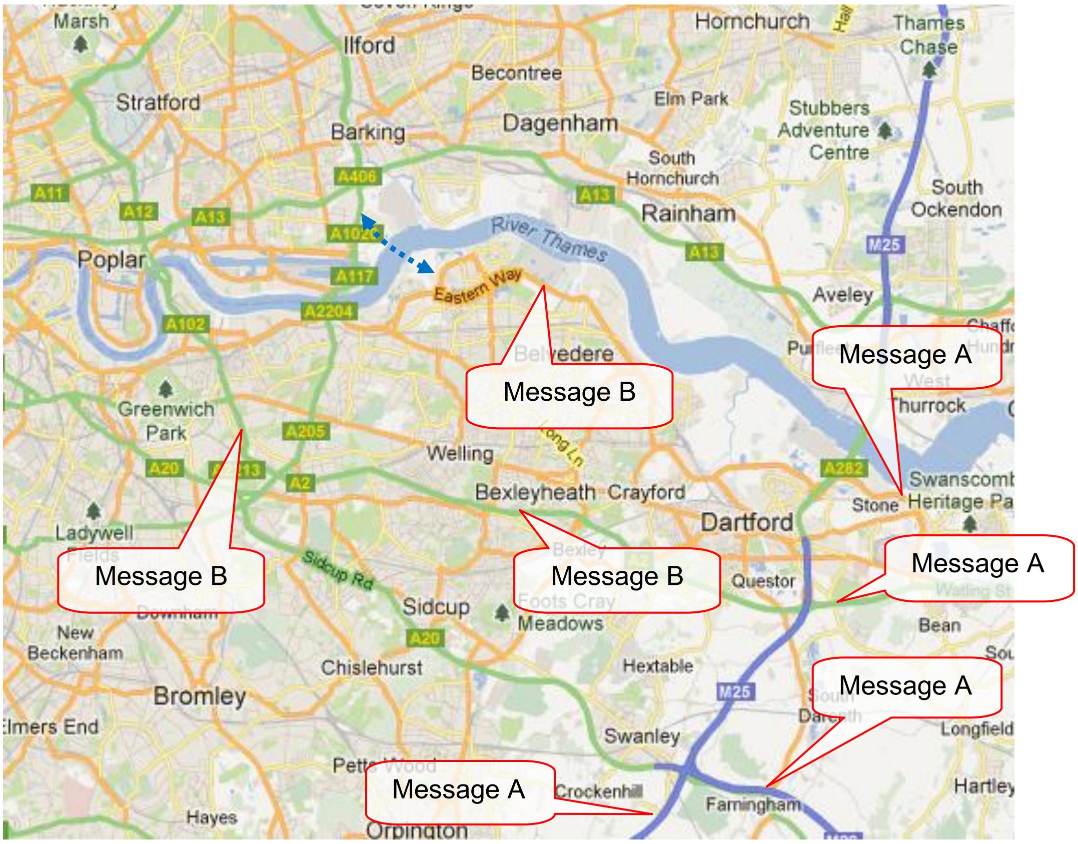


Figure I10 – Southern Signing Strategy

Northern Strategy

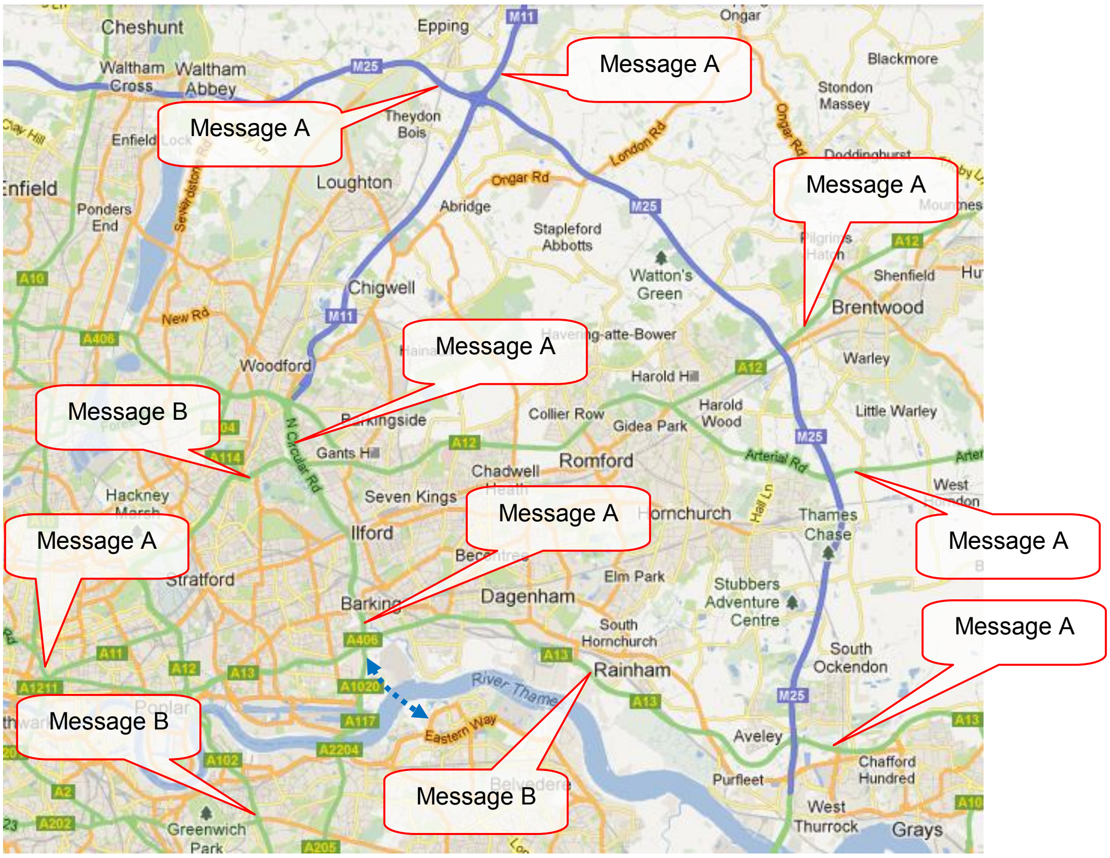


Figure I11 – Northern Signing Strategy

Message A *– Blackwall Crossing Long Delays – Use Dartford Crossing*

Message B *– Blackwall Crossing Long Delays*

Signage will need to be agreed with appropriate highway authorities.

The alternative crossings at Dartford, The Rotherhithe Tunnel and The City bridges are some way from Blackwall and the Woolwich Ferry is capacity constrained and already becomes significantly overloaded when problems occur with the Blackwall Tunnels. Thus when the Gallions Reach Crossing is operational the Variable Message Signing (VMS) text can be adjusted to suit, in effect Message A becoming "Blackwall Crossing Long Delays – Use Dartford and Gallions Reach Crossings"

There is a need to differentiate between the localised Tunnel TM, such as for the reversed working, and the wider Signal and VMS based signage. Localised TM will be under direct Tunnel Control and use dedicated infrastructure – inter-alia tolling gantries as well as mounting tunnels signals etc on other TfL and third party structures

Wider Measures will be a mix of Urban Traffic Control (UTC) timing plans at key locations derived from the ELoHAM predictions and demand management using either existing or new VMS. The UTC will be additional sets of timing plans for appropriate UTC cells north and south of the crossing. VMS will play a greater role in the outer reaches and UTC will have more of a role in the central areas.

Access to the Tunnel

Because of the nature of the northern junction, access to and from the Silvertown from the surrounding area is not restricted.

At the south the junction is less accommodating. The tunnel approaches do not reach ground level until some way towards Blackwall Lane. Thus direct access to the tunnel is not possible; albeit a bus link from North Greenwich is being considered. Access to the crossing will be via the Blackwall Lane junction and thus a two way link has been created from Tunnel Avenue to accommodate this access from the west side of the peninsula which currently has to travel via the O2. There is a master planning exercise underway for the west Peninsula and the local Borough also has aspirations. These will need to be included in the design development. Access to the crossing from the east of the Peninsula will continue to be via Millennium Way.

Severance and Opportunity

The junctions at either end of the Silvertown Tunnels will have some affect on the local environment and land use, however the impact is greater in the south.

Discussions have been held with master planners for both the north and south. Some issues, such as direct access to the tunnels from a point north of Blackwall Lane are unlikely to be achievable, but other issues, such as severance, both new and existing, will be addressed as will resilience with regards to access to the O2, especially for event occasions.

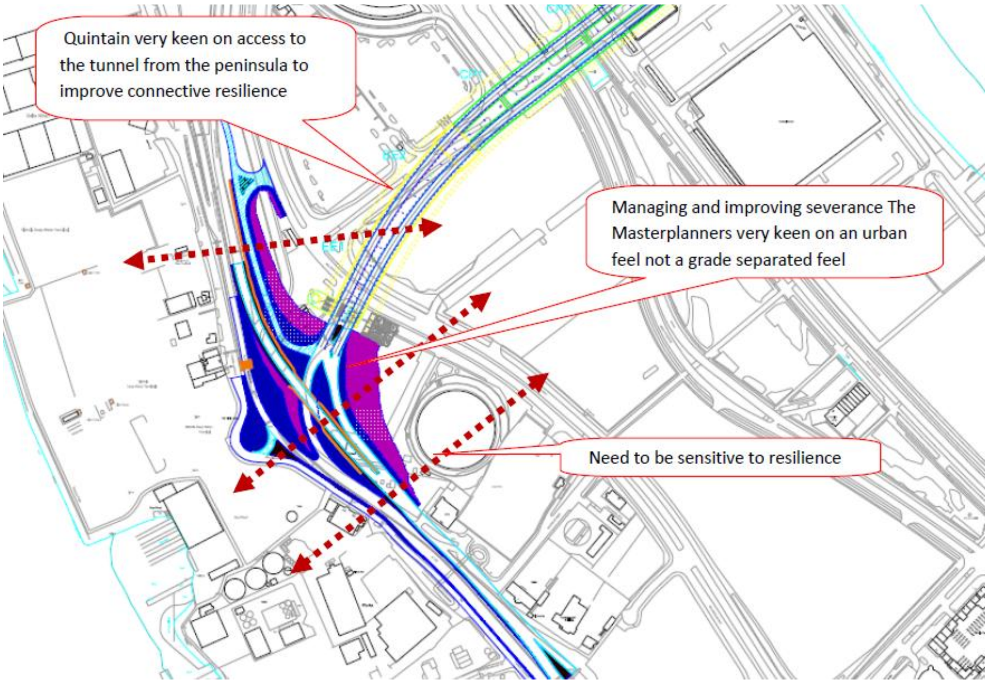


Figure I12 – Access Resilience and Severance (South)

At the north end of the tunnel the junction is however more compact. Thames Wharf is one of the wharves identified in the GLA review of 2011 which gives potential opportunities for reconfiguration of Dock Road. It does not appear to be possible to keeping Dock Road fully operational during tunnelling activities, however there may be scope as part of the redevelopments of the wharves from Peruvian through to Bow Creek for a completely new alignment of Dock Road, which could then provide a central access corridor to the wharves and the river as well as maintaining the link during tunnel construction.

DLR has a safeguarding for a station, Thames Wharf Station, close to the northern junction. The design development of Dock Road and the northern junction will need to take account of this safeguarding which needs to be considered further as the plans for the area unfold.

Thames Wharf – from GLA Study

Figure I13 – Extract from GLA Study

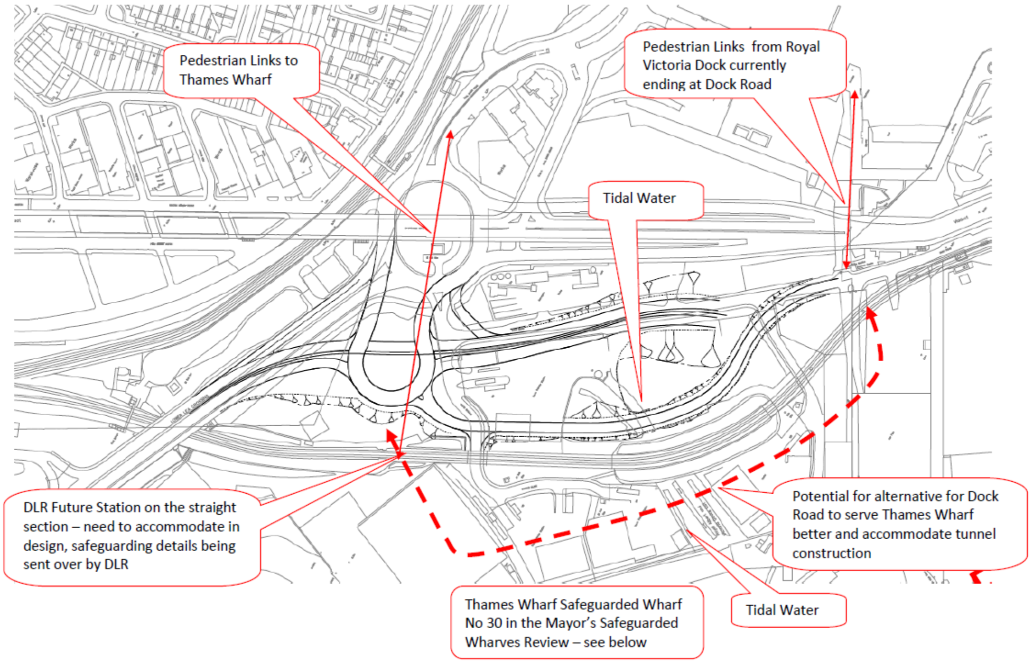


Figure I14 - Access Resilience and Severance (North)

Pedestrians Cyclists and Buses

Pedestrian and cycle connectivity is a fundamental element of London's multimodal transport system, enabling easy journeys to be made on foot or by bicycle using a permeable network of streets and footways. It is vital to consider the impact of the accesses to the new crossing on pedestrian and cycle movement north and south of the river to minimise severance effects caused by the new road connection, and facilitate local movement between neighbourhoods and places.

Spatial analysis will be developed, in conjunction with the adjacent master-planning, for the built environment in the area affected by the Silvertown tunnel. This will identify the key routes for pedestrians and cyclists, and show how these are affected by new infrastructure related to the crossing and how they will link to the adjacent developments and current and future infrastructure such as the Jubilee Line and the Emirates Airline.

This will include an assessment of the Silvertown Crossing highway layouts to the north and south of the river to identify the key strengths, weaknesses, opportunities and threats to walking and cycling in the local areas. This will provide inputs to the development of the design to accommodate journeys on foot or by bicycle.

Key Outputs of this will include naps of pedestrian and cycle accessibility, SWOT analysis of the impact on pedestrian and cycle movement of the Silvertown tunnel scheme, high level plans of pedestrian and cycle network, indicating recommended locations for required and desirable connections to minimise severance in the area. A case study of previous analysis for the Greenwich Peninsula is attached as Appendix I.

Bus access from the north will be along the Lower Lea Crossing or via the junction with Dock Road. At the south there is an aspiration for a bus link to the tunnel from North Greenwich. Further discussion regarding the bus network will be required with the Bus Network Planning team.

Height Restriction

Adjustments will be needed to the current height restriction control measures for the Blackwall Tunnel. The current physical measures would still be appropriate for the new layout however they would need relocating south to ensure that all vehicles unsuitable for Blackwall Tunnel have ample warning and can be effectively directed to the Silvertown Tunnel.

Section J

Interfaces

Significant work has been undertaken as part of this study to ensure that the tunnelling operations and the development of the highway infrastructure are fully integrated and deliverable as part of a coherent construction operation. This can be developed further as the project moves beyond selection of preferred options by considering:

- **Function** – What the interface has to achieve to ensure delivery of the project objectives?
- **Operational** – What are the operational parameters that facilitate the interface?
- **Physical** – What needs to be delivered during construction for the interface to have been successful?

As an example, for the tunnel drainage system this interface hierarchy would be:

- Functional – The interface has to ensure that the volume and condition of the surface and sub-surface water arriving at the tunnel portal can be managed.
- Operational – Consideration needs to be given to sumps, pumps, sub-surface water exclusion and pollution control measures.
- Physical – Includes design calculations and volumetric run-offs, design drawings which are consistent and mutually explanatory.

Interface protocols have already been established and can be developed further in the form of an engagement plan which identifies all key elements and is developed as the project moves forward. Section I of this report identifies all stakeholders that have so far been consulted. A fully integrated construction phase plan should also be developed with consideration for the inter-dependability of the surface access and tunnelling operations.

Information transfer protocols and interfaces will also be required on matters such as environmental impact and planning.

The following is indicative of the key functional design interfaces:

- **Highway Alignment** – to ensure consistency between the highway in the tunnel and the junctions at each end. This has been ensured to date by using one main highway alignment model, which can be developed further as part of the wider use of BIM in the overall project development.
- **Drainage** – Integration of the tunnel and highway drainage systems has been ensured by considering the catchment and surface water run-offs which need to be accommodated in the tunnel portal sumps.
- **Programme** – A single integrated overarching construction programme has been developed which considers critical linkage between tunnelling operations and the highways infrastructure.

- **Utilities** – Utilities corridors have been identified for the diversion of known services to ensure that both the tunnels and the junctions can be constructed. TfL do not intend to provide a utilities corridor within the tunnel.

Other Interfaces required in the detailed design stage include, but are not limited to:

1. **Geotechnical**
   a. Soil Parameters
   b. Ground Water
   c. Structural Loading
2. **Alignment**
   a. Line, Level and Gradient
   b. Lane Usage
   c. Highway Cross Sections
   d. Pavement Design
   e. Walkways and Zones
   f. Fencing etc
3. **Structures**
   a. Structural Forms
   b. Physical Interface
   c. Load Transfer
   d. Structural Connections
4. **Safety**
   a. Tunnel Fire Strategy
   b. Escape Routes
   c. Access for Emergency Services
   d. Wider Emergency Planning
5. **Mechanical & Electrical**
   a. Water Supply
   b. Drainage
   c. Sumps and Pumps
   d. Ventilation
   e. Power
6. **Communications**
   a. Emergency Phones
   b. VMS and Emergency
7. **Construction Strategy and Planning**
   a. Dependant on how the tunnel is procured

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