TRANSPORT FOR LONDON

RIVER CROSSINGS:
SILVERTOWN TUNNEL

SUPPORTING TECHNICAL DOCUMENTATION

FURTHER DEVELOPMENT OF TUNNEL ENGINEERING

Mott MacDonald

July 2013

This report builds upon previous studies to develop the bored tunnel concept and addresses design development of key areas.

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.

Silvertown Tunnel

Further development of Tunnel Engineering

298348/MNC/TUN/002

July 2013
Transport for London

Mott MacDonald

Silvertown Tunnel

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Content

Appendix D. Reference Documents

D.1. Tunnel diameter and clearance study

Silvertown Tunnel-Internal Clearances

Tunnel Engineering

April 2013
Transport for London

Mott MacDonald

Silvertown Tunnel-Internal Clearances

Tunnel Engineering

April 2013

Transport for London

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Content

1. Introduction

In November 2009, Mott MacDonald was commissioned to develop options for a bored tunnel road link across the river Thames to link Greenwich and Silvertown. In June 2012 further studies were carried out to examine the bored tunnel and immersed tunnel crossings of the Thames at Silvertown. Refer to Mott MacDonald report; Silvertown Crossing Study - Rev002, dated 22nd June2012.

In the aforementioned report the proposed bored tunnel option provides a twin 2 lane traffic only connection between the A102 on Greenwich Peninsula and the Tidal basin roundabout on Silvertown Way. The running tunnels are of circular cross section connected by pedestrian cross passages to facilitate intervention in an emergency. Internal clearances are generally provided in accordance with BD78/99.

TfL has subsequently commissioned Mott MacDonald to carry out further development of the tunnel engineering to refine the bored tunnel option. As part of this work a number of questions raised by TfL are to be addressed. In relation to the tunnel internal clearances TfL have requested clarification of the maintained headroom and the safety zone above the maintained headroom, and a review of the risks of vehicle strikes if the road surface undulates. This report addresses those specific questions.

2. Basis of Design

2.1 Scope of this report

This report outlines the issues with regard to the bored tunnel internal clearances. It summarises the design approach adopted and the rationale behind it. It also investigates the impact that would arise from a notional increase of the internal diameter if a further 270mm clearance were to be added into the tunnel, in response to TfL comment no. 19 on the previous Silvertown Tunnel report of July 2012.

The key areas addressed in this report are the following:

- Design criteria
- Carriageway dimensions according to current UK/EU practice
- Possible impacts on diameter considering a notional increase in clearance
- Risks of vehicle strike

2.2 Design Criteria – Headroom Clearance

2.2.1 Current UK/European practice

The clearances of the bored tunnel cross section shall be carefully related to specific standards, geometry and procedures in order to achieve and maintain an equivalent level of safety, economy and efficiency. A number of specifications on Geometric Design of Highways and Roads are published by the Highway Agency in order to facilitate continued effective and safe operation. The following Highway Agency standards are used for the design of geometrical configurations of road tunnels about cross section elements and should principally comply with the following documents:

- TD 27/05 – Cross–Sections and Headrooms
- BD 78/99 – Design of Road Tunnels
- PIARC Road Tunnels Manual

Although, compliance with the aforementioned standards are not strictly necessary for TfL's road tunnels, TD 27/05 and BD 78/99 do represent the UK benchmark in overall terms for the acceptable level of safety. In addition to the above highway design standards, geometrical design for road tunnels must consider tunnel systems such as fire life safety elements, ventilation, lighting, traffic control, fire detection and protection, communication, etc.

From an international perspective, the minimum headroom clearance depends on the maximum height of HGVs and varies from country to country. In the European Union generally the maximum height of HGVs is 4.00m, but in the UK there is no legislation restricting vehicle height. Up until 1997 the Road Vehicles (Construction and Use) Regulations 1986 limited vehicle heights to 4.57m. Therefore the majority of HGV's on the roads in the UK are less than 4.5m in height. However this is no longer a legal restriction and current practice for new UK road tunnels and bridges is to apply a 'maintained headroom' clearance of 5.03m according to TD27 Table 6.1. This allows vehicles up to a height of 4.95m to travel unrestricted in the UK, with a 75mm safety zone between the top of the vehicle and the structure.

Within tunnels it is normal practice to allow an additional safety zone of 250mm above the maintained headroom to give the installed mechanical and electrical systems additional protection from high vehicles carrying compressible loads that have passed under the portal soffit, loose ropes, flapping tarpaulins etc. This is set out in BD78/99.

It should be noted that the "new construction headroom" described in TD27/05 is not used in tunnels as it is not usual to build up the road surface over the life of the structure. This is explained further below.

2.3 Tunnel Cross Section Geometry

The bored tunnel cross section is shown on drawing MMD-298348-TUN-206. Refer to Mott MacDonald report; Silvertown Crossing Study - Rev002, dated 22nd June2012, the 'maintained headroom' is provided as opposed to the 'new construction headroom' due to the special requirements of road tunnels. Due to difficulties associated with movement of services and alteration of walkway levels, relaying of the road surface will be achieved through removal of the old surface, before placement of the new, and as such the additional 270mm allocated for this purpose within the new construction headroom is not required.

In addition, the internal lining diameter of 11.0m is determined principally by the demands of the required traffic gauge. A minimum footway width of 1200mm is considered to allow a wheelchair to travel on the footway and turn through a right angle and enter a cross passage exit. All equipment of the tunnel shall be placed outside of the equipment gauge. To prevent damages of equipment mounted above the carriageway by flapping tarpaulins and "soft" equipment, an additional allowance of 250 mm is applied. A cladding system has been allowed for on the side walls to a height of 4m above the carriageway..

The dimensions of the bored tunnel cross section are as those shown on drawing MMD-298348-TUN-300 and the dimensions are principally as follows:

- Vertically
  - 5.03m maintained headroom (TD 27/05 Table 6-1).
  - 250mm clearance allowance for vehicle 'bounce', flapping lorry covers and the like (BD 78/99 Clause 4.25).
  - Allowance for sag curve as per TD27/05 (70mm for the proposed alignment).

- Horizontally
  - 7.3m between kerb faces (TD 27/05 Figure 4-4a).
  - 75mm battered kerb to ease access onto the footway in particular for wheel chair access.
  - 1.2m verge with 2300mm headroom to allow wheelchairs to travel on the footway and to negotiate a 90 degree turn into an emergency cross passage (BD 78/99 Table 4.5).
  - 600mm horizontally from edge of kerb for full maintained headroom height to electrical and mechanical equipment.

It is noted that the approach taken follows the same rationale as adopted for recent new-build road tunnels in the UK such as the A3 Hindhead tunnel (completed in 2010) and the New Tyne Crossing (completed in 2012).

2.3.1 Impact of using 'New Construction Headroom'

In TfL's comments on the July 2012 report, concern was raised over "the reduction of the 270mm vertical safety zone, especially regarding any undulating road surface or changes in road surfacing over time, leaves no space for flapping tarpaulins etc. "

It is noted that the 270mm is not intended to be a “safety zone” as such but an allowance for future construction. The safety zone of 250mm is provided separately in accordance with BD78/99. This is added to the 75mm safety zone between the maximum vehicle height and the maintained headroom, so the total clearance between vehicle and installed M&E systems is 325mm. This is considered sufficient to accommodate loose or soft items on the top of high vehicles.

Regarding the change of road surfacing over time, it is assumed that there will not be overlay and that when the road surface has to be replaced it will be planed out and re-laid to the original levels. This is the normal approach in road tunnels and is considered to be the most cost effective rationale. Therefore there is no need to allow for this additional headroom. Nevertheless, to illustrate the impact that an increase in headroom of 270mm would have on the tunnel an alternative tunnel cross section drawing has been prepared, ref drawing MMD-298348-TUN-301.

The dimensions of the bored tunnel cross section are principally as follows:

- Vertically
  - 5.30m (5.03m + 0.27m) maintained headroom (TD 27/05 - 6.2.1).
  - 250mm clearance allowance for vehicle ‘bounce’, flapping lorry covers and the like (BD 78/99 Clause 4.25
  - Allowance for sag curve as per TD27/05 of 70mm.

- Horizontally
  - 7.3m between kerb faces (TD 27/05 Figure 4-4a).
  - 75mm battered kerb to ease access onto the footway in particular for wheel chair access (BD 78/99).
  - 1.2m verge with 2300mm headroom to allow wheelchairs to travel on the footway and to negotiate a 90 degree turn into an emergency cross passage (BD 78/99 Table 4.5).
  - 600mm horizontally from edge of kerb for full maintained headroom height to electrical and mechanical equipment.

For both cross-sections, the implications of Emergency points (EPs) and Electrical Distribution Panels have not been considered in detail in this stage of design. While it will be easier to allocate space for these provisions within the larger tunnel bore, the minimal depth of these provisions mean a suitable space allowance will be possible for both configurations using the space provided for the construction tolerance, cladding tolerance and within the curvature of the tunnel.

A high level cost comparison of the implications of increasing the tunnel size has been undertaken. While it will be unlikely there would be any major labour or programme change, the diameter increase will have significant impact on the construction costs associated with spoil management and the TBM/Segments used:

	% increase in construction cost
Segments	5%
Grout	5%
Spoil disposal	10%
TBM cost	5%
Combined Total	6%

In summary, the impact would be as follows for the bored tunnel sections:

Impact of increased headroom	Base scheme	+270mm headroom
Diameter (O.D.)	12.1m	12.75m
Concrete volume (approximate)	20450m^3	22550 m^3
Excavated volume (approximate)	117850 m^3	130850
Increased cost	-	Approx. +£20m (6%)

2.4 Risks of vehicle strikes

TfL have asked for the risk of vehicle strike to be clarified for the proposed internal tunnel clearances. This could arise from one of the following:

- Vehicle mounting the kerb
- Undulating road surface
- Flapping tarpaulins or loose/soft materials on the top of high vehicles

The following provisions are made to protect against this:

Vertically

- Maintained headroom is provided of 5.03m. This gives 75mm safety to the top of the highest vehicle
- 250mm additional clearance above the maintained headroom is provided.

This gives a safety zone of 325mm between the tops of the highest vehicles and installed equipment. This is well in excess of height variation arising from undulating surfaces or from a vehicle mounting the kerb. It is therefore considered adequate and in accordance with current good practice.

Horizontally

- The maintained headroom is provided for 600mm over the verge from the face of the kerb in accordance with BD78/99.

This offers an appropriate safe zone in the event that a vehicle mounts the kerb and ensures the effect of an undulating road surface will not result in a vehicle strike to the tunnel wall or cladding. The height to width ratio of a maximum height vehicle is approximately 2:1. Therefore if the road surface were to locally thin by, say, 50mm, the corresponding horizontal movement at the top of the vehicle would be in the order of 100mm. If the 150mm thick surfacing was removed entirely, the corresponding horizontal movement would be in the order of 300mm. Therefore it can be seen that the 600mm clearance offers a high degree of protection from vehicle strikes.

2.4.1 Assessment of risk

Horizontal and vertical clearances have been provided that significantly limit the risk of a vehicle strike to the tunnel walls, tunnel cladding or to the overhead installed mechanical and electrical systems.

Approximately 3.5% of the UK articulated vehicle traffic is double deck trailers with heights up to 4.95m (1), though it is not known how this may change with EU current legislation and the corresponding decision made with EU and UK and European hauliers on their preferred trailer arrangement and heights. The majority of vehicles using the tunnel will therefore be well below this height and therefore have increased clearance to the tunnel structure and installations. In addition, proposed EU legislation may limit vehicle heights in the future thus further reducing risks of vehicle strikes.

By adopting the requirements of BD78/99 and TD27/05 the risks are considered to be extremely low, if not negligible.

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1 Source: Freight Transport Association 2010

3. Conclusions & Recommendations

3.1 Conclusions

The clearances included in the outline tunnel design are in accordance with current UK highway and tunnel standards.

A safety zone is provided above the maintained headroom to accommodate flapping tarpaulins, loose or soft materials on top of high vehicles.

The risk of vehicle strikes due to an undulating road surface is deemed to be negligible.

Additional allowance of 270mm for future overlay road construction is not considered appropriate and so is not allowed for.

3.2 Recommendations

The internal clearances shown on drawing MMD-298348-TUN-300 should be adopted for the further development of the Silvertown Tunnel project.

Appendices

Appendix A. Drawings

Appendix B. Comments received from TfL

D.2. Cladding Study

Silvertown Tunnel

Review of cladding options

April 2013
Transport for London

Mott MacDonald

Silvertown Tunnel

Review of cladding options

April 2013

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02	15.04.13	D Naylor	J Baber	M Savill	Tunnel Report Issue

Content

1. Introduction

Mott MacDonald's report "Silvertown Crossing Study - Tunnel Engineering" revision 002 dated June 2012 recommended that cladding be installed to a height of 4m above the carriageway level.

The report also noted there could be further investigation into the possibility of omitting this cladding if adequate reflectance properties could be achieved by other means, such as a painted cast insitu wall or painted segments.

TfL have asked for this to be considered further based on the expense associated with cladding systems and the need to replace them regularly, and the fact that inspection is made more expensive due to the need to take down and re-fix the panels.

The report noted that the cladding can be of assistance in dealing with rogue seepage through the notionally watertight tunnel lining.

TfL have questioned whether provision is needed in the crown of the tunnel to manage any incidence of seepage should it occur above the carriageways.

The purpose of this report is to review the options for cladding to the walls and to the soffit to fulfil the necessary functional requirements within the tunnel, taking into account safety, aesthetics, operations, maintenance and whole life costs. Recommendations are given for the proposed solution that is carried through to the cost estimate and project risk analysis.

The report has separate chapters dealing with wall cladding and crown cladding as the issues driving the selection of each are different.

2. Review of Wall Cladding Options

2.1 Introduction

A number of options are available for the treatment of the walls up to a 4m height to each side of the carriageway in each tunnel. Many modern road tunnels install a panel system that is fixed to a support frame which is in turn attached to the tunnel structure. Panels are demountable and coated to give a high quality finish. Joints between panels are sealed with strips that give the appearance of a near-continuous surface through the tunnel. In the UK a ceramic coated stainless steel panel has been used in the majority of tunnels. However other systems are used elsewhere in Europe and around the world, such as powder coated aluminium panels, that may offer a slightly lower cost solution, but perhaps at the expense of longevity of the system.

Other options are to install a ceramic tile finished by gluing tiles directly to the internal surface of the tunnel structure. This system is favoured in the USA, it provides a clean simple finish but is not necessarily to the taste of all clients, being somewhat Victorian in appearance. Often in the USA tiles are pre-mounted onto precast panels which may offer some additional fire protection and speeds up the installation. However this takes up additional space within the tunnel.

It may be possible to omit cladding and provide the necessary aesthetics and reflectance by painting the walls of the tunnel. This approach has been taken on tunnels which have a secondary cast lining with a smooth finish. For a TBM tunnel with regular joints and features in the tunnel segments that are required for their handling and installation the surface does not have a smooth appearance. Either this would have to be accepted or a secondary treatment on the inside of the tunnel would be required to provide a smooth surface for painting.

A secondary treatment may be a secondary concrete lining either partial height or for the full circumference of the visible tunnel lining above carriageway level. This would be a self-supporting lining. Two approaches are possible in terms of structural design:

- it can be non-structural and the tunnel segmental lining is the watertight lining that fully resists the ground and ground water loading.

- It can be a structural part of the tunnel lining. The initial segmental lining may be a thinner structure and not intended to be watertight, and the second lining contributes to the main tunnel structure resisting ground and hydrostatic loads. A waterproofing membrane is installed between the initial and secondary lining. This is known as a two-pass tunnel lining.

For all options, the variable for potential passive fire protection has not been considered in any of the tunnel lining options. It would be expected to specify poly-propylene fibres in the tunnel lining segments. Cabling and ducting would be run in verges /cable routes beneath the road so should have a good level of protection. A separate fire life safety assessment is being undertaken co-currently with this assessment which will assess the appropriate fire systems to be installed within the tunnel structure.

These options are discussed in more detail in the following sections of the report.

2.2 Performance requirements

There are a number of key performance characteristics that the wall finish must achieve. These are described below.

2.2.1 Reflectance level

A minimum level of reflectance is required. The tunnel lighting is at a high level and the reflectance of light from the cladding onto the road provides a safely lit environment for car drivers. In accordance with BD78/99 reflectance levels should not be less than 0.6 and the durability of the surface providing this reflectance should be a minimum of 15 years, this being the approximate period between major refurbishments. In developing the detailed design, reference to BS 5489 Part 2 & A1 2008 will be required in order to develop the necessary height of cladding system.

2.2.2 Aesthetics

As well as assisting with the performance of the lighting system, the walls should have a degree of aesthetic quality that provides the tunnel users with a sense of safety and enables clear recognition of signage within the tunnel, both in normal operation and in emergency conditions. Therefore clean smooth surfaces along each side the carriageway to a height of 4m are desirable. Surface mounted cabling and ducting is undesirable in this respect as it may create a cluttered appearance and will attract dirt.

Tunnel owners/operators may also have a view of the appearance of the tunnel interior which can range from functional to state-of-the-art depending on a cost benefit assessment.

2.2.3 Safety

Although not strictly a requirement for the cladding, in the event of water ingress to the tunnel it is a benefit if the wall lining can enable this to be managed. A finish that does not cater for seepage management and could result in a wet carriageway surface would be undesirable.

2.2.4 Maintenance

Wall finishes must be low maintenance in that minor attention may be necessary during routine tunnel closures for cleaning, but the finish system should ideally last 15 years without the need for any significant amount of maintenance work, and ideally be designed to be durable for a much longer period with selective renewal or replacement of parts. The surface should therefore be resistant to stone chips and be suitable for washing with brushes and detergent and be resistant to exhaust fumes, water and salt spray.

The finishing system should not introduce its own maintenance requirement that requires more onerous interventions that would be necessary for the civil engineering structures or the installed M&E systems required for safe operation.

It should also enable ready access to panels, drainage and installed systems so as not to cause any significant difficulty in undertaking maintenance and inspections. It should be noted that for a panel system, space for storage of spare panels and parts will be required.

2.3 Panel systems

Panel systems are most commonly ceramic coated steel panels mounted on stainless steel frames. Joints between panels are sealed but remain visible. They create a smooth, clean continuous surface.

Special panels are used to fit around emergency and equipment panels and doorways. Panels are designed to be demounted and re-fixed should inspection of the structure be required behind them. Consequently a variety of the cladding panels would be required to be safely stored on site for such maintenance opertaions.

Panels can be designed to be watertight and this type of system is often used in tunnel refurbishments where the underlying structure exhibits leakage or is in poor condition, for example in the Saltash Tunnel in Cornwall. The void behind the cladding panel is useful for running cables to M&E equipment installed in the tunnel, although the primary longitudinal cable route should ideally be in cable troughs below verges.

2.4 Tiled finish

Tiled interiors are common in tunnels in the USA, such as the Ted Williams tunnel operated by the MTA, shown in the photograph. The practice in the US is to have a raised maintenance/emergency walkway to one side, where emergency equipment is mounted on the surface. Tiles may be directly applied to the tunnel walls but are often applied to precast panels that are installed to leave a void between the panel and the wall of the tunnel. This void can be used for seepage control. If there is no void then seepage, staining and accumulation of deposits may be visible on the surface of the tiles.

Massachusetts Turnpike Authority

2.5 Painted segment finish

Very few road tunnels exist that have a plain painted finish to the tunnel precast segmental lining. One example is the Tunnel Calle in Madrid. This has painted segments up to the height of a suspended ceiling. The bolt recesses for the segments remain visible, as do the joints between each segment. Equipment and associated cabling is surface mounted on the tunnel lining. Surfaces tend to look more cluttered and the finish quality is not to everyone’s taste. Any seepage that occurs would run down the painted surface potentially leaving staining and

accumulation of deposits.

2.6 Painted secondary lining

Painted finishes have been widely used in the UK. Recent examples include the Hindhead Tunnel and the Dublin Port Tunnel. The Hindhead tunnel was constructed with a sprayed concrete lining and had a secondary cast lining for the area for wall finishes to provide a smooth uniform finish ready for painting.

Dublin Port Tunnel was a two-pass tunnel lining construction so although the initial lining was constructed as a segmental lining it had a secondary cast insitu lining that could then be painted. A waterproofing membrane was installed between the initial and secondary lining.

A two-pass lining is not preferred for Silvertown as it would have programme disadvantages for construction. It takes longer overall to construct a segmental lining, apply waterproofing and construct the structural secondary lining.

This approach allows ductwork for cabling to be hidden by being cast into the lining and hence can create a clean finish.

The secondary lining should be self-supporting and so will be a reinforced concrete structure. This could be formed over the complete surface or just to a height of 4m for the application of the reflective paint system. A similar depth of construction to a panel cladding system would be required. Such a concrete structure may also require minimal work for repair after a traffic collision when compared to some of the other systems discussed.

There is the opportunity with this concept to have less than a lining is less than 4m tall (see comments within Appendix A). This is an opportunity for future design and has not been considered further here to keep the assessment parameters the same for all options.

2.7 Evaluation of Cladding options

Option 1	**Cladding panels**
Lighting reflectance levels	High quality durable finish enables reflectance levels to be maintained with regular planned cleaning operations.
Aesthetics	High quality construction and installation will generally result in a high level of aesthetic appearance. This is the most commonly used system around the world. Enables colours, patterns and branding to be incorporated.
Safety	Cladding system is offset from wall allowing drip channels to be used to manage any seepage water and direct it to the road gulley drainage, with no effect on aesthetics. This offers the highest possible level of safety where water can be prevented from reaching the road surface.
Maintenance	Should seepage occur that needs special attention over and above the normal seepage management, panels must be removed to obtain access. This is possible within a short period of time to allow works to be undertaken. Principle Inspections may require panels to be removed or a representative number of panels to be removed for inspection of the tunnel lining. This requires a greater level of effort and cost that a non-cladding solution. TfL's tunnels and structures team have raised a number of maintenance concerns with such a system (see Appendix A) including H&S for above height work, requirement for inspections of support structure and ease of damage and orrosiion to support structure/systems.
Whole Life Cost	There is a high initial capital cost outlay for the system as it utilises high quality materials. Thereafter the system has a long life expectancy. Minimum 20 years should be expected but this could be extended up to 40 years, though there are some instances of reduced life due to corrosion. Ongoing maintenance is cleaning, inspection of fixings, replacement of sealing strips if dislodged or damaged, replacement of damaged panels from vehicle impacts. Care required to avoid damage to panels on removal. Heavy lifting equipment required to manage health and safety issues with overhead work.
Option 2	**Ceramic tile finish**
Lighting reflectance levels	High quality durable finish enables reflectance levels to be maintained with regular planned cleaning operations.
Aesthetics	Considered “old-fashioned” in appearance, though commonly used in USA. Dirt in joints may be more apparent towards end of period between washing due to small size tiles and multiple joints. Enables colours, patterns and branding to be incorporated. Requires surface mounted cabling to equipment which can be unsightly and collect dirt. Will reflect concrete cracking or joint movements unless mounted on precast panels. May exhibit staining and build-up of deposits if applied direct to the tunnel walls and seepage occurs.
Safety	Unless mounted on a precast panel, tiles are glued directly to the tunnel primary lining which would not allow a hidden seepage management system to be used. There is therefore the risk of seepage water finding its way onto the road surface which is undesirable.
Maintenance	Relatively low maintenance and tiles easily replaced if damaged by impacts. May need washing at closer intervals than a panel system.
Whole Life Cost	Low initial capital, cost and low level of ongoing maintenance limited to cleaning and replacement of damaged tiles.

Option 3	Painted secondary lining
Lighting reflectance levels	Painting can provide the necessary reflectance levels, but the surface quality is faster to deteriorate and the quality of the surface finish may lead to accumulation of dirt in the periods between washing.
Aesthetics	A painted concrete surface will require a very smooth finish to provide similar level of aesthetic appearance as a cladding system. Enables colours, patterns and branding to be incorporated.
Safety	Allows a hidden seepage management system to be used. Therefore the risk of seepage water finding its way onto the road surface is low.
Maintenance	Paint system unlikely to be as durable as a cladding system so will need refreshing on a more regular basis. Input from TfL's tunnels and structures team has recommended that this could be overcome through the use of a compound such as "Ceramicoat". Likely to need washing at closer intervals than a panel system. Cast insitu lining prevents access to the lining for inspection. Minor disadvantage.
Whole Life Cost	Ongoing maintenance limited to cleaning and repainting. Depending on the paint system selected, paint may not be as durable as ceramic coatings however so may need repaints at closer interval than panel replacement interval. Some high performance coatings may have similar life expectancy to ceramic coated steel panels.
Option 4	**Painted segment finish**
Lighting reflectance levels	Painting can provide the necessary reflectance levels, but the surface quality is faster to deteriorate and the quality of the surface finish may lead to accumulation of dirt in the periods between washing.
Aesthetics	Bolt recesses, joints and other features of segments forming the lining disrupt the smooth appearance. A painted concrete surface will require a very smooth finish to provide similar level of aesthetic appearance as a cladding system. A primer/substrate coating may be required for this. Limited examples of painted segmental linings to date. Enables colours, patterns and branding to be incorporated. Requires surface mounted cabling to equipment which can be unsightly and collect dirt.
Safety	Does not allow a hidden seepage management system to be used. There is therefore the risk of seepage water finding its way onto the road surface which is undesirable, or unsightly drip channels to be mounted on the wall surface.
Maintenance	Paint system unlikely to be as durable as a cladding system so will need refreshing on a more regular basis. Likely to need washing at closer intervals than a panel system.
Whole life Cost	Low initial capital; cost and low level of ongoing maintenance limited to cleaning and repainting at set intervals. However increase in whole life costs as cleaning interval may need to be increased.

The following tables indicates our assessment of how each option performs in relation to the functional requirements of the project.

	Lighting	Aesthetics	Safety	Maintenance	Whole Life Cost
Option 1	Positive	Positive	Positive	Neutral	Neutral
Option 2	Positive	Neutral	Neutral	Neutral	Positive
Option 3	Positive	Positive	Positive	Positive	Positive
Option 4	Neutral	Negative	Neutral	Neutral	Neutral

Positive indicates the option fulfils or exceeds the criteria

Neutral indicates the option may meet the criteria but has disadvantages compared to other options

Negative indicates the option may fail to meet the required performance criteria or has significant drawbacks

On a qualitative basis it can therefore be seen that a cladding panel system using a ceramic-steel system or a secondary lining that has a paint coating is preferred. The space requirements and costs are expected to be similar for both of these solutions.

3. Crown cladding for water ingress management

A high level of watertightness in the tunnel lining will be aimed for irrespective of the cladding/painting solution. High specification gaskets will be used to seal the joints between the tunnel lining segments, with the intention of creating a watertight tunnel. The choice of interior finish will not affect the detailing of tunnel joints in this respect.

The segment joints can also feature a caulking groove at the inside face of the lining which can act as a back-up to the gasket. This allows a sealant to be applied as a matter of course during the construction process and, if seepage is apparent, a caulking material can be chosen that expands and seals the leak.

Other options to improve watertightness are available, such as a double gasket in the segment joint or a hydrophilic seal in addition to the gasket, but they have disadvantages and do not necessarily give value for the additional expenditure. A more effective measure is grouting post construction to seal water ingress. Although this can sometimes require perseverance to chase a leak to its source and seal it, it is generally the most common and effective way a contractor can seal seepage.

The combination of a high quality gasket, caulking and grouting generally results in a largely watertight construction. The risk of any residual leakage above the road occurring is small. It is usual to give the contractor some performance criteria in this respect that defines what “watertight” actually means and the definition that is acceptable to the tunnel Owner.

TfL have asked the question as to why there is no cladding over the roof of the tunnel if there is a risk of rogue seepage. Generally this is not done unless there is a severe leakage problem that cannot be sealed or managed by another means. For example, in tunnel refurbishments where a tunnel lining is in such poor condition that the only practical method of controlling existing and potential future leakage may be to install crown cladding. This was done on the Saltash Tunnel in Plymouth, for example.

It is generally considered to be much more cost effective to install drip trays to manage specific points of leakage as and when they occur over the life of the tunnel. The soffit of the tunnel is dark, usually painted black, so the drip trays are not visible, and they can be quickly fixed during routine maintenance closures to channel leakage water to behind the cladding and away to the tunnel drainage system.

The options to install full cladding versus wall cladding plus selected drip trays to manage individual incidences of leakage are compared below.

3.1 Evaluation of Options

Option 1	Full cladding
Impact to watertightness	Leakage is likely to be low level seepage or dampness rather than dripping. Therefore cladding is of no great benefit although in principle it should assist with water management if a faster leak did occur in the future. Cladding would need to be made watertight with overlapping details between panels and effective seals around all penetrations for cabling and hangers for vent fans.
Maintenance	A significantly greater level of effort is required to removed the cladding when the tunnel lining behind the cladding is to be inspected – probably at 6 yearly intervals for Principal Inspections.
Whole Life Cost	Although the cladding over the soffit does not need a reflective coating. It will nevertheless need to be painted and will have the same support structure and complex jointing and sealing arrangements to make it watertight as the wall cladding. There for the costs can be extrapolated from the wall cladding. An additional capital cost of £13m will be incurred. For ongoing maintenance, costs will again be extrapolated, and will be approximately 2.5 times the cost for just the wall cladding.

Option 2	No cladding – install drip trays as required
Impact to watertightness	Drip trays installed to channel specific leaks to the tunnel drainage system can provide an equivalent level of performance as a full cladding solution.
Maintenance	There is no significant increase in maintenance other than occasional installation of a drip tray if leakage is detected.
Whole Life Cost	Drip trays are relatively cheap and simple and quick to install with little or no ongoing maintenance requirement. Costs would be expected to be <£1m.

The following tables indicates our assessment of how each option performs in relation to the functional requirements of the project.

	Impact to watertightness	Maintenance	Whole Life Cost
Option 1	Positive	Negative	Negative
Option 2	Positive	Positive	Positive

Positive indicates the option fulfils or exceeds the criteria

Neutral indicates the option may meet the criteria but has disadvantages compared to other options

Negative indicates the option may fail to meet the required performance criteria or has significant drawbacks

A qualitative assessment shows that option 2 – to install drip trays as required is the preferred option. A simple cost-benefit assessment shows that the no-cladding solution can give the same performance at a fraction of the cost.

4. Recommendations

4.1 Wall Cladding

A panel cladding system with a reflective coating, or a secondary lining that has a robust durable reflective paint system applied, would offer an acceptable solution. Either of these options can be taken forward in the design and would require the same space within the tunnel envelope when the requirements for the cladding support structure and waterproof membrane requirements for the secondary lining are considered.

A more detailed cost assessment has been undertaken beyond the initial coarse qualitative assessment in order to ascertain which option would be the recommendation to take forward. Based on a painted fibre reinforced concrete secondary lining with a sprayed waterproof membrane for just the bored tunnel, it is ascertained that there is a possible 15% cost saving with the secondary lining option. If the secondary lining was continued into the cut and cover sections of the tunnel, the saving on cladding cost saving could be approximately doubled.

Given this information and the viewpoints expressed within Appendix A from the tunnel operators viewpoints, a secondary lining option would be the preference for the project. A cladding system however remains a feasible option if a very high quality finish was desired and this would have no impact upon the spatial requirements within the tunnel.

4.2 Crown Cladding

A high degree of watertightness is expected to be achieved with the tunnel lining. It is not considered cost effective to provide crown cladding in the new tunnel to manage any leakage that might occur. Watertightness will be achieved against specified criteria with a combination of high quality gaskets between the segments forming the tunnel lining, caulking of the segment joints and grouting as necessary to seal leaks identified during construction. Over the life of the tunnel the installation of drip trays to deal with occasional leaks can be carried out at relatively low cost during planned maintenance closures.

Appendix A. Comments received from TfL

/O=MOTT MACDONALD GROUP/OU=FIRST ADMINISTRATIVE GROUP/CN=RECIPIENTS/CN=NAY39283

From: Fielder David [DavidFielder@tfl.gov.uk]
Sent: 27 March 2013 08:25
To: Naylor, David
Cc: Wilson Tony (Planning); Evans John F
Subject: FW: Silvertown Tunnel - cladding and internal clearance reports (to be included in final report)
Attachments: trailer_height_briefing_note.pdf; lorry trailer briefing paper.pdf; Ceramicoat paint Specification.PDF

David

Please find below Surface comments on cladding and clearance reports etc.

Our only additional comment is that we suggest you should include suggestions/examples of currently available ‘proprietary’ systems.

Sorry for the delay in forwarding.

Thanks

Dave

From: Evans John
Sent: 20 March 2013 10:40
To: Fielder David
Subject: FW: Silvertown Tunnel - cladding and internal clearance reports (to be included in final report)

From: Poole Garry (ST)
Sent: 20 March 2013 09:13
To: Evans John
Cc: Ryan Steve (ST); Kumar Anil
Subject: FW: Silvertown Tunnel - cladding and internal clearance reports (to be included in final report)

John

Below are our comments on the cladding and internal clearance report you asked us to review by tomorrow.

It seems we need to firm up TfL’s policy on what vehicles will be permitted to use the tunnel. It may make sense to height restrict the crossings so as not to become and alternative to the M25 and ensure the tunnel serves Londoners’ interests. I am also of the view that the crossing should be ADR Category E restricted as are the other three Thames and two A13 tunnels. These are fundamentally import policy decisions affecting the geometry and fire life safety design requirements.

Regards
Garry

From: Kumar Anil

Sent: 19 March 2013 10:21
To: Poole Garry (ST)
Cc: Johnson Alan (ST); Wilson Alex; Ryan Steve (ST)
Subject: FW: Silvertown Tunnel - cladding and internal clearance reports (to be included in final report)

Garry,

Steve has well captured all comments. I am nothing to add more.

With regards,

Anil

From: Ryan Steve (ST)
Sent: 15 March 2013 14:33
To: Poole Garry (ST); Kumar Anil
Cc: Johnson Alan (ST); Wilson Alex
Subject: RE: Silvertown Tunnel - cladding and internal clearance reports (to be included in final report)

Garry,

Having reviewed the two documents my comments are as follows:-

Tunnel Engineering Report

1. Design Criteria – This section suggests that up until 1997 the road Vehicles construction and Use regulations) limited vehicle heights to 4.57m. The EU are trying to Phase in by 2014 a new Regulation for Single deck Vehicle heights to be no more that 4m. But will allow double deck heights up to 4,95m sanctioned in each member state. The current UK Carbon efficient Teardrop vehicles exceed the single deck heights of the EU standards. As this will effect the majority of UK Haulage firms requiring a phased trailer replacement, keep the fuel costs and mileage down and in order for the UK to meet its Carbon emissions targets, are there any initial indications on the % uptake on haulage firms moving to double deck trailers to 4.88m plus? I would anticipate a greater uptake in order to be competitive with EU hauliers and therefore potentially have a greater impact on the tunnel by the time it is completed in 2020. Please comment.

2. Having the slightly larger bore to meet the “New Construction Headroom” would have a benefit of either additional walkway width which may assist with the installation of EP and EDP’s (depth @ 400mm) whilst still leaving the Min Footway width of 1200mm to meet the equality act in accommodating wheel chairs etc.

3. Drawing No MMD – 298348-TUN-301 needs updating as the indicated measurements are incorrect, it currently indicates that for a an increase in internal bore size by 500mm there is no increase in external dimensions. Also the width would be greater giving you an additional 250mm? on ether walkway for the same carriageway width. Needs revisiting.

Review of Cladding Options

1. The options do not identify the potential benefits / dis-benefits of Passive Fire protection, either in there use to protect the structure or preferably of protecting the Longitudinal Services such as electrical and communication cabling.

2. With respect to 2.2.1 Reflectance levels, you need to make reference to BS 5489 Pt2 2003 + A1 2008 Code of practice for the design of road lighting Pt 2 lighting in tunnel.
   I assume the Tunnel to be a class 3 (i.e. High Traffic Intensity >1500 vplh, Motorised only, if the tunnel has a mixed type or occasional 2 way traffic flow then it would be a class 4).
   If the tunnel is a class 3 the average luminance of that part of the tunnel walls up to a height of 2m should be not less than 60% of the average road surface illuminance in the corresponding area.
   However, if it is a class 4 then the wall average luminance should not be les than the average road surface luminance up to 2 mts.
   Spill and reflection will light higher up the wall to 4 mts but is not required to meet the levels laid down in the BS. above, therefore there is a question as to the benefits of cladding up to that height and not just painting in a magnolia or lite colour for driver visual appearance.

3. By minimising the cladding height will assist with maintenance handling if panels were installed without specialist lifting equipment and slowing the structural inspection regime down.

4. Various sized spare cladding panels would have to be safely stored to prevent their damage and any corrosion forming to replace damaged panels in the bore.

5. Experience has shown, Metal coated cladding panels have a number of maintenance issues:-

   a. Health and Safety in Man Handling above head height
   b. Corrosion of the hold down screws, including Bi metallic issues depending on the support infrastructure type and screw materials
   c. Panel coating is often damaged on installation and removal causing ongoing panel coating failures
   d. Support infrastructure needs regular inspection for failures
   e. I would question the longevity of the panels and their supports identified in your option 1 statement

6. Slight confusion in the comments between 3.1 option1, suggests that the water ingress in the crown would be limited by the sealing of the tunnel, yet it is a safety issue at wall height in option1. Surely the water ingress management is a drainage issue and not a cladding issue?

7. Option 3 suggests that a painted secondary lining will have to be regularly repainted, yet Industrial and marine coatings “Ceramicoat” product has a min life expectancy of 20 years if applied correctly.

8. I would question your statement in option 3 maintenance, Ceramicoat coating on a secondary smooth lining or use of panels would have little difference in cleaning intervals as they will both get the same traffic film build up on their surfaces. However, depending on the smoothness of the concrete surface of the secondary lining it may need an additional pass with the washer. This can be offset by the potential damage to a cladding panel of a 10 bar pressure washer and mechanical brush of the tunnel cleaning vehicle.

9. With the above comments in mind, from my maintenance experience I would suggest your table Option 1 maintenance would be neutral or even slightly negative and option 3 Whole life costs would be positive.

10. Following a vehicular impact damage to a concrete secondary lining would potentially need less cat 1 work at the time compared to a Panelled surface which would need the damaged panel removed / replaced and the supporting infrastructure inspected around the a joining area for movement / damage

requiring additional Cat 1 removal.

Regards

Steve

Steve Ryan
Tunnels Technical Manager
Tunnels & Structures
Roads Directorate
🖃 Transport for London | Palestra | Floor 8, Green Zone 2, D258 | 197 Blackfriars Road | London | SE1 8NJ |
☎ Office 020 3054 1341 | Auto 81341 | Mobile 07595236653 |
💻 SteveRyan1@tfl.gov.uk

From: Poole Garry (ST)
Sent: 13 March 2013 16:54
To: Kumar Anil; Ryan Steve (ST)
Cc: Johnson Alan (ST); Wilson Alex
Subject: Fw: Silvertown Tunnel - cladding and internal clearance reports (to be included in final report)

Anil and Steve

Please would you liaise and collate comments by Wed next week. I can then review and forward the in time for the Thur 'deadline'.

I am on my Blackberry so have not read the attach. However I am not convinced cladding panels is the best way forward. We have muted a preference for Ceramicoat of the concrete lining,which may have passive fire protection applied to it where required. Can we firm up our views on this please.

Thanks
Garry
......

From: Evans John (DLR)
Sent: Wednesday, March 13, 2013 04:31 PM
To: Poole Garry (ST)
Cc: Wilson Tony (Planning); Fielder David
Subject: Silvertown Tunnel - cladding and internal clearance reports (to be included in final report)

Garry,
Could you please arrange for your team to review the attached and let us have any comments by midday Thursday 21 March '13.
Thanks in anticipation.
Regards, John

From: Naylor, David [mailto:David.Naylor@mottmac.com]
Sent: 11 March 2013 10:31
To: Evans John (DLR); Fielder David
Cc: Baber, Jonathan
Subject: RE: Silvertown - Structure for final report

John, David,

Further to my email on Friday, please find attached the initial drafts of the cladding and internal clearance reports.
At the last progress meeting you suggested we propose a deadline for comments – would a fortnight be suitable in order to obtain meaningful comments from within TfL?

Any queries or questions please don't hesitate to get in touch.

Regards,

David Naylor
Engineer
Tunnel Division

Ext: 3686
t: +44 (0)20 8774 3686
f: +44 (0)20 8681 5706
w: www.tunnels.mottmac.com
e: David.Naylor@mottmac.com

D.3. Assessment for implications of change to traffic category

D.3.1. Introduction

The implications of changing the Dangerous Goods (DG) category of the tunnel (ADR 2011, 1.9.5.2.2 [11]) from category E to category A (i.e. unrestricted) are discussed in this section. Consideration is given to the tunnel life safety arrangements plus possible additional operating measures that might be required. An indicative, order of magnitude estimate of the additional costs (both capital and operating) associated with such a change are provided.

D.3.2. Nature of DG hazards

The ADR regulations for tunnels use five DG groupings, ranked A to E in order of increasing restrictions concerning goods permitted in tunnels:

Grouping A:	All dangerous goods loadings authorised on open roads.
Grouping B:	All loadings in grouping A except those which may lead to a very large explosion (“hot BLEVE” or equivalent).
Grouping C:	All loadings in grouping B except those which may lead to a large explosion (“cold BLEVE” or equivalent) or a large toxic release (toxic gas or volatile toxic liquid).
Grouping D:	All loadings in grouping C except those which may lead to a large fire.
Grouping E:	No dangerous goods (except those which require no special marking on the vehicle).

These groupings are based on the assumption that there are three major hazards in road tunnels which may cause numerous victims and possibly serious damage to the structure: explosions, releases of toxic gas or volatile toxic liquid, and fires.

If Silvertown tunnel is designated Category A, then consideration would need to be given to implementing additional risk mitigation measures to cater for these major hazards:

Large explosions

Two levels of large explosions can be distinguished:

- “Very large” explosion, typically the explosion of a full loading of LPG in bulk heated by a fire (Boiling Liquid Expanding Vapour Explosion (BLEVE) followed by a fireball, referred to as “hot BLEVE”), but other explosions can have similar consequences.
- “Large” explosion, typically the explosion of a full loading of a non-flammable compressed gas in bulk heated by a fire (BLEVE with no fireball, referred to as “cold BLEVE”).

A “very large” explosion (“hot BLEVE” or equivalent) will kill all the people present in the whole tunnel or in an appreciable length of tunnel and cause serious damage to the tunnel equipment and possibly its structure. The consequences of a “large” explosion (“cold BLEVE” or equivalent) will be more limited, especially regarding damage to the tunnel structure. There are generally no possibilities to mitigate the consequences, particularly in the first case.

Large toxic gas releases

A large release of toxic gas can be caused by leakage from a tank containing a toxic gas (compressed, liquefied, dissolved) or a volatile toxic liquid. It will kill all the people near the release and in the zone where the ventilation (either natural or mechanical) will push the gas. A part of the tunnel may be protected but it is not possible to protect the whole tunnel, especially in the first minutes after the incident.

Large fires

Depending on the tunnel geometry, traffic and equipment, a large fire will have more or less important consequences, ranging from few victims and limited damage to several dozens of victims and serious damage to the tunnel.

D.3.3. Societal risk issues

DG accidents can occur on open routes as well as in tunnels. Notably, explosions and toxic releases could be particularly hazardous in densely populated areas. Consequently, when considering societal risks, the whole route network used for DG transport needs to be taken into account and not just tunnels.

The Silvertown tunnel would provide an alternative route option for DG traffic to travel across London. This would include:

a. ‘long distance’ DG traffic that currently uses the M25 or other routes to go around London; and
b. ‘local’ DG traffic serving sites within London that currently has to find other ways across the River Thames. In some cases, this presumably involves significant detours outwards from the centre, around and back into London.

Changing from category E to category A would be expected to attract long distance DG traffic (situation “a” above) into and through London and thereby increase societal risk. For local DG traffic (situation “b” above), the situation would vary on a case by case basis. Where the tunnel offers a shorter more direct alternative to a long detour, then societal risk might actually be reduced by use of the tunnel.

A detailed study would be needed to determine the current DG traffic patterns and associated societal risks across London and the impact of the Silvertown tunnel on those risks. This would involve the comparison of risks along the alternative routes using quantitative risk assessment (QRA) techniques. This could be carried out using the QRA Model (QRAM) software developed jointly by PIARC and OECD for dangerous goods transport through tunnels (http://www.piarc.org/en/knowledge-base/road-tunnels/qram_software/ [3]). The QRAM takes account of accident frequencies (derived from historical datasets), the physical consequences of incidents within tunnel(s) and along the open routes, escape and sheltering effects, and the effects of hazards (such as toxic gas or smoke) on people. The results for different routes and traffic are calculated in terms of Societal Risk. This reflects the range of possible outcomes of an accident, each with different frequencies. There might be a low chance of injuring most of the people in a built-up area, or a higher chance of injuring just a few of them. The risks can be described by an 'F-N curve', where F is the frequency of N or more fatalities (and/or injuries). The F-N curves can be produced for fatalities and/or injuries, and for road users and/or the local population.

D.3.4. Mitigation measures

Options for enhancing safety provisions to reflect the additional potential major hazards are outlined below:

Enhanced tunnel ventilation

Additional jet fans would be needed to control smoke backlayering from the larger fires that could potentially occur if hydrocarbon fuel tankers were permitted. In countries such as France and the Netherlands, a design fire size of 200 MW is adopted for tunnels through which such tanker traffic is permitted.

Smoke control simulations have been carried out using the Mott MacDonald Hotflow software. Based on these simulations, it is estimated that in each bore a total of 28 × 54 kW jet fans (1.12m) would be required to control smoke from a 200 MW fire, compared to 20 × 44.4 kW jet fans for a 100 MW design fire. The additional power requirement associated with the increased jet fan requirements would therefore be approx 624 kW. Extra floor space would be required at each tunnel service building to accommodate the larger switchgear and associated equipment.

Enhanced drainage system

An effective drainage system is important in order to minimise the size and duration of pools occurring on the carriageway and the potential severity of pool fires. The European Directive on road tunnel safety states that where DG transport is permitted, a slot gutter system or a system of equivalent performance is to be installed. Continuous slot gutter systems are advocated in several European countries, following trials involving continuous and ‘instantaneous’ releases of large liquid volumes and measurements of the resulting pool areas.

For example, Figure D.3.1 shows a comparison of pool shapes and sizes observed in spillage tests carried out in different French road tunnels with discrete gullies or continuous slot gutter systems (CETU, 1994 [12]). Two zones are indicated: zone B (dark shading) corresponds to the initial longitudinal and lateral spread near the source, and zone A (light shading) corresponds to the elongated part of the pool spreading along the gutter.

The capacity of the mid-tunnel sump would need to be sufficient to hold the whole contents of a hazardous tanker spillage. The sump would be equipped with an inert foam suppression system, which would be activated in the event of a build-up of flammable vapour within the sump in the unlikely event of both duty and standby sump pumps failing. Otherwise hazardous liquids would generally be pumped to the main impounding sump.

Traffic surveillance, control systems and signage

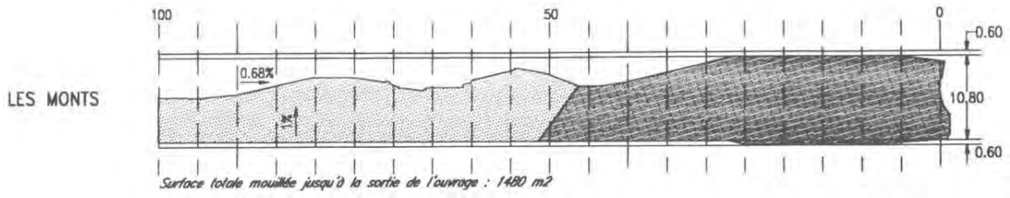
Irrespective of the dangerous goods considerations, the tunnel would be equipped with a range of monitoring, detection, warning and communications systems.

A possible additional measure would an ANPR-type system to detect DG traffic. Such systems look for the DG vehicle placards that indicate the hazard identification numbers (HINs) and emergency action codes (EACs). This system could be useful in an incident to highlight the presence of DG vehicles within the tunnel and the nature of their loads. This would be helpful for determining the appropriate emergency responses.

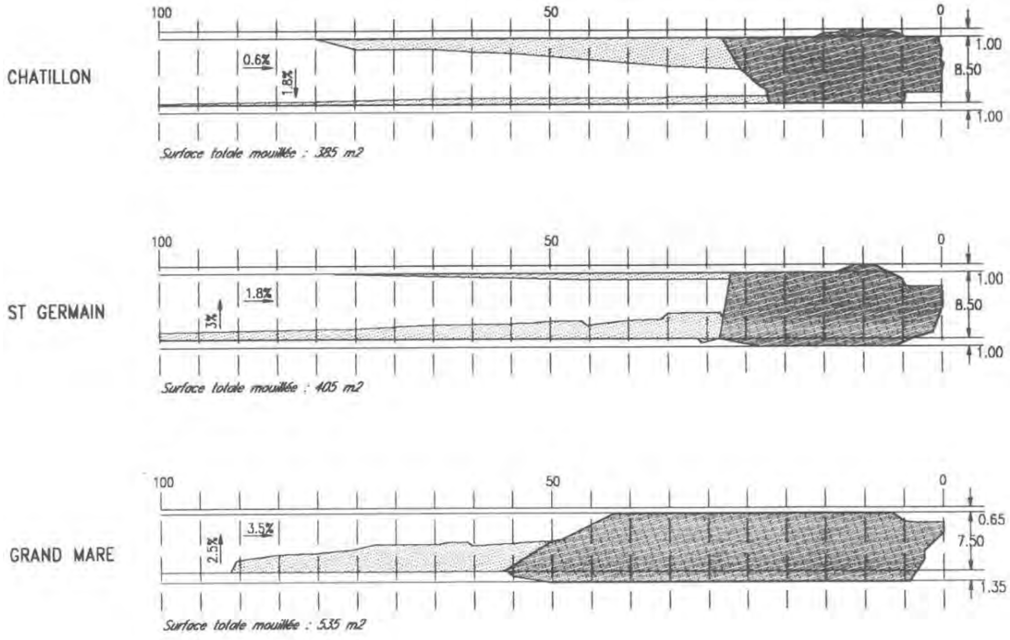
The requirements for DG-related traffic signage on approach routes would depend on the operational regime adopted. If escorting was not adopted, then there would not be a need for additional signage. If escorting was adopted then of course additional signage would be necessary on the approaches. The issues for escorting DG loads are outlined below.

Figure D.3.1 Illustration of the effect of drainage systems on spillages
(observed dimensions for instantaneous release of 10 m^3)

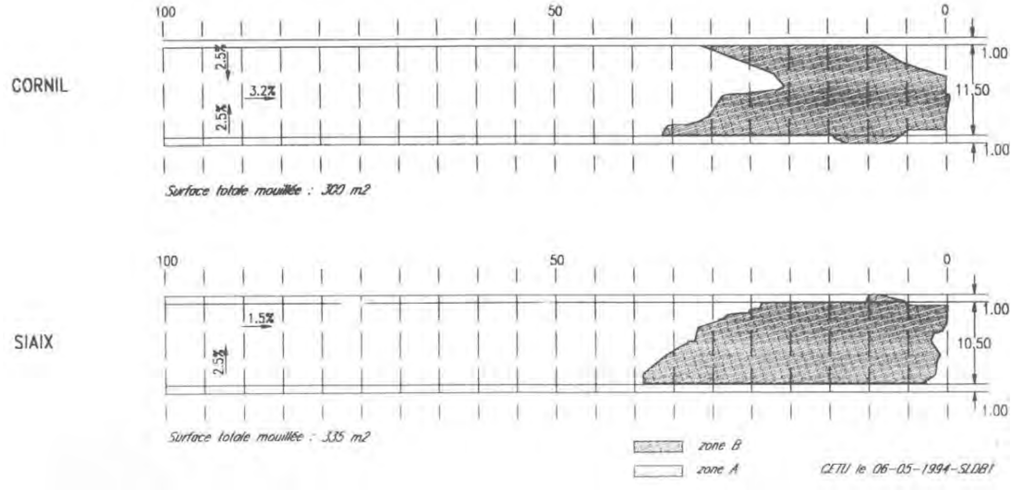
Gullies at 50m intervals



Gullies at 11m intervals



Continuous slot system



Escorting

The principal options for escorting include escorting all or just selected categories of DG vehicles, and escorting at all times or during certain hours only. The potential benefits include the possibility to respond rapidly to incidents, thereby preventing escalation, and to ensure an adequate spacing between the dangerous goods vehicles and other vehicles. The main disadvantages are the operational demands and the costs of marshalling areas, escort vehicles, staff and training.

Concerns are sometimes expressed that grouping tankers together into a convoy increases the possibility of catastrophic consequences. However, it is judged that the combination of driver education and the rapid response capability should minimise the likelihood of such an event.

In the UK, escorting is carried out at the Dartford and Tyne toll tunnels, by trained tunnel staff using Land Rover type vehicles. These staff are suitably trained and equipped for first aid fire fighting, as well as for routine operational duties. Dedicated fire crews are provided at a few tunnels, e.g. at the Mont Blanc tunnel, but these are exceptional cases.

The cost of a establishing and maintaining an escorting regime would high and would probably not be justifiable on cost-benefit terms even for significant DG traffic volumes. For example, during 2007, Mott MacDonald carried out an independent review of measures for the transport of dangerous goods through the Dublin Port Tunnel for Dublin City Council. A survey carried out in 25 July 2007 recorded a total of 313 fuel tankers (UN 1202, 1203, 1223 and 1863) including 141 tankers carrying gasoline. A QRA study found that the safety improvement provided by escorting was equivalent to a risk reduction of the order of 0.02 fatalties/year. It was estimated that if the cost of escorting tankers exceeded € 50,000/year then the cost could be viewed as grossly disproportionate to the benefits. At Dublin Port Tunnel, the annual cost of escorting was estimated to be an order of magnitude greater.

Another possibility at some tunnels, but probably not at the Silvertown tunnel, would be to control traffic to ensure that tankers and other vehicles are segregated. The idea would be to allow tankers to travel unescorted through the tunnel, and to hold other vehicles on the approaches until the convoy has exited the tunnel, or perhaps to allow other vehicles to follow after an interval of 2 minutes, say.

Implications for fire fighting operations

A key issue is whether fire fighters would be able to move close enough to a burning DG vehicle in order to extinguish the fire. The high temperatures, long flames and low visibility would make it almost impossible to attack a fire from the downstream side. With longitudinal smoke control, the tunnel would be clear of smoke on the upstream side of the fire, but the radiation levels would be high close to the fire. A radiation level of 5 kW/m2 for approximately 5 minutes may be considered as the upper limit for fire fighters in protective clothing. To withstand longer durations and carry out hard physical activities, radiation levels must be lower.

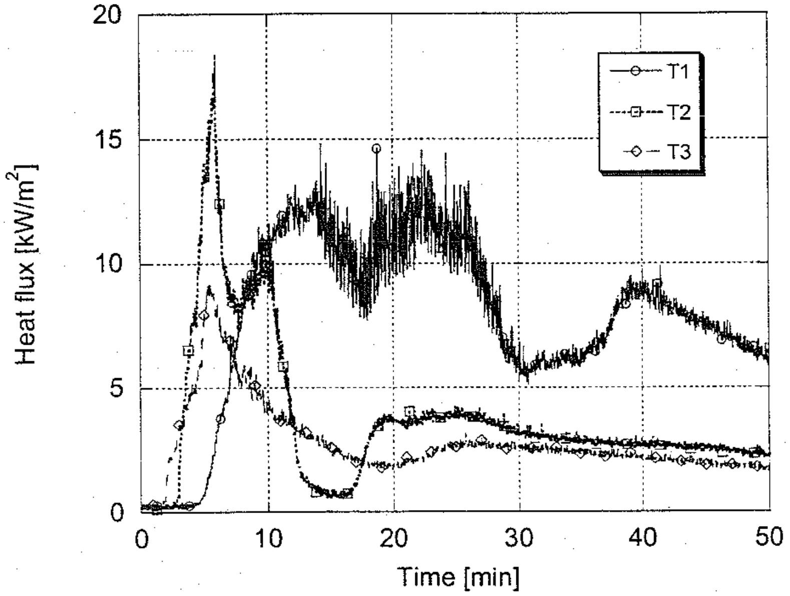
Measurements of radiation levels recorded during the Runehamar tunnel tests in Norway are summarised in Table D.3.1 (Lönnermark, 2005 [13]). This indicates that fire fighters would have to work at approximately 20m from the fire, when the fire intensity is at its peak.

Figure D.3.2 shows how the radiation levels varied with time at a distance of 10m upstream of the fire. Once a combustible load catches fire in the tunnel, it would be very difficult to bring the fire under control until it starts to decay.

Table D.3.1 Peak radiation levels upstream of HGV fires in the Runehamar tests

Test No.	Peak fire size (MW)	Radiation level (kW/m^2)		
		5m upstream	10m upstream	20m upstream
T1	202	80	14	2
T2	157	35	18	3
T3	119	20	9	2
T4	66	40	10	4 (at 15m)

Figure D.3.2 Radiation at 10m upstream of fire in the Runehamar tests



These results indicate that in the event of a 200 MW tanker fire, conditions may be too severe for fire fighting operations.

D.3.5. Cost Estimate

Cost estimates for the changes in tunnel design are given below. These are the estimated extra costs above the baseline cost estimate for the existing tunnel design. The extra costs associated with the drainage and tunnel ventilation changes would be required if the tunnel category changed. Implementing an escorting regime would be an additional mitigation measure subject to further cost benefit analysis.

Drainage

Slot Gutters – It is estimated that installing a slot gutter drainage system instead of gullies would add in the order of £100k to £200k to the cost estimate.

Tunnel Ventilation

Increasing the design fire size will increase the power and number of jet fans required. 20 x 44.4 kW fans required per bore for a 100 MW fire. This will increase to 28 x 54 kW per bore for a 200 MW fire. The cost of extra and more powerful jet fans is estimated as £300k to £400k.

The extra power demand for a 200MW design fire will be 624 kW. The cost of installing this extra power in terms of electrical equipment (larger transformers, incoming supplies, LV switchgear) and floor space is estimated to be in the order of £100k to £200k.

Escorting

To implement a tunnel escort system would require marshalling land, escort vehicles and associated buildings and staff. The land area required for this is estimated to be 5000 m2 (cost of this land not estimated). The cost of extra the buildings and vehicles is estimated to be £500k to £1m. The operational costs for running the escorting regime could be of the order of £500k to £1m per annum.

Total Cost Increase

It is estimated that the total capital cost increase would be £1.0m to £1.8m (including implementing a regime change).

There would also be an estimated increase in operational costs of £500k to £1.0m.

D.4. Phase 1 Settlement Assessment

Silvertown Tunnel

Stage 1 Potential Damage Assessment

April 2013
Transport for London

Mott MacDonald

Silvertown Tunnel

Stage 1 Potential Damage Assessment

April 2013

Transport for London

Windsor House 42-50 Victoria Street, London SW1H 0TL

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	23/04/2013	R Harper	G R Taylor	J Baber	Draft for comment
			Graham Taylor		

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Content

1. Introduction

1.1 Scope

Mott MacDonald were commissioned by Transport for London (TfL) in February 2013 to undertake further design development of the proposed Silvertown tunnelled crossing of the River Thames between Greenwich and Silvertown in east London. This report presents the results of Stage 1 of the Potential Damage Assessment procedure including the greenfield ground surface settlement contour plot for the currently proposed Silvertown Tunnel scheme. A comprehensive understanding of the likely magnitude and areal distribution of the ground movements induced by the proposed construction works is needed in order to:

- Develop a safe and economic design;
- Facilitate project risk management and reduce construction uncertainty;
- Assess the potential effects of the proposed works on adjacent infrastructure, e.g. the various buildings and sub-surface structures within the vicinity of the proposed works; and
- Enable a design to be developed that limits the need for additional mitigation measures.

The construction of the tunnels, cross passages, Tunnel Boring Machine (TBM) launch/reception chambers and tunnel portals associated with the proposed Silvertown Tunnel scheme will inevitably result in excavation-induced ground movements. The magnitudes of these movements will be dependent upon a number of factors including the ground and groundwater conditions, the construction methods to be employed, the quality of workmanship and level of supervision. Existing surface buildings, sub-surface structures and services/utilities in the vicinity are all likely to be affected by such works. Ground movements at the Silvertown Tunnel site may be induced by:

- Excavation of the tunnels, cross passages, TBM launch/reception chambers and tunnel portals/approaches; and
- Consolidation and equilibration of pore pressures in the long term following the change in boundary conditions induced by underground construction.

The results presented in this document are restricted to the immediate ground movements induced by excavation; the effects of long term ground movements are not addressed. In general little damage has been recorded due to such consolidation settlement alone but where damage has been induced during construction or existing defects/lines of weakness exist, concentrations of strain can significantly increase the degree of damage (Harris, 2002).

The guidance given in the following London Underground Limited (LUL) Engineering Standards and manuals of good practice with regards ground movement estimation and potential damage assessment has been taken into account in the preparation of this report:

- LUL Engineering Standard 2-01304-001, Civil Engineering – Common Requirements.
- LUL Engineering Standard 2-01304-006, Civil Engineering – Deep Tube Tunnels and Shafts.
- LUL Manual of Good Practice 5-01304-006, Civil Engineering – Deep Tube Tunnels and Shafts.

- LUL Ground Movement Guidelines, June 2008.
- LUL Good Practice Guide, Managing Underground Heritage, Issue 1 09/06.
- LUL Manual of Good Practice, G-058A9, Civil Engineering – Technical Advice Notes.

1.2 The Proposed Scheme

The proposed 12.1m diameter bored tunnel is to provide a dual 2-lane connection between the A102 on the Greenwich Peninsula and the Tidal Basin Roundabout on Silvertown Way. There will be 3 No. cross passages at a spacing of typically 350m along the alignment of the bored tunnel section. The 4.55m diameter cross passages are to be formed employing the Sprayed Concrete Lining (SCL) technique.

The tunnel approaches are to consist of cut and cover tunnelled sections and open cut ramps. The embedded retaining walls will be formed using a combination of diaphragm and secant pile walling techniques.

Relevant section drawings of the proposed scheme are given in Appendix A.

2. Potential Damage Assessment

2.1 General

Ground displacement is an inevitable consequence of underground construction; the deformations and resultant damage that may occur from such sub-surface works must be assessed. In order to assess the potential for excavation-induced damage it is necessary to:

- predict the zone of influence of anticipated ground movement;
- estimate the magnitude of ground displacements within this zone; and
- determine how these influence (and may be modified by the presence of) existing structures.

The widely accepted three-stage approach to potential damage assessment (Mair et al., 1996) is to be adopted on this project, with an increased level of rigour being applied at each stage of the process. The three-stage approach proposed herein has been successfully used recently on the Jubilee Line Extension, Channel Tunnel Rail Link and Crossrail projects amongst others in the UK. The procedure is shown graphically for buildings in Figure 2.1. Similar staged approaches are adopted for sub-surface assets and services/utilities.

The potential damage assessment process is intended to be conservative such that those structures at risk of sustaining unacceptable damage can be identified and thereby allow more detailed study to be concentrated in problematic areas (Mair et al., 1996). The greenfield ground surface settlement contours determined as part of this process are not intended to serve as a prediction of the expected effects but should be used as a filter to identify infrastructure that is potentially at risk (Moss & Bowers, 2005).

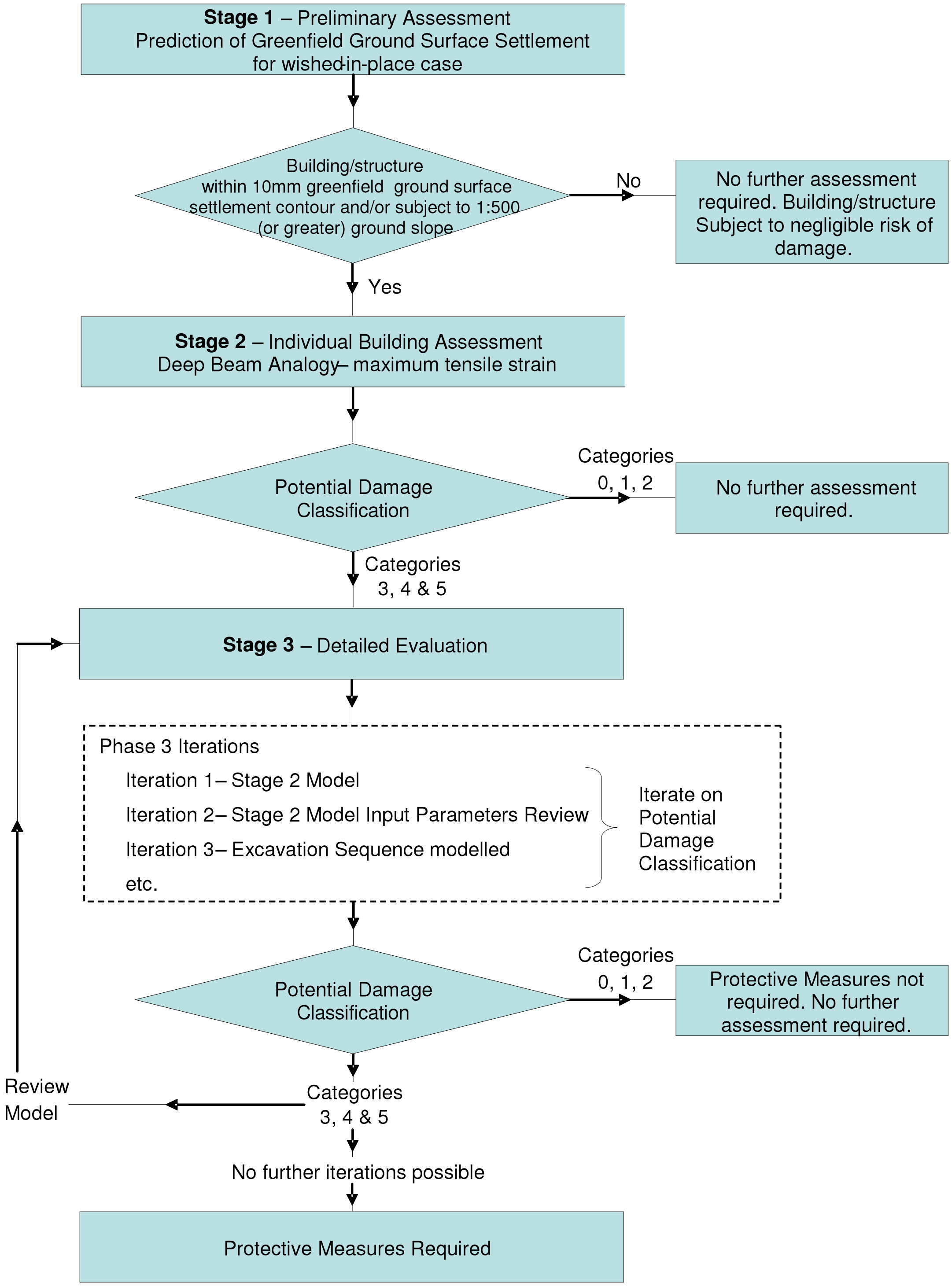

Figure 2.1: Potential Damage Assessment procedure.

2.2 Stage 1 Potential Damage Assessment

Stage 1 of the potential damage assessment process comprises the production of contours to identify, in the first instance, the number of structures within the zone of influence attributable to excavation-induced ground movement. This zone of influence is usually defined as the 1mm greenfield ground surface settlement contour. A greenfield assessment ignores any positive contribution made by existing structures in mitigating the effect of excavation-induced ground movement. Structures outwith the 1mm settlement contour are usually not considered further. Generalised criteria, for example a minimum settlement of 10mm or a slope of 1:500 for buildings (Rankin 1988), are then applied to select structures within the zone of influence for further consideration during Stage 2. Experience on recent tunnelling projects undertaken in the London area has shown that the effects on buildings of ground movements less than 10mm are not significant. However, the criteria should be applied with thought rather than on a purely mechanical basis; exceptions are usually made for Listed Buildings. The existing condition, presence of sensitive features and potential lines of weakness as well as long-term settlement effects can all combine to produce significant damage in structures, which would otherwise be eliminated from further consideration at Stage 1.

The calculations are simple and straightforward adopting the conventional empirical greenfield formulations for settlement estimation, and provide a useful method of identifying structures which will be affected by the relatively rapid movements that occur during construction. The empirical greenfield formulations are based on well-established and widely accepted methods determined from the back analysis of case histories of short-term volume loss movements (for example O'Reilly and New (1982), Attewell and Woodman (1982), and New and Bowers (1994)).

There is no widely accepted method for estimating the ground movements generated by the excavation of boxes and open cut ramps. Settlement estimation procedures have been developed for use on the Crossrail project and it is proposed that these procedures are adopted on this project. The procedures are based on the case histories of box and shaft excavations in stiff clays presented in CIRIA C580; most of the limited data available relates to excavations within London Clay.

3. Settlement Prediction Methodology

3.1 Notation

The general notation used to define ground response to excavation is as follows:

- S_v is the vertical ground movement (settlement/heave) at any point.
- S_h is the horizontal ground movement at any point. The horizontal ground movement has components in two orthogonal directions. The value of S_h is the vector sum resolved into the direction of the relevant analysis section line.

3.2 Settlement due to Tunnelling

The ground surface settlement induced by tunnel construction is commonly described by a Gaussian Error function in the transverse direction (for example O'Reilly & New, 1982) and a Cumulative Error function in the longitudinal direction (Attewell & Woodman, 1982). Figure 3.1 illustrates the assumed inverted normal probability distribution curve settlement profile and input parameters for tunnels adopting the point sink approach of O'Reilly & New.

For a single tunnel running between a starting point (x_i, y=0) and a finishing point (x_f, y=0) the corresponding surface settlement trough is defined by the following equation:

$$s_v = s_{v\max} \cdot e^{\left(\frac{-y^2}{2i^2}\right)} \left[\varphi\left(\frac{x-x_i}{i}\right) - \varphi\left(\frac{x-x_f}{i}\right)\right]$$

where

$S_{v\max}$ = maximum settlement at the centre of the trough due to a single tunnel (m). The maximum settlement is calculated from:

$$s_{v\max} = \frac{V_l \pi \, r^2}{i\sqrt{2\pi}}$$

V_l = volume loss expressed as a percentage of the tunnel excavated volume (%);

r = excavated radius of tunnel (m);

i = point of inflexion (m);

x, y = planar co-ordinates (m);

ϕ (α) = normal cumulative distribution function.

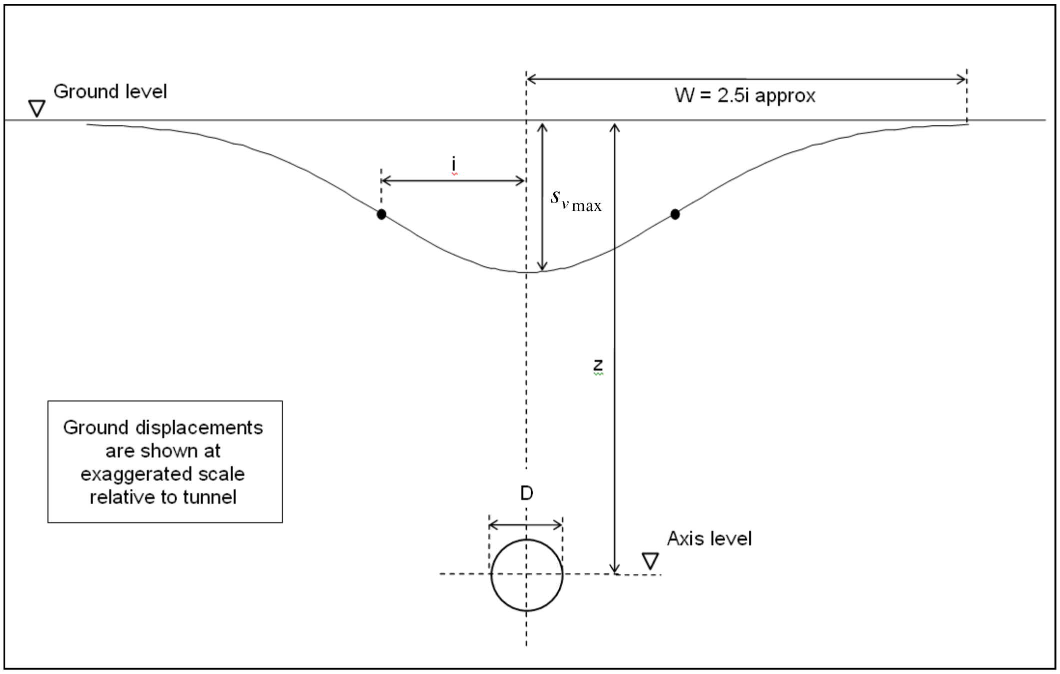

Figure 3.1: Settlement due to tunnelling.

Depending on the position of the proposed tunnel in relation to the position where the ground movements are to be determined different approaches may have to be adopted. When determining ground movements within one tunnel diameter of the crown of the proposed tunnel the 'ribbon' sink assumption, which is the basis of the approach of New & Bowers (1994), is considered to give a better representation of the anticipated movements than that of the 'point' sink assumption. The 'point' sink assumption is the basis of the approach of O'Reilly & New (1982). The Stage 1 Potential Damage Assessment presented in this report has been undertaken adopting the point sink approach.

3.2.1 Volume Loss

The volume loss parameter is assumed to be equal to the volume of the ground surface settlement trough per unit length. Volume loss in tunnelling results from the following four ground movement effects:

- movement towards the unsupported excavated face;
- movement prior to effective support of the heading;
- movement associated with the passage of the shield (if applicable); and
- movement associated with the lining deformation.

These effects have been combined into a single parameter representing the volume loss expressed as a percentage of the assumed excavated volume. Thus, the ‘volume lost’ is expressed as:

$$V_s = V_l \frac{\pi \mathrm{D}^2}{4}$$

3.2.2 Trough Width

The width of the ground surface settlement trough is assumed to be directly proportional to the depth of the tunnel, and the nature of the surrounding soils (O’Reilly and New, 1982). The trough width is related to the depth to the tunnel axis by the trough width parameter, K, as follows:

$$i = Kz$$

where:

i = point of inflexion (m);

K = trough width parameter (an empirical constant);

z = depth to tunnel axis (m).

The trough width parameter is dependent upon the ground conditions through which the tunnel will be constructed and those above the tunnel. The choice of an appropriate value of K requires interpretation of the ground conditions, and in particular whether the material is cohesive or granular, and in the latter case on whether the tunnel is above or below the water table.

3.3 Settlement due to Box and Retained Cut Excavations

Adopting the procedures developed from case histories presented in CIRIA C580, the settlement trough is described by the hogging zone of the inverted normal probability distribution curve settlement trough adopted for tunnels. The following equation is used to calculate the ground surface settlements anticipated from box and retained cut excavations, assuming a variation in settlement from a maximum at the wall to a minimum at a distance *W* from the wall:

$$S_v = \delta_v e^{\left(\frac{1}{2}-\frac{1}{2}\left(1+1.5\frac{y}{W}\right)^2\right)}$$

where

S_v = settlement due to the box construction (m);
δ_v = settlement at the box wall face (m);
y = distance from the box outer wall (m);
W = extent of the settlement trough (m).

Figure 3.2 illustrates the assumed ground settlement profile (related to the hogging section of the inverted normal probability curve) and parameters required for modelling box and retained cut excavations.

The horizontal movement is defined by the following equation:

$$h = s\frac{\delta_h}{\delta_v}\left(1+1.5\frac{y}{W}\right)$$

where

δ_h = horizontal ground movement at the box wall face (m).

For box and retained cut excavations, ground movement is dependent upon the ground conditions, depth of the excavation and support system stiffness. The values of the settlement at the wall (δ_v) and the extent of the settlement (*W*) are expressed as functions of the support system stiffness and the excavation depth (*Z*).

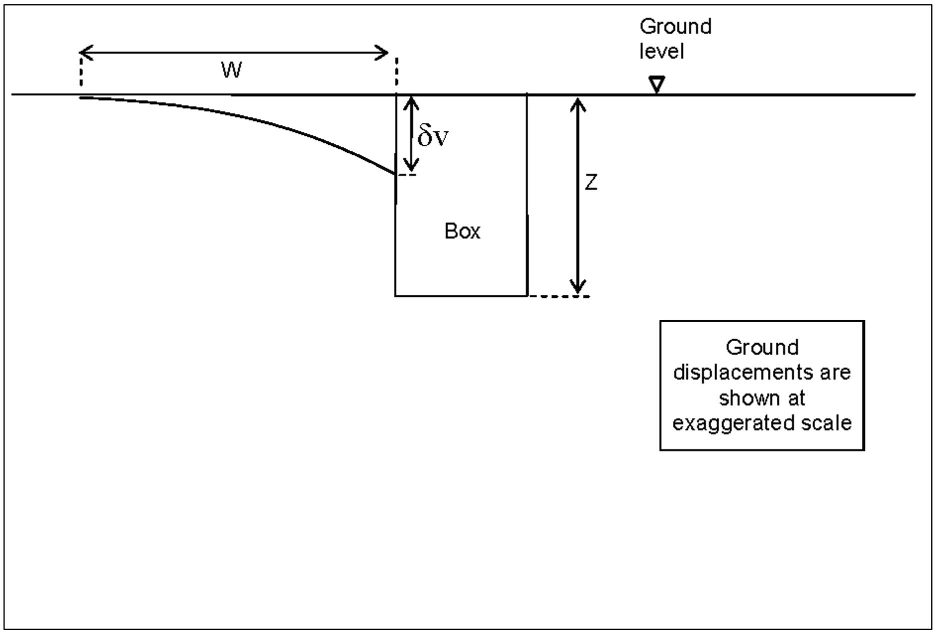

Figure 3.2: Settlement due to box excavation.

3.4 Input Parameters

3.4.1 Tunnel Parameters

The volume losses assumed during Stage 1 of the potential damage assessment process have been based on a review of the proposed works, including the ground and groundwater conditions, ground treatment proposals and tunnelling techniques to be used. Table 3.1 summarises the volume losses adopted in the determination of the tunnelling-induced ground movements. These values are based on our experience of past projects in London in similar ground conditions and at this stage in the implementation process, i.e. the planning stage; they are considered to be ‘conservative’ values. They are historic and based on both open and closed-face tunnelling in London Clay/ the Lambeth Group. The values of these parameters shall be critically reviewed at later stages in the procurement process as the design is developed.

A trough width parameter of K = 0.5 has been adopted throughout. This reflects the predominantly cohesive nature of the soil through which these tunnels and cross-passages are to be constructed.

Table 3.1: Input parameters – tunnels.

Element	Construction Method	Trough Width (*K*)	Volume Loss (%)
Running Tunnels	TBM	0.5	1.7
Cross Passages	SCL	0.5	2

3.4.2 Box and Retained Cut Parameters

For box and retained cut excavations, ground movement is dependent upon the depth of the excavation and the support system stiffness provided. The input parameters adopted for the box and retained cut excavations associated with the construction of the Silvertown Tunnel are presented in Table 3.2. It has been assumed that all the box and retained cut excavations for the proposed works are to have high support system stiffness.

Table 3.2: Input parameters - box and retained cut excavations.

Excavation	Support stiffness category	$\delta v/Z$ (%)	W/Z	$\delta h/\delta v$
Cut and cover box	High support system (propped)	0.18	2.5	1.0
Retained cut	High support system (propped)	0.18	4.0	1.0

The Mott MacDonald in-house computer program Ground Response Programme (Version 5.0.5) has been used to determine the greenfield ground surface movements. This program has been fully validated and extensively employed on recent projects in London including Crossrail and LUL's Victoria Station and Bank Station Capacity Upgrade projects. The corresponding settlement contour plot was prepared using Golden Software's Surfer® software package.

4. Assessment Results

The Stage 1 Potential Damage Assessment greenfield ground surface settlement contour plot is presented in Appendix B. The areal distribution of the anticipated ground movements are as expected, the maximum settlements occurring over the proposed tunnels, decreasing with increasing distance from the proposed works.

4.1 Surface Structures

On the basis of the results of the Stage 1 Potential Damage Assessment the surface structures summarised in Table 4.1 are referred for Stage 2 assessment. The generalised criteria after Rankin (1988), a greenfield ground surface settlement of less than 10mm or a slope flatter than 1:500, have been employed to eliminate structures within the zone of influence from further consideration.

There are no Listed Buildings located within the 1mm predicted settlement contour. The ‘Entrance to Blackwall Tunnel’ is a Grade II Listed Building but lies some distance outside of the 1mm predicted settlement contours and as such, has not been referred for further assessment.

It is understood that historically on projects such as the Silvertown Tunnel it has been TfL policy to undertake condition/defect surveys of all surface structures (or part thereof if applicable) located within the 1mm greenfield ground surface settlement contour. Those surface structures located within the 1mm greenfield ground surface settlement contour (but not the 10mm greenfield ground surface settlement contour) are listed in Table 4.2. These assets have not been referred for Stage 2 assessment.

Surface structures which are in conflict with the proposed scheme are listed in Table 4.3. It is assumed that these structures are to be demolished as part of the proposed works and thus, no further assessment is required.

The locations of the surface structures listed in Tables 4.1 and 4.2 are shown in Figures 4.1 and 4.2.

4.2 Infrastructure

Existing transport infrastructure located within the ground movement zone of influence associated with the proposed Silvertown Tunnel scheme are as follows:

- Blackwall Tunnel Southern Approach;
- DLR viaduct running between West Silvertown and Canning Town stations; and
- Silvertown Way viaduct which runs parallel to Dock Road within the vicinity of the proposed northern tunnel portal.

It should be noted that although the Blackwall Tunnel Southern Approach lies outside of the 10mm predicted greenfield ground surface settlement contour, it is considered prudent to undertake further assessment due to its interface with the proposed scheme. The anticipated ground movements in the vicinity of the Silvertown Way viaduct are such that no further assessment is considered necessary.

Depending upon the nature (i.e. flexible or rigid) of the road pavement of the surface road network, e.g. Millennium Way, the A102, Edmund Halley Way, etc, in the vicinity of the proposed southern tunnel portal, mitigation measures may be required.

4.3 Buried Services

Drainage infrastructure associated with the Royal Victoria Dock clashes with the proposed retained cut excavations: a drainage channel which runs from a pumping station located at the western end of the Royal Victoria Dock and outfalls into the River Thames. It is understood that the drainage channel will be diverted around the retained cut excavations associated with the northern tunnel portal; however, the impact of excavation-induced ground movements on the drainage channel will still require further assessment.

There is also a comprehensive network of buried services including water mains, sewers, gas mains and telecommunications cables within the zone of influence attributable to excavation-induced ground movements associated with the proposed Silvertown Tunnel. Further details of tunnel/pipe alignment, material and diameter will be required in order to carry out further assessment of the impact of the proposed works on these assets.

Table 4.1: Surface structures requiring further assessment.

Structure No.	Structure	Grade Listing	Assessment Level Required
1	Emirates Greenwich Peninsula Cable Car Terminal	N/A	Stage 2
2	Cable Car South Tower and ship protection	N/A	Stage 2
3	Electrical substation north of Edmund Halley Way	N/A	Stage 2
4	Thames River Wall – South	N/A	Stage 2
5	Blackwall Tunnel Southern Approach (retaining walls)	N/A	Stage 2
6	Thames River Wall – North	N/A	Stage 2
7	Warehouse building north of Bell Lane (possibly associated with Laing O'Rourke)	N/A	Stage 2
8	Warehouse building north of Bell Lane (possibly associated with ES Global)	N/A	Stage 2
9	Warehouse building north of Bell Lane (possibly associated with ES Global)	N/A	Stage 2
10	Warehouse building north of Bell Lane (possibly associated with ES Global)	N/A	Stage 2
11	Warehouse building north of Bell Lane (possibly associated with ES Global)	N/A	Stage 2
12	Warehouse building north of Bell Lane (possibly associated with ES Global)	N/A	Stage 2
13	Cable Car North Intermediate Tower	N/A	Stage 2
14	Docklands Light Railway viaduct	N/A	Stage 2

Table 4.2: Surface structures for which no further assessment is required.

Structure No.	Structure	Grade Listing	Assessment Level Required
15	Unknown buildings south of DLR viaduct	N/A	Stage 1
16	Laing O'Rourke Operations Centre	N/A	Stage 1
17	Waterfront Studios Business Centre	N/A	Stage 1
18	Electrical substation located south of DLR viaduct	N/A	Stage 1
19	Electrical substation north of Dock Road	N/A	Stage 1
20	Silvertown Way viaduct	N/A	Stage 1

Table 4.3: Buildings assumed to be demolished as part of the proposed works.

Structure No.	Structure	Grade Listing	Assessment Level Required
21	Unknown buildings south of Ordnance Crescent	N/A	N/A
22	Unknown building east of the Blackwall Tunnel Approach	N/A	N/A

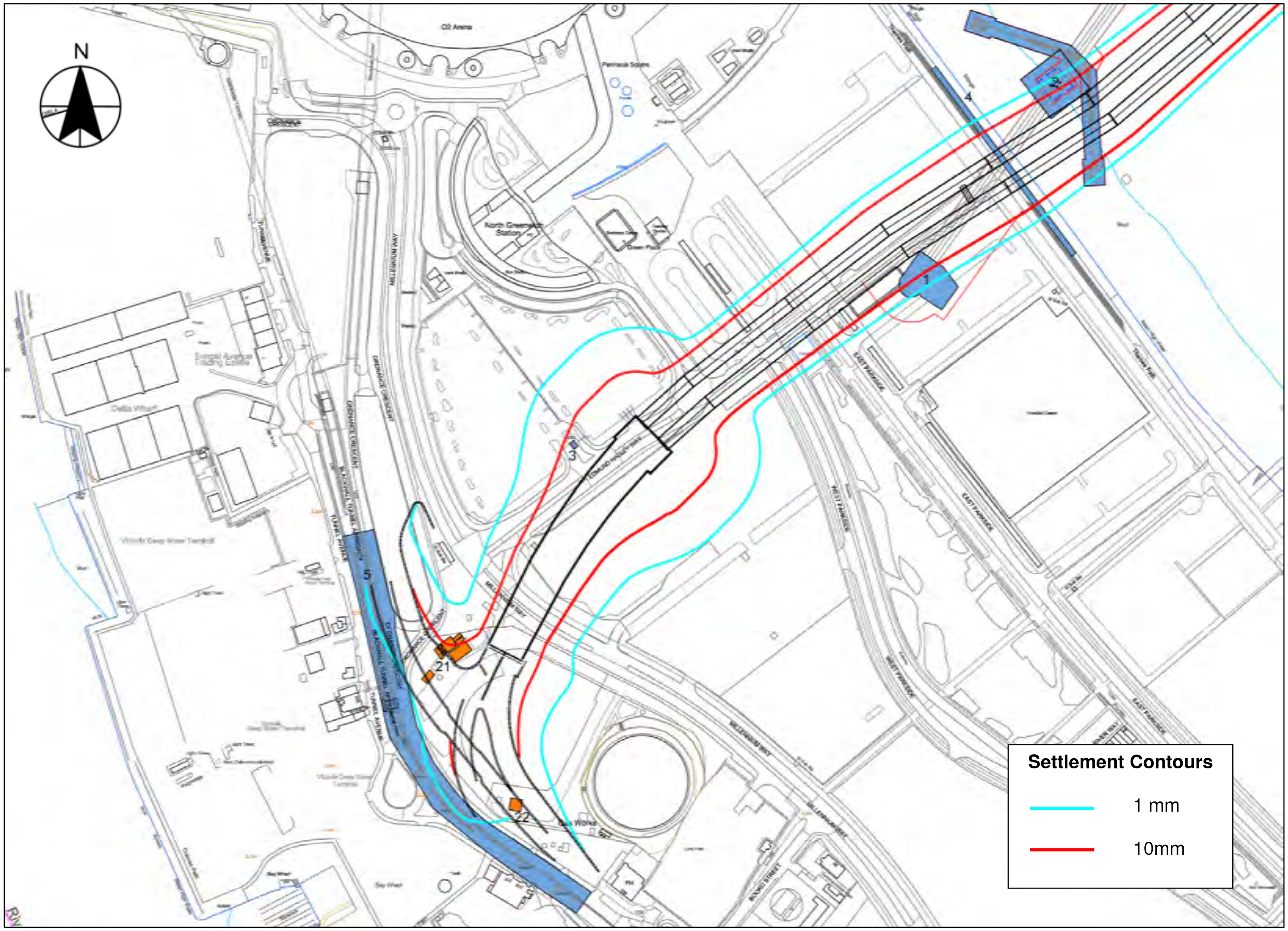

Figure 4.1: Buildings south of the River Thames.

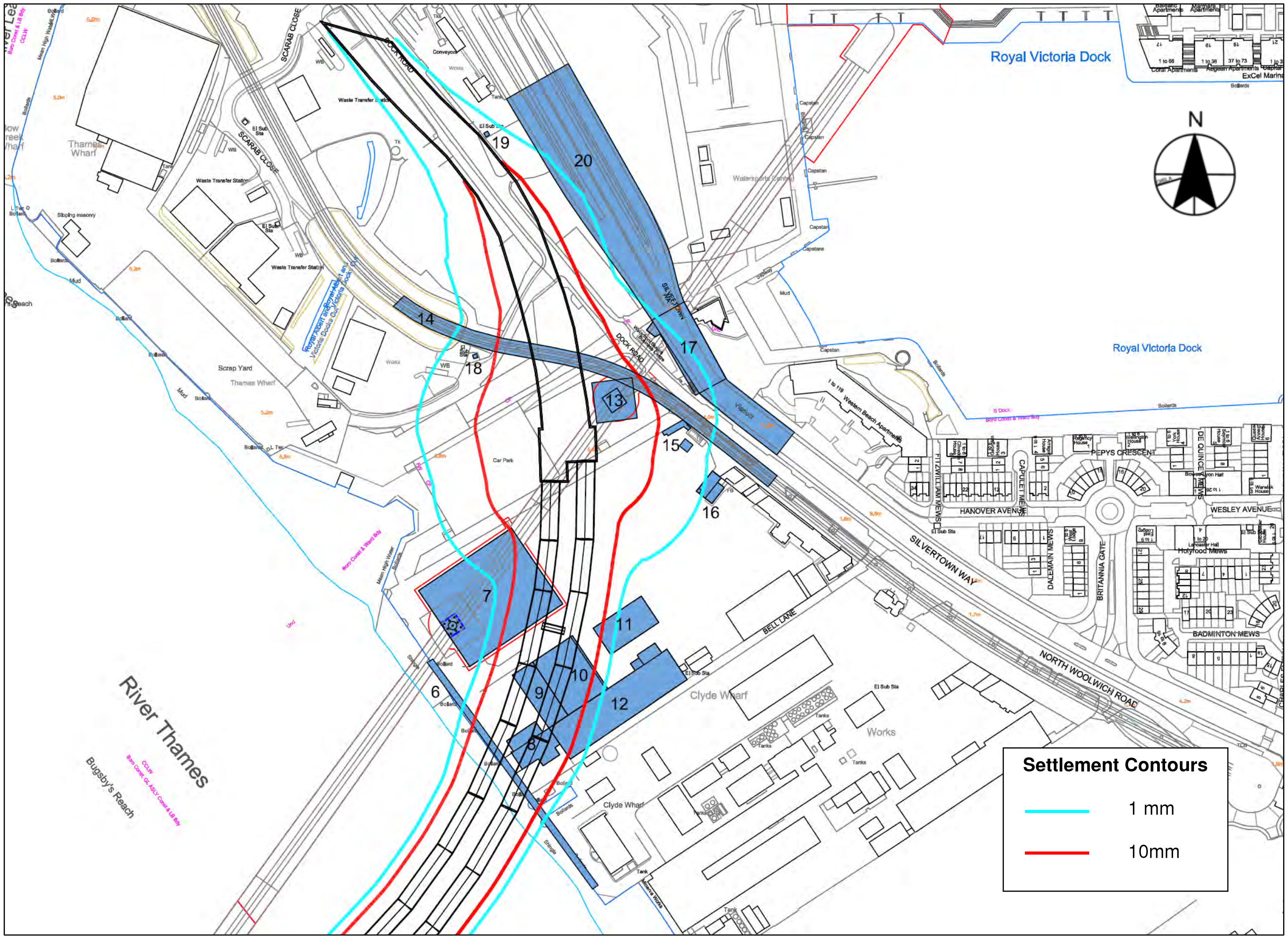

Figure 4.2: Buildings north of the River Thames.

5. Preliminary Mitigation Measures

There are various mitigation measures which can be applied to limit the impact of excavation-induced ground movements on buildings and other infrastructure, including:

Design Modifications – modifications to the design of the temporary and/or permanent works to minimise the impact of ground movements on a particular building or facility. The impacts of ground movements should be considered as an integral part of the design process. Design modifications to the proposed underground works, for example the tunnel size and alignment, are usually considered to be the most cost effective mitigation measure option.

At-source Measures – techniques designed to reduce the magnitude of excavation-induced ground movements at source. In general, these comprise the installation of additional and/or stiffer support to the ground at the earliest practicable point within the excavation sequence and are over and above normal good practice, for example forepoling or soil nailing in the tunnel face.

For tunnelling operations, the selection of an appropriate excavation technique and lining method is important in minimising ground movements, for example the incorporation of a pilot tunnel in the construction sequence. In box and retained cut construction, the methods employed to support the ground as excavation progresses will dictate the magnitude of the adjacent ground movements.

Strengthening of the ground – this can be achieved by grout injection (cement or chemical) or by ground freezing. Such ground treatment is usually undertaken in granular water-bearing strata. The primary purpose of such works is to provide a layer of increased stiffness below building foundation level or to prevent ground loss at the tunnel face during excavation.

Permeation grouting – the injection of cement grout into gravels or sands to bind the soil together and thus redistribute loads and resist local deformations; there would also be a decrease in permeability of the ground. The grout is normally injected through pipes (Tube à Manchettes) from the ground surface or from basements/shafts.

Ground freezing – the temporary artificial freezing of the ground to stabilise it, through the provision of structural support to and/or exclusion of groundwater from an excavation, thus enabling construction.

Jet grouting – the controlled replacement of the ground with grout. After treatment the ground is stronger, stiffer and less permeable.

Strengthening of the structure – to sustain the additional stresses or accommodate the corresponding deformations induced by excavation-induced ground movements without significant distress buildings can be strengthened. These strengthening works may include the use of tie rods, bracing and temporary/permanent propping. However, such work can be very intrusive and may result in greater impacts on the structure than simply allowing some cracking to occur which can be repaired subsequently. Consequently these works should be carried out in a manner which does not interfere with or damage any historic features or aspects of a structure.

Underpinning – the introduction of an alternative foundation system to eliminate or minimise differential movements induced by excavation. If the existing foundations are inadequate or in a poor condition, underpinning may be used to strengthen them and provide a more robust and stiffer support system.

Mechanical jacking – the insertion of hydraulic or screw jacks at appropriate locations within the structure so that, as the foundations move down as a result of excavation-induced ground movement, the level of the structure above can be adjusted and maintained. The jacks are removed on completion of the works and the integrity of the structure reinstated. This measure may also be used where a building houses sensitive equipment.

Installation of a Physical Barrier – the installation of, for example a slurry trench wall or a row of secant bored piles, between a foundation and the source of the excavation-induced ground movements. Such a barrier is not structurally connected to the foundation and therefore does not provide direct load transfer. The intention is to modify the shape of the settlement trough and reduce ground displacements adjacent to and beneath the structure.

Compensation grouting – the controlled injection of cement grout into the soil between the proposed tunnel and the affected structure in response to observations of ground and building movements during tunnelling. As the name implies the technique is intended to *'compensate'* for the ground loss. Grout is injected in stages as excavation proceeds. This technique is suited to the clay soils underlying most buildings in Central London; it has also been successfully applied to sands and gravels. Shafts usually have to be constructed to enable the grout to be injected at the appropriate level in the soil. Detailed instrumentation and monitoring is also required as part of the process.

Burland (2001) commented that compensation grouting is a very expensive protective measure and that careful consideration should be given to its use. In addition, he noted that the actual level of damage sustained by many of the buildings along the route of the Jubilee Line Extension was less than that anticipated on the basis of the results of the staged assessment process. Burland concluded that compensation grouting was thus not strictly required to the buildings overlying the running tunnel alignments. He also noted that there was little doubt that compensation grouting was necessary above the major underground stations at Westminster, Waterloo and London Bridge but that it was likely that lower volumes of grout could have been used.

Monitoring - Monitoring does not mitigate the effects of settlement, but it can be used as appropriate to check that the magnitudes of the anticipated movements are not being exceeded. It can also be used where needed to determine whether reactive mitigation works need to be implemented.

Making Good - If some minor cracking does occur with residual impacts which are all assessed as Not Significant, appropriate conservation techniques can be employed to effect sympathetic repairs to historic fabric.

In the first instance, the mitigation measure to be adopted would comprise in most cases a 'do nothing' approach with 'making good' on completion of the works. If this was not acceptable then consideration would be given to mitigation of the excavation-induced ground movements at source, including design modifications. Other more significant mitigation measures, for example ground treatment or intrusive works to the structure under consideration, would only be considered if these initial approaches were not feasible. Instrumentation and monitoring would form a fundamental part of all these approaches.

The actual mitigation measures to be adopted for specific structures will be developed on completion of further asset-specific impact assessment as part of the potential damage assessment process.

6. Conclusions

This document has presented the results of Stage 1 of the Potential Damage Assessment process for the Silvertown Tunnel scheme including the greenfield ground surface settlement contour plot as well as the assumptions made in its generation. The structures referred for Stage 2 assessment on the basis of the results of the Stage 1 Potential Damage Assessment have also been presented as have those which require no further assessment.

The widely accepted three-stage approach to potential damage assessment (Mair et al., 1996) is to be adopted on this project, with an increased level of rigour being applied at each stage of the process. The three-stage approach proposed herein is in accordance with that outlined in LUL's 'Ground Movement Guidelines'. The potential damage assessment process is intended to be conservative such that those structures at risk of sustaining unacceptable damage can be identified and thereby allow more detailed study to be concentrated in problematic areas (Mair et al., 1996). The greenfield ground surface settlement contours determined as part of this process are not intended to serve as a prediction of the expected effects but should be used as a filter to identify buildings and infrastructure that is potentially at risk (Moss & Bowers, 2005).

The various mitigation measures which can be applied to limit the impact of excavation-induced ground movements on buildings and other infrastructure are described in Section 5. The actual mitigation measures to be adopted for specific structures will be developed on completion of further asset-specific impact assessment as part of the potential damage assessment process.

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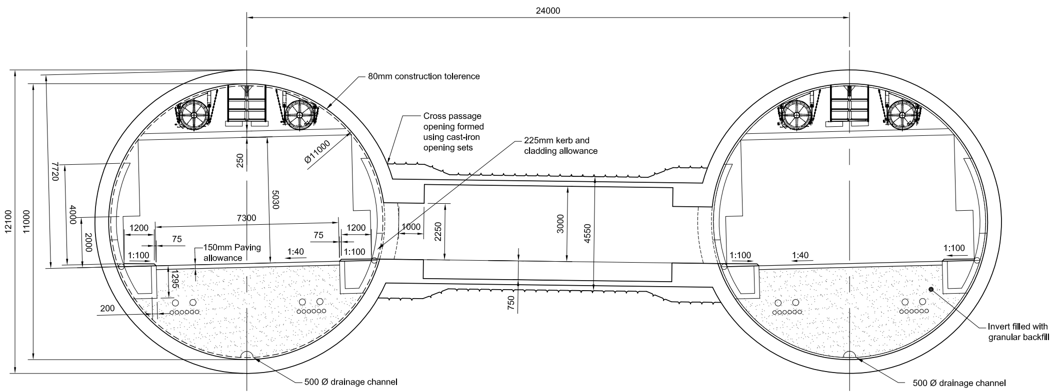
Appendices

Appendix A. Scheme Drawings



Cross Section

Scale 1:100

0 5m 10m

Horizontal Scale 1:100 @ A1

Notes

Key to symbols

Reference drawings

P1	17/02/12	RK	Preliminary Issue	AE	ML
Rev	Date	Drawn	Description	Ch'k'd	App'd

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Title

Silvertown River Crossing
Bored Tunnel Option
Bored Tunnel Cross Section

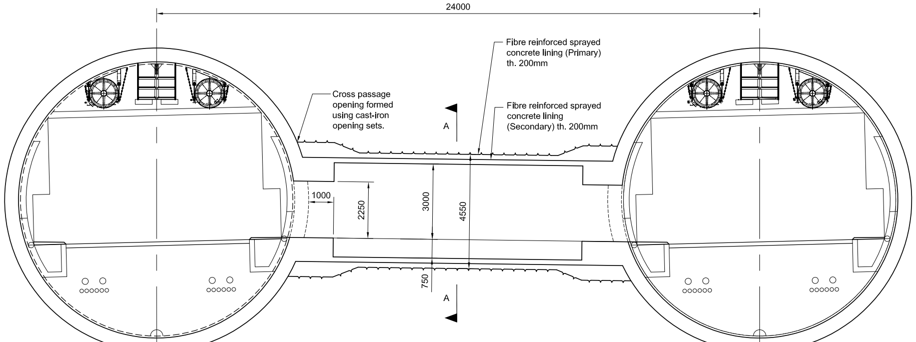
Designed	AE		Eng check	NT
Drawn	RK		Coordination	NT
Dwg check	AE		Approved	ML

Scale at A1 1:100

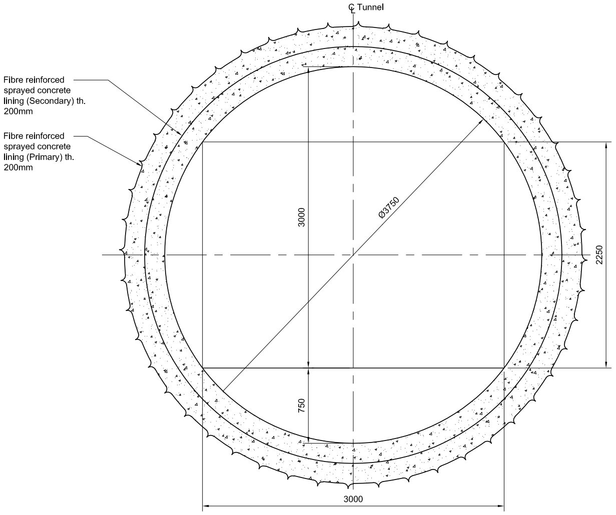
Status PRE

Rev P1

Drawing Number MMD-298348-TUN-206



Typical Emergency Escape Cross Passage
Scale 1:100



Emergency Escape Cross Passage Section A-A
Scale 1:25

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Horizontal Scale 1:25 @ A1

0 5m 10m
Horizontal Scale 1:100 @ A1

Notes

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	17/02/12	RK	Preliminary Issue	AE	ML

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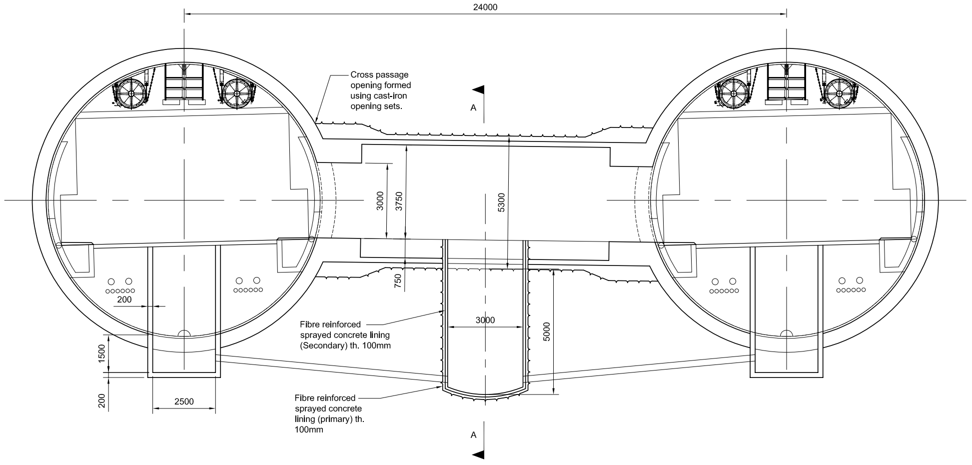
SW1H 0TL

Title

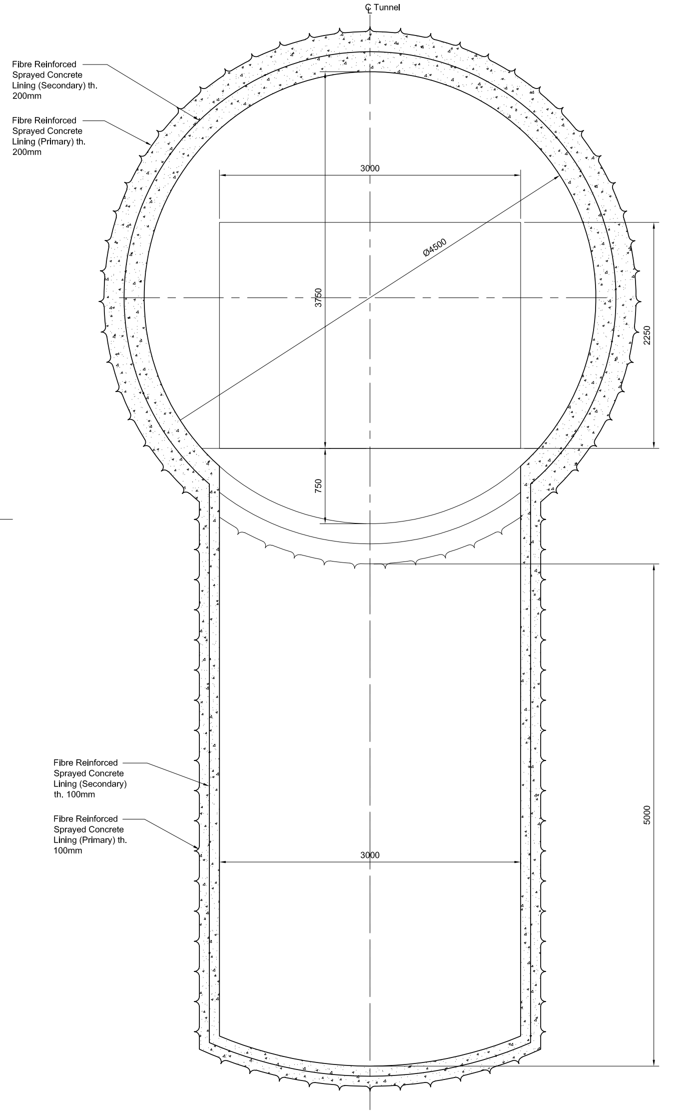
Silvertown River Crossing
Bored Tunnel Option
Emergency Escape Cross Passages

Designed	AE		Eng check	NT
Drawn	RK		Coordination	NT
Dwg check	AE		Approved	ML
Scale at A1 As Shown		Status PRE		Rev P1

Drawing Number
MMD-298348-TUN-207



Emergency Escape Cross Passage With Sump
Bored Tunnel Alternative 1
Scale 1:100



Emergency Escape Cross Passage With Sump Section A-A
Scale 1:25

0 1.00m 2.0m
Horizontal Scale 1:25 @ A1

0 5m 10m
Horizontal Scale 1:100 @ A1

P:\Croydon\MMH\Tunnels\298348 Silvertown Tunnel\Drawings\Perament Works\Bored\MMD-298348-TUN-208.dwg Feb 20, 2012 - 2:15PM kni56149

Notes

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	17/02/12	RK	Preliminary Issue	AE	ML

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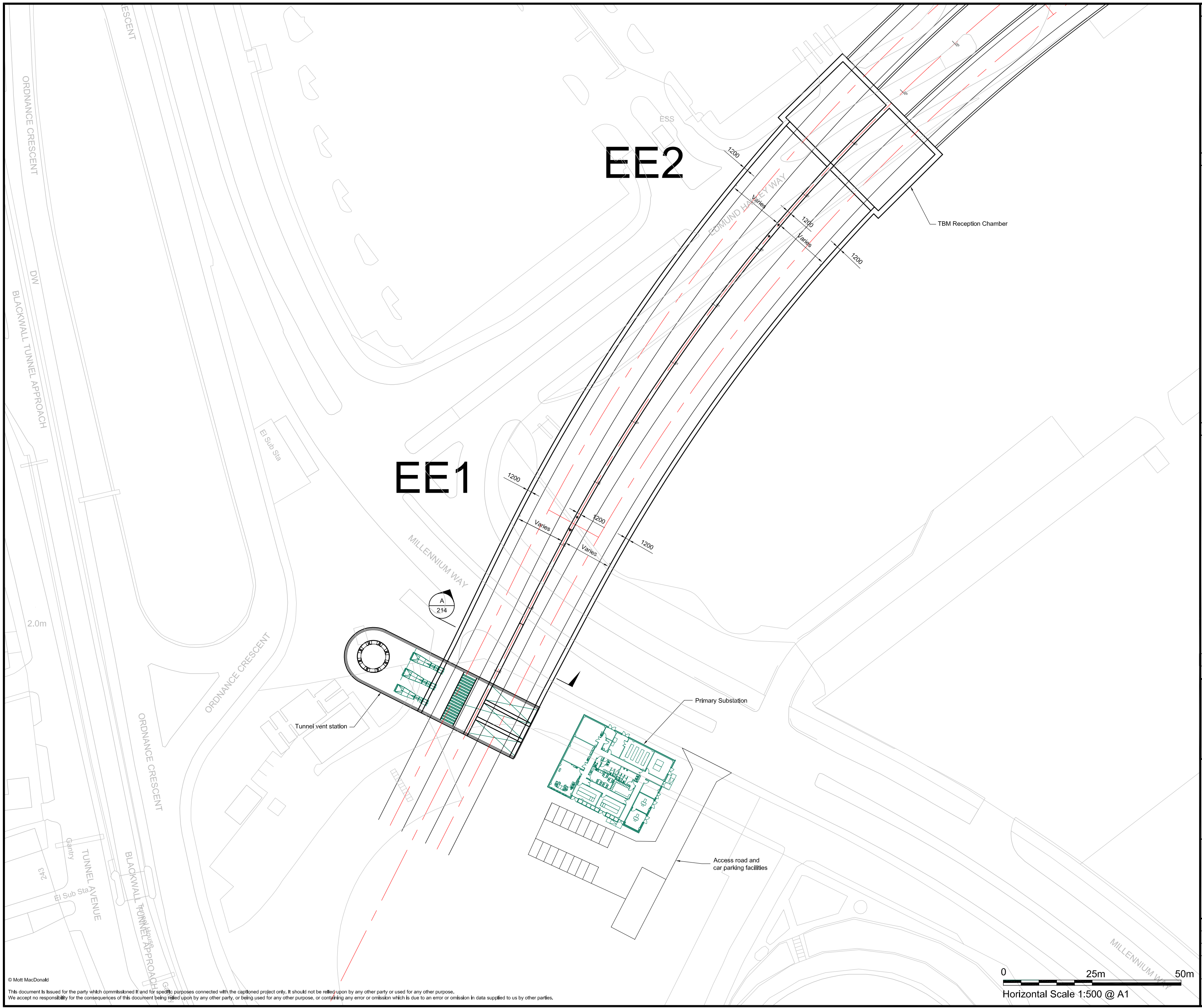
Title

Silvertown River Crossing
Bored Tunnel Option
Cross Passage & Sump

Designed	AE	Eng check	NT
Drawn	RK	Coordination	NT
Dwg check	AE	Approved	ML

Scale at A1	Status	Rev
As Shown	PRE	P1

Drawing Number
MMD-298348-TUN-208



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Notes

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Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	17/02/12	RK	Preliminary Issue	AE	ML

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Title

Silvertown River Crossing
Bored Tunnel Option
Greenwich Approach Structures
Plan

Designed	AE	Eng check	NT
Drawn	RK	Coordination	NT
Dwg check	AE	Approved	ML

Scale at A1
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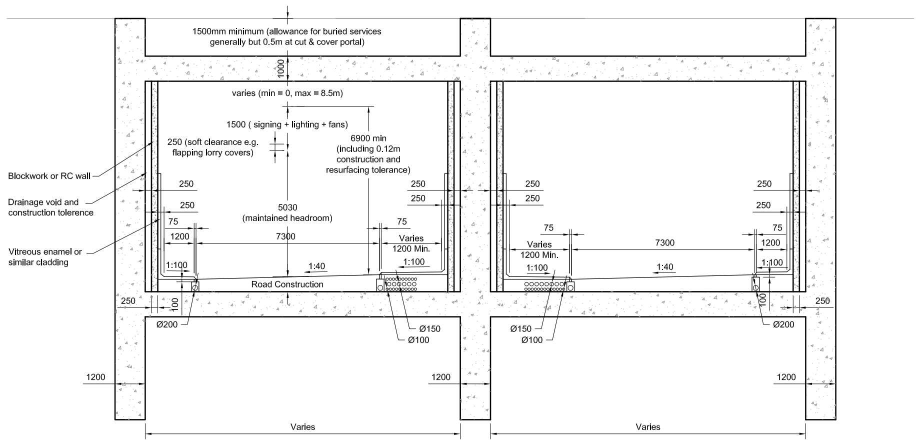
Status
PRE

Rev
P1

Drawing Number
MMD-298348-TUN-210



Section A 401
1:100

Cut and Cover Twin Tunnels
Cross Section

0 5m 10m
Horizontal Scale 1:100 @ A1

P:\Croydon\MMH\Tunnels\298348 Silvertown Tunnel\Drawings\Perament Works\Bored\MMD-298348-TUN-211.dwg Feb 20, 2012 - 2:56PM EVA38820

Notes

Key to symbols

Reference drawings

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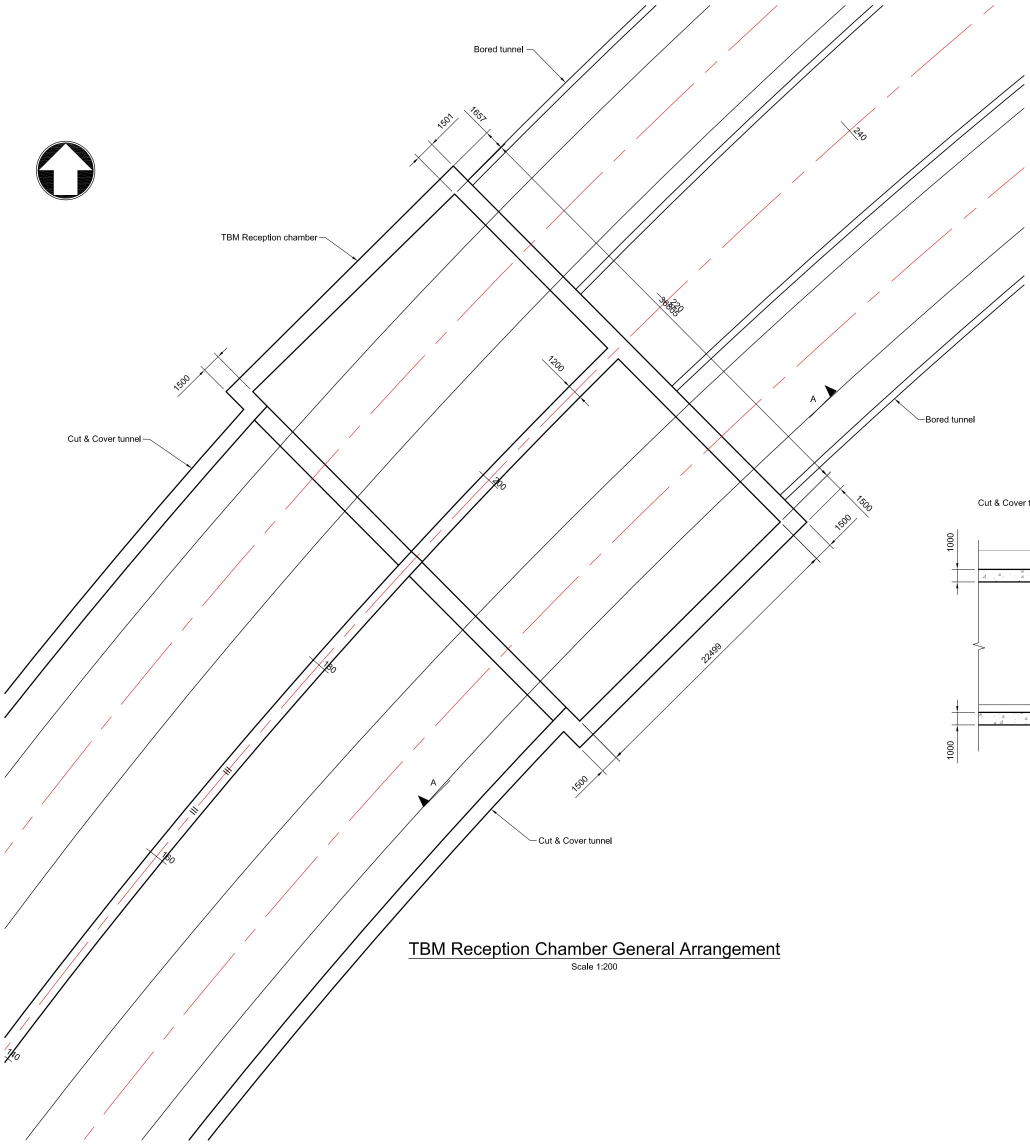
Title

Silvertown River Crossing
Bored Tunnel Option
Greenwich Approach Structures
Sections Sheet 1

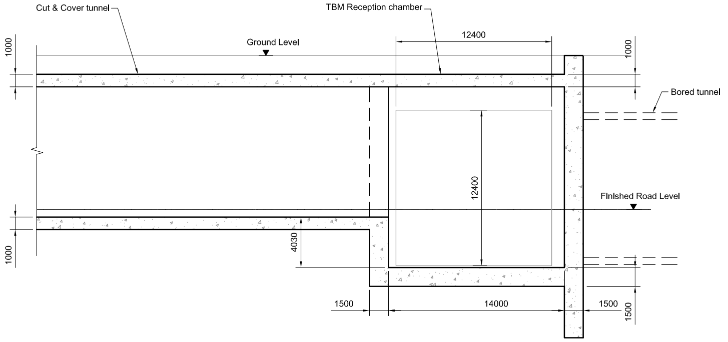
Designed	AE		Eng check	NT
Drawn	RK		Coordination	NT
Dwg check	AE		Approved	ML
Scale at A1		Status PRE	Rev P1	

Drawing Number
MMD-298348-TUN-211



TBM Reception Chamber General Arrangement

Scale 1:200



Section A-A

Scale 1:200

Notes

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Reference drawings

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P1	17/02/12	RK	Preliminary Issue	AE	ML

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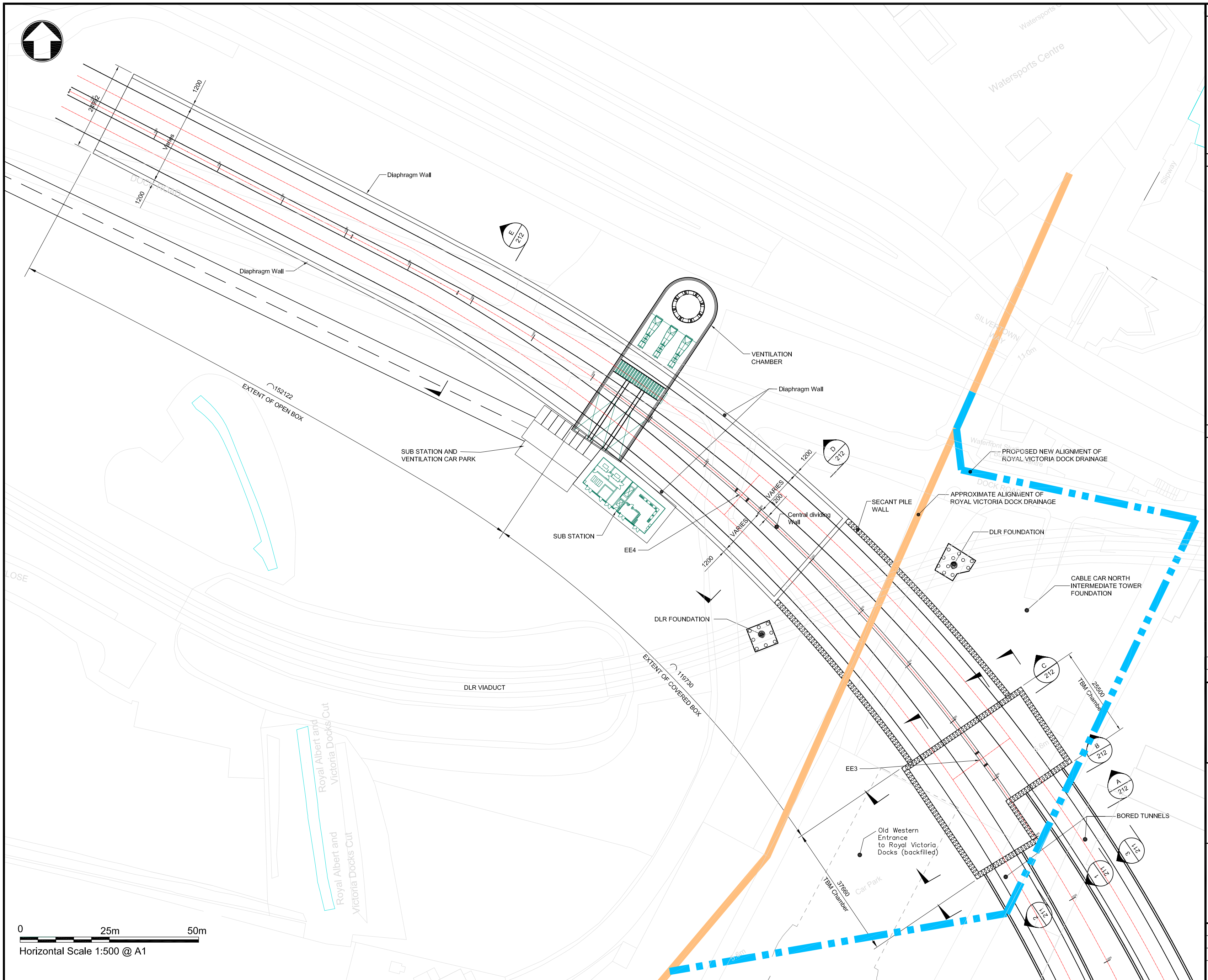
Title

Silvertown River Crossing
Bored Tunnel Option
Greenwich Approach Structures
Sections Sheet 2

Designed	AE		Eng check	NT	
Drawn	RK		Coordination	NT	
Dwg check	AE		Approved	ML	
Scale at A1 1:200		Status PRE		Rev P1	

Drawing Number
MMD-298348-TUN-212

0 10m 20m
Horizontal Scale 1:200 @ A1



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Notes

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	17/02/12	RK	Preliminary Issue	AE	ML

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Title

Silvertown River Crossing
Bored Tunnel Option
Silvertown Approach Structures
Plan

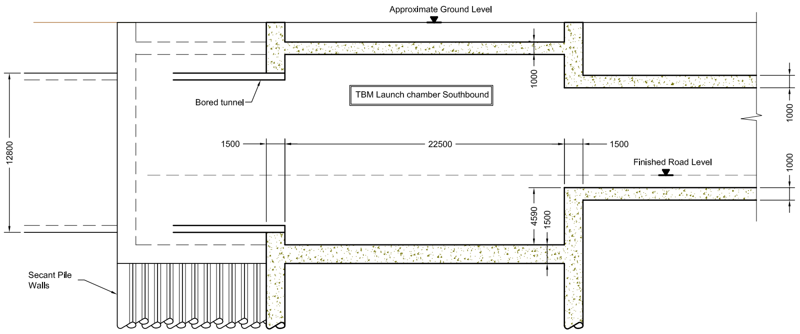
Designed	AE		Eng check	NT	
Drawn	RK		Coordination	NT	
Dwg check	AE		Approved	ML	

Scale at A1
1:500

Status
PRE

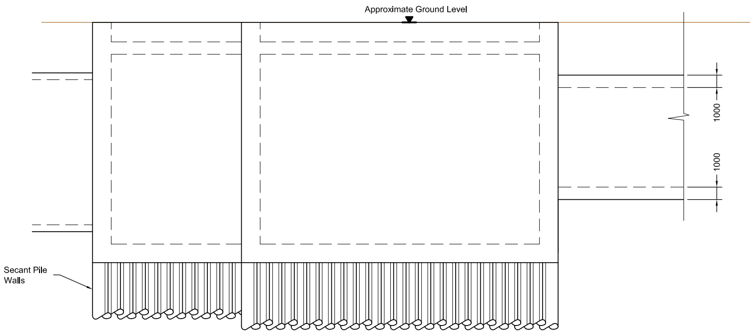
Rev
P1

Drawing Number
MMD-298348-TUN-213



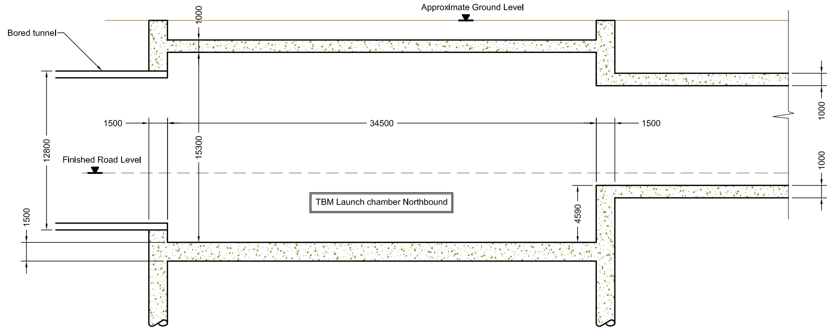
Section 1-1 Along C ℄ Carriageway

Scale 1:200



Section 3 - 3 Side Elevation

Scale 1:200



Section 2-2 Along ℄ Carriageway

Scale 1:200

0 10m 20m

Horizontal Scale 1:200 @ A1

Notes

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	17/02/12	RK	Preliminary Issue	AE	ML

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Title

Silvertown River Crossing
Bored Tunnel Option
Silvertown Approach Structures
Sections Sheet 1

Designed	AE	Eng check	NT
Drawn	RK	Coordination	NT
Dwg check	AE	Approved	ML

Scale at A1	Status	Rev
1:200	PRE	P1

Drawing Number
MMD-298348-TUN-214

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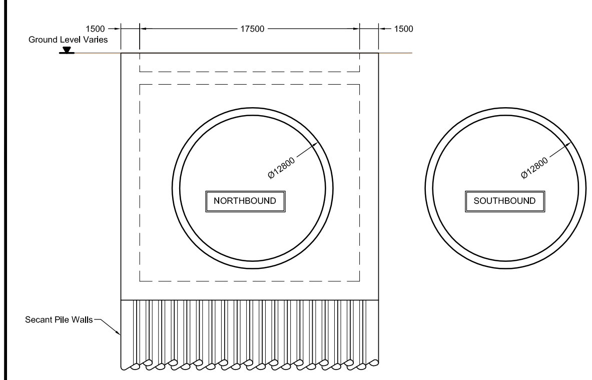
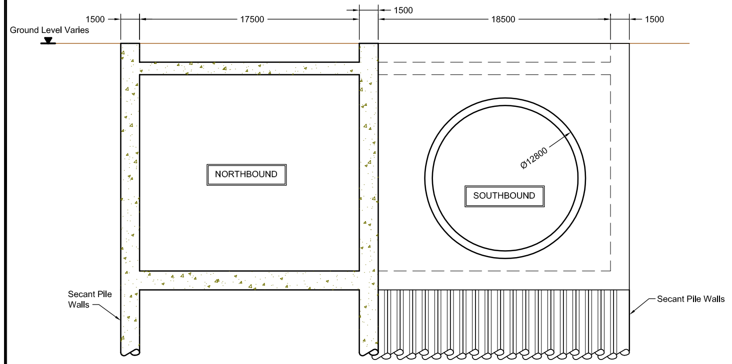
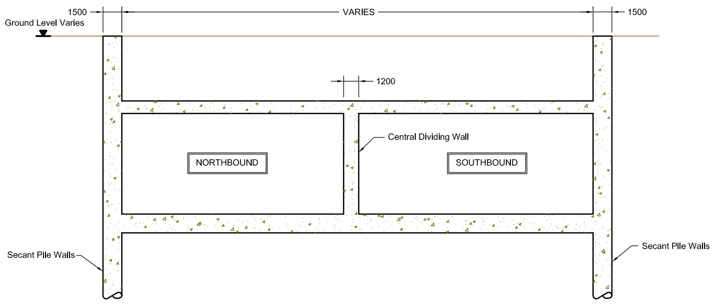


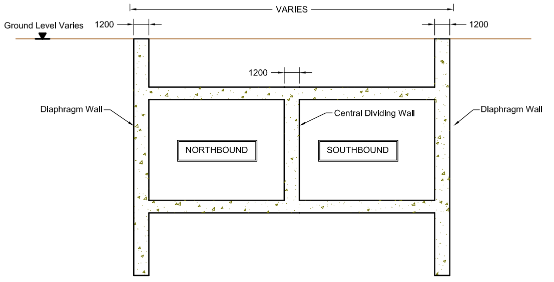
Section A-A
Launch Chamber Northbound Tunnel
Spatial Cross Section



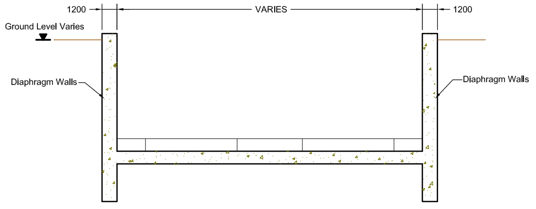
Section B-B
Launch Chamber Southbound Tunnel
Spatial Cross Section



Section C-C
Launch Chamber Southbound Tunnel
Cross Section



Section D-D
Covered box Carriageways Spatial Cross Section



Section E-E
Open box Carriageways Spatial Cross Section

0 10m 20m

Horizontal Scale 1:200 @ A1

Notes

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	17/02/12	RK	Preliminary Issue	AE	ML

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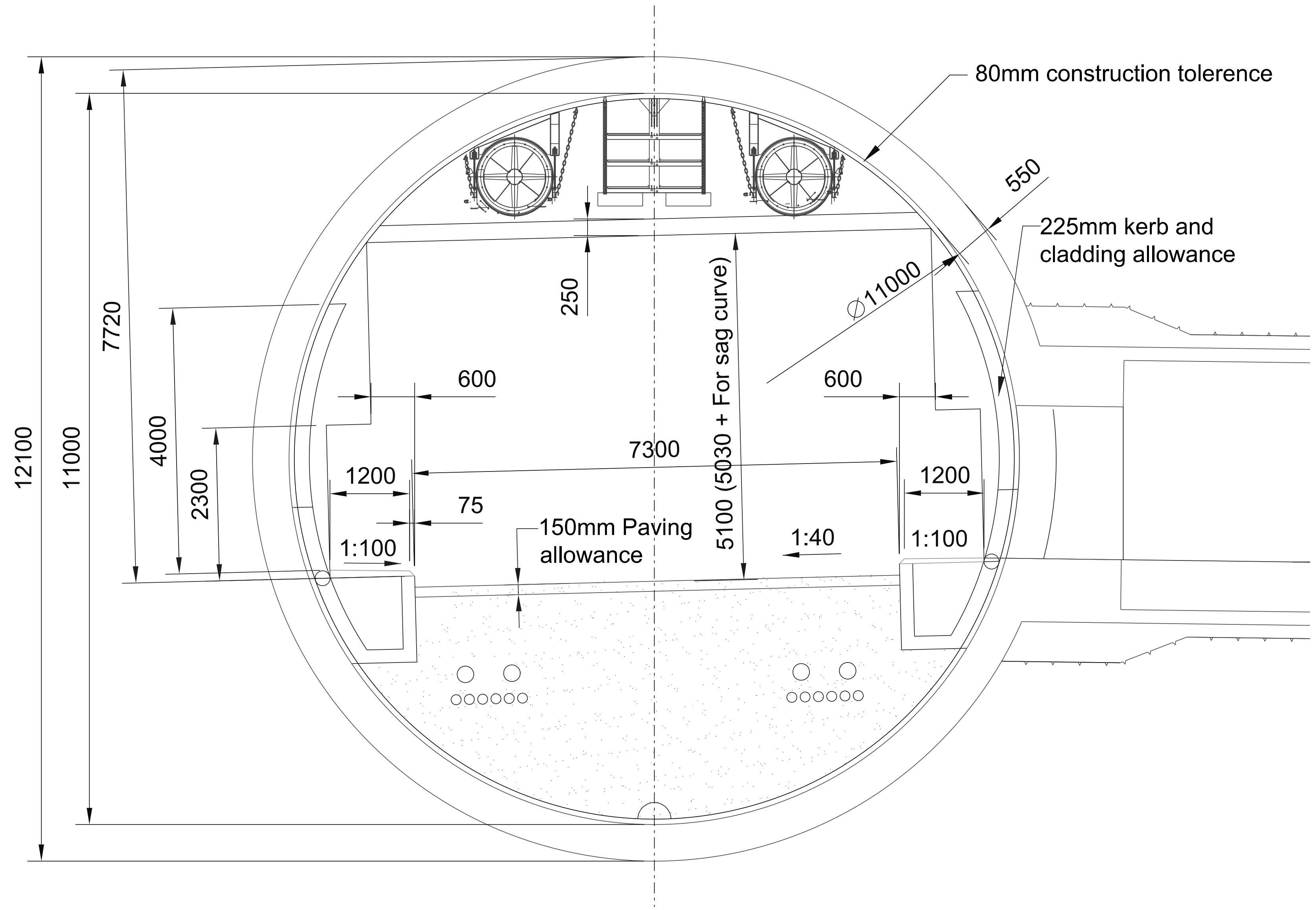
Title

Silvertown River Crossing
Bored Tunnel Option
Silvertown Approach Structures
Sections Sheet 2

Designed	AE		Eng check	NT	
Drawn	RK		Coordination	NT	
Dwg check	AE		Approved	TAR	ML
Scale at A1 1:200		Status PRE		Rev P1	

Drawing Number
MMD-298348-TUN-215



Notes

1. All dimensions in millimetres
2. Clearances and Tolerances in accordance with 8D78/99 and TD 27/05
3. Drawing for comparison purposes. To be read in conjunction with
with report " Silvertown Tunnel - Internal Clearances"

Key to symbols

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
1.0	08/03/2013	RGH	Preliminary issue	DN	JB

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Title

Silvertown River Crossing
Bored Tunnel Cross Section

Designed	DN		Eng check	DN	
Drawn	RGH		Coordination	JB	
Dwg check	DN		Approved	JB	

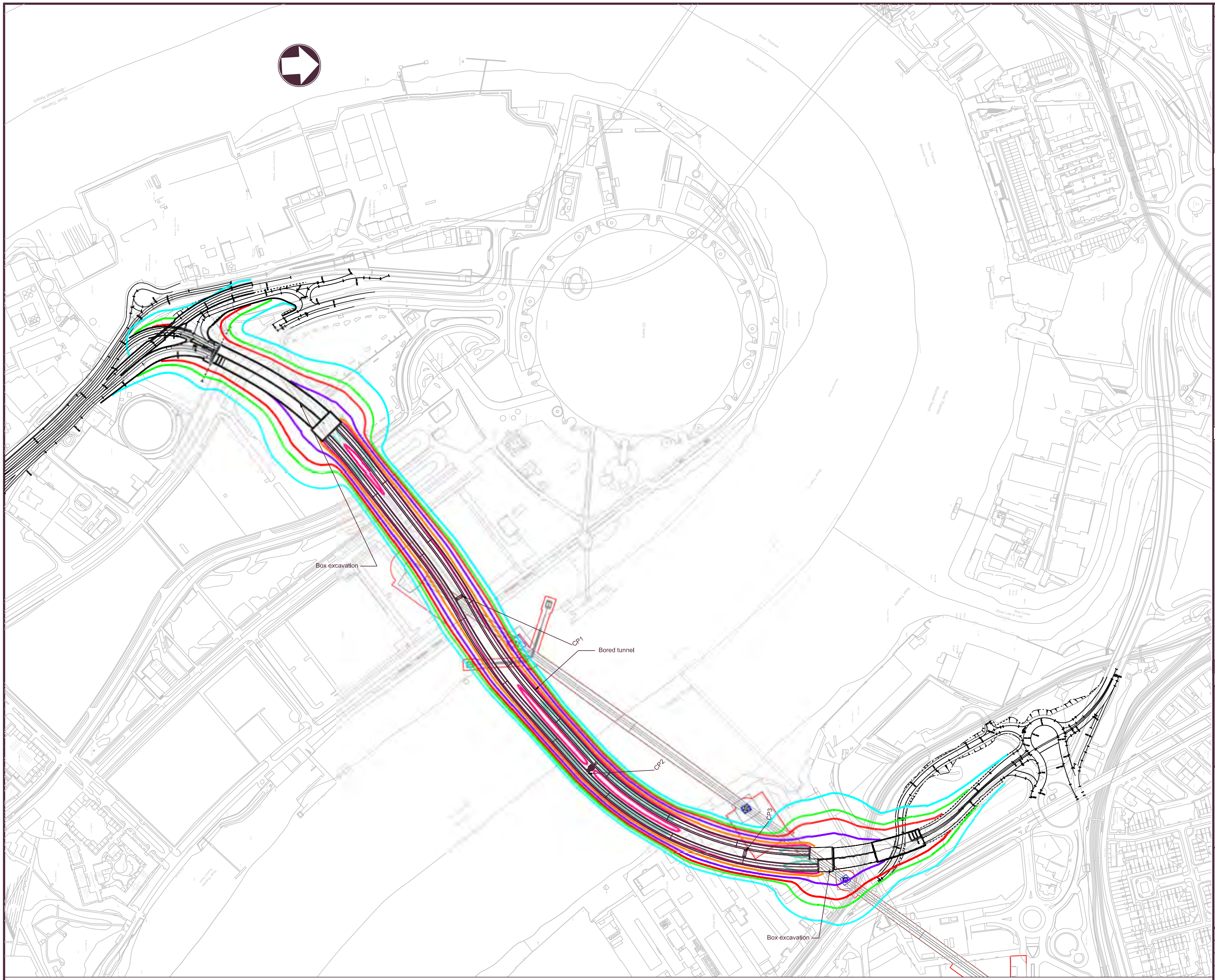
Scale at A1
1:200@A1

Status
PRE

Rev
1.0

Drawing Number
MMD-298348-TUN-300

Appendix B. Stage 1 Greenfield Ground Surface Settlement Contour Plot



Notes

1. Settlement contours presented are those predicted at ground surface level for assumed greenfield site.
2. Contours presented are those associated with short term excavation-induced settlement only. Long term excavation-induced settlement and dewatering-induced settlement are not considered.
3. Tunnelling induced ground surface settlement is calculated assuming a gaussian error function in the transverse direction (O'Reilly & New, 1982) and a cumulative error function in the longitudinal direction (Attewell & Woodman,1982).
4. Ground settlements are calculated assuming the following tunnel input parameters:

Assumed Volume Losses (%)	
Cross Passages (SCL)	2.0
Bored Tunnels (TBM)	1.7

5. Ground settlements are calculated assuming the following box input parameters:

Box Excavation Parameters	
δv/Z0	0.18%
W/Z	2.5

6. Input parameters for the settlement analysis are based on experience gained on similar projects and on relevant case histories. The degree of conservativeness of these values is considered adequate for the purpose of this design.

Tunnelling-induced ground movement based on Point Sink approach after "O'Reilly & New (1982)"
Box-induced ground movement based on "CIRIA C580"

Key to symbols

LEGEND

1mm SETTLEMENT CONTOUR
5mm SETTLEMENT CONTOUR
10mm SETTLEMENT CONTOUR
25mm SETTLEMENT CONTOUR
50mm SETTLEMENT CONTOUR
75mm SETTLEMENT CONTOUR
100mm SETTLEMENT CONTOUR

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	22/04/2013	RGH	PRELIMINARY ISSUE	DN	JB

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Title

Silvertown Tunnel Crossing Greenfield Ground Surface Settlement Contours

Designed	RH	Eng check	GRT
Drawn	RGH	Coordination	DN
Dwg check	RH	Approved	JB

Scale at A1 1:2750 | Status PRE | Rev P1

Drawing Number
MMD-298348-G-DR-00-ZZ-1000

THIS DRAWING TO BE PRINTED IN COLOUR

D.6. Outline Site Waste Management Plan



Silvertown Tunnel Crossing

Flood Risk Analysis

Transport for London
April 2013

Mott MacDonald

Silvertown Tunnel Crossing

Flood Risk Analysis

Transport for London

April 2013

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
0	04/04/2013	J Preston	R Gamble	R Gamble	First Issue
1	15/04/2013	K Piech	R Gamble	R Gamble	Second Issue

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Content

Executive Summary

Mott MacDonald has been commissioned to perform a flood analysis on the proposed Silvertown Tunnel Crossing scheme, in Greenwich London. The objective of this analysis is to understand the nature and magnitude of flood risk to the tunnel, including consideration of the need for specific flood protection measures. The Silvertown Tunnel Crossing is a proposed road tunnel under the Thames that will connect Silvertown on the northern bank of the Thames to the Greenwich Peninsula on the southern bank.

The main source of flood risk to the scheme is from breach of existing flood defences. Both tunnel approaches will be in areas that are protected by existing tidal defences that, in combination with the Thames Barrier, provide a 1 in 1000 year standard of flood protection. Breach modelling has previously been carried out for the Newham Strategic Flood Risk Assessment (SFRA) and the Greenwich SFRA, covering the areas of the proposed northern and southern tunnel approaches, respectively. For a breach during the 0.5% AEP event allowing for predicted climate change to 2107, the northern tunnel approach could be expected to flood to a depth of 3.1m between 2 hours and 13 hours of the breach occurring. For the same event, the southern tunnel approach could be expected to flood to a depth of 2.6m within 4 hours of the breach occurring.

The risk of extreme tidal events is by definition low, and the likelihood of defence failure is also very low. The probability of flooding due to breach of defences in combination with an extreme tidal event is therefore extremely low. Nonetheless, the consequence remains very high as demonstrated in the breach modelling results from the Newham and Greenwich SFRAs.

Consideration has been given to providing flood gates which could be put in place in the event of flooding being predicted. However, even if such gates were provided, the tunnel could not continue to operate during a flood event. The possibility of a flood resulting from a breach in the defences has therefore been weighed against the damage that would be done to the tunnel and associated infrastructure in the case of the tunnel filling with water. Although some damage would inevitably be incurred, the tunnel itself is substantially resilient to immersion. It is therefore considered uneconomical to provide flood gates to guard against the very small risk of the Thames defences being breached.

The more important consideration is that an Emergency Plan should be prepared and put in place to address emergency evacuation of the tunnel in the event of a flood event. It is expected that such a plan would form part of the wider emergency planning for incidents that might arise with the tunnel.

1.1 Introduction

Mott MacDonald has been commissioned to perform a flood analysis on the proposed Silvertown Tunnel scheme, in Greenwich London. The Silvertown Tunnel is a proposed road tunnel under the River Thames that will connect Silvertown on the northern bank of the Thames to the Greenwich Peninsula on the southern bank. The objective of this analysis is to understand the nature and magnitude of flood risk to the tunnel, including consideration of the need for specific flood protection measures.

1.2 Proposed development

The northern portal of the tunnel will be located on what is currently Dock Road, at OS grid reference TQ 398 807. It will be located approximately 250m north east from the closest point to the bank of the River Thames, and approximately 200m east of the confluence of the River Lea and the Thames. The existing ground level at this point derived from the topographic survey is 1.69 mAOD.

The southern portal will be located on what is currently the Blackwall Tunnel Approach road, at OS grid reference TQ 391 793. It will be located approximately 200m east from the closest point to the bank of the Thames. The existing ground level at this point derived from the topographic survey is approximately 2.2 mAOD.

See Appendix A for proposed tunnel location.

1.3 History of flooding

According to the Newham Strategic Flood Risk Assessment (SFRA), the northern approach to the tunnel lies within the flood extent for the 1928, the 1947 and the 1953 flood events. The southern approach is approximately 400m north of an area flooded during the 1928 flood event.

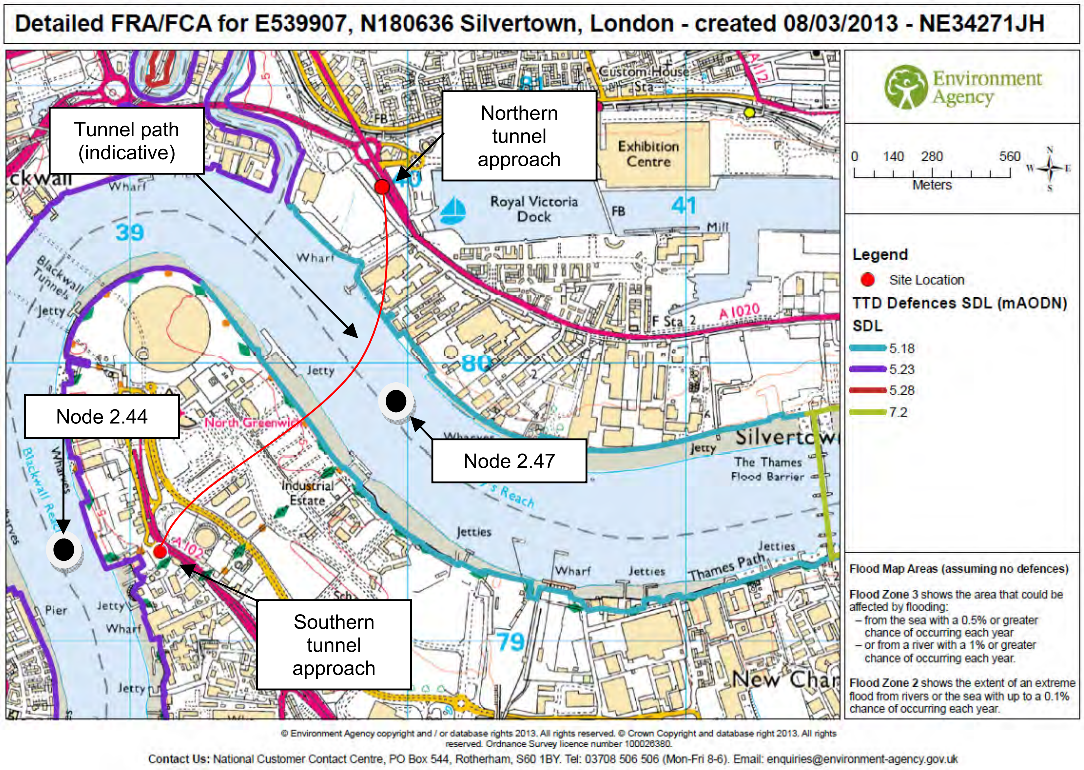
See Appendix B for Environment Agency map of historic flooding.

1.4 Existing flood defences

Both the northern and southern tunnel approaches are classed as being in an “Area Benefitting from Defences” (ABD). The flood defences along the tidal Thames in this area are all raised, man-made and privately owned. They provide a Standard of Protection (SoP) of 1 in 1000, protecting against tidal flooding that has a 0.1% annual exceedance probability (AEP). This remains true allowing for predicted climate change up to the year 2070, after which the SoP will begin to decrease. However, the Thames Estuary 2100 plan divides the Thames Estuary into policy units, and gives each policy unit a policy (P1 to P6). The right bank of the River Thames in the vicinity of the southern tunnel approach is within the Greenwich policy unit and has been given a “P5” policy, which means “Take further action to reduce the risk of flooding (now and/or in the future).” The left bank of the River Thames is within the Royal Docks policy unit and has been given a “P4” which means “Take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).” Therefore it can be assumed that the defences which provide protection to the proposed tunnel approaches will be maintained into the future.

The defences are inspected by the EA twice a year to ensure that they remain fit for purpose. They must be maintained by their owners to a crest level of 5.18 mAOD (the Statutory Flood Defence Level in this reach of the Thames). The overall condition grade for defences in the area is recorded as 2 (good) on a scale of 1 (very good) to 5 (very poor).

Figure 1.1 – Flood defences and modelled tidal level nodes



Source: Contains Environment Agency data

Tables 1.1 and 1.2 contain modelled tidal levels for the River Thames. These levels take into account the operation of the Thames barrier.

Table 1.1 – Modelled tidal levels (mAOD) for Node 2.44 (southern tunnel approach)

Year	Annual Probability of Occurrence						
	10%	5%	2%	1%	0.5%	0.2%	0.1%
2005	4.68	4.72	4.75	4.77	4.79	4.81	4.83
2055	4.75	4.76	4.77	4.78	4.79	4.79	4.80
2107	4.77	4.77	4.78	4.79	4.80	4.81	4.90

Source: Contains Environment Agency data

Table 1.2 – Modelled tidal levels (mAOD) for Node 2.47 (northern tunnel approach)

Year	Annual Probability of Occurrence						
	10%	5%	2%	1%	0.5%	0.2%	0.1%
2005	4.68	4.72	4.75	4.77	4.79	4.81	4.83
2055	4.75	4.76	4.77	4.78	4.79	4.79	4.80
2107	4.77	4.77	4.78	4.79	4.80	4.81	4.90

Source: Contains Environment Agency data

It can be seen from Table 1.1 that the 1 in 1000 year plus climate change to 2107 modelled flood level for node 2.44 (the southern approach) is 4.90 mAOD. The defence elevation at this point is 5.23 mAOD, resulting in a freeboard of 0.33m.

It can be seen from Table 1.2 than the 1 in 1000 year plus climate change to 2107 modelled flood level for node 2.47 (the northern approach) is 4.86 mAOD. The defence elevation at this point is 5.18 mAOD, resulting in a freeboard of 0.32m.

As stated, the defences are regularly inspected by the Environment Agency for any signs of degradation; therefore, the risk of a breach is unlikely. However, both tunnel approaches would be at risk in the event of a breach. Breach analysis is discussed below.

1.5 Assessment of Flood Risk due to Breach of Defences

The main source of flood risk to the scheme is from breach of existing defences in combination with extreme tidal levels. Risk of breach is considered a residual risk, as it is a risk which inherently remains after implementation of a mitigation measure (in this case, existing tidal defences).

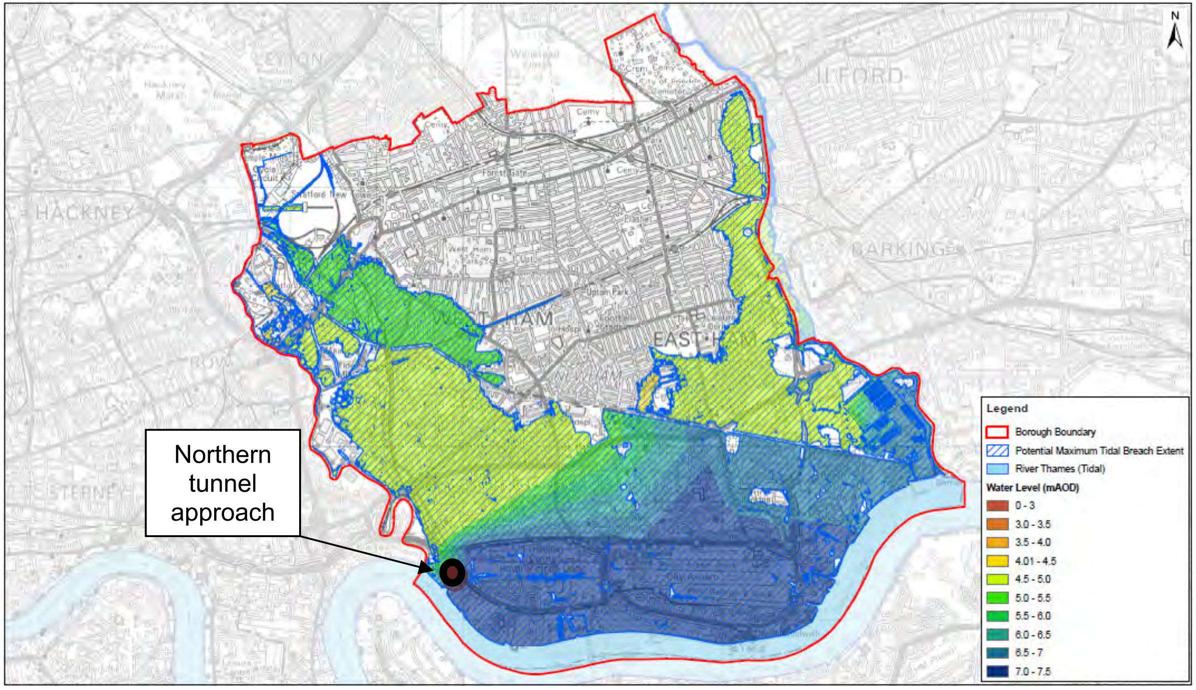
The risk of extreme tidal events is by definition low, and the likelihood of defence failure is also very low. The likelihood of flooding due to breach of defences in combination with an extreme tidal event is therefore extremely low. As noted in the Newham SFRA, assigning an accurate probability to a breach or failure of a defence in combination with a tidal flood event is particularly difficult and therefore the probability of this occurrence has not been calculated.

Although the likelihood of a breach combined with an extreme tidal event is very low, the consequence remains very high as demonstrated in the breach modelling results in the Newham and Greenwich SFRAs. The results of the SFRA breach studies are included in Sections 1.5.1 and 1.5.2 below.

1.5.1 Northern Tunnel Approach

The Newham SFRA modelled several breaches in the Thames flood defences in the area. Figure 1.2 shows the potential modelled maximum tidal breach extent for the 0.5% AEP tidal event allowing for predicted climate change to 2107.

Figure 1.2 – Potential Maximum Tidal Breach Extent, 0.5% AEP (2107)



Source: Newham SFRA, June 2010

It can be seen from the SFRA map that the northern tunnel approach is located in an area that could potentially be subject to water levels of up to 7mAOD. The existing ground level at the northern tunnel approach is 1.69 mAOD, resulting in a potential depth of 5.31m. This is assumed to disregard the presence of the Thames Barrier. However, based on the modelled flood levels in this area of 4.80 mAOD (Table 1.2) for the 0.5% AEP event (2107) which takes into account the operation of the Thames Barrier, a depth of 3.1m is more appropriate. The SFRA also states that the tunnel approach is located in an area where inundation would be expected between 2 and 13 hours after a breach event.

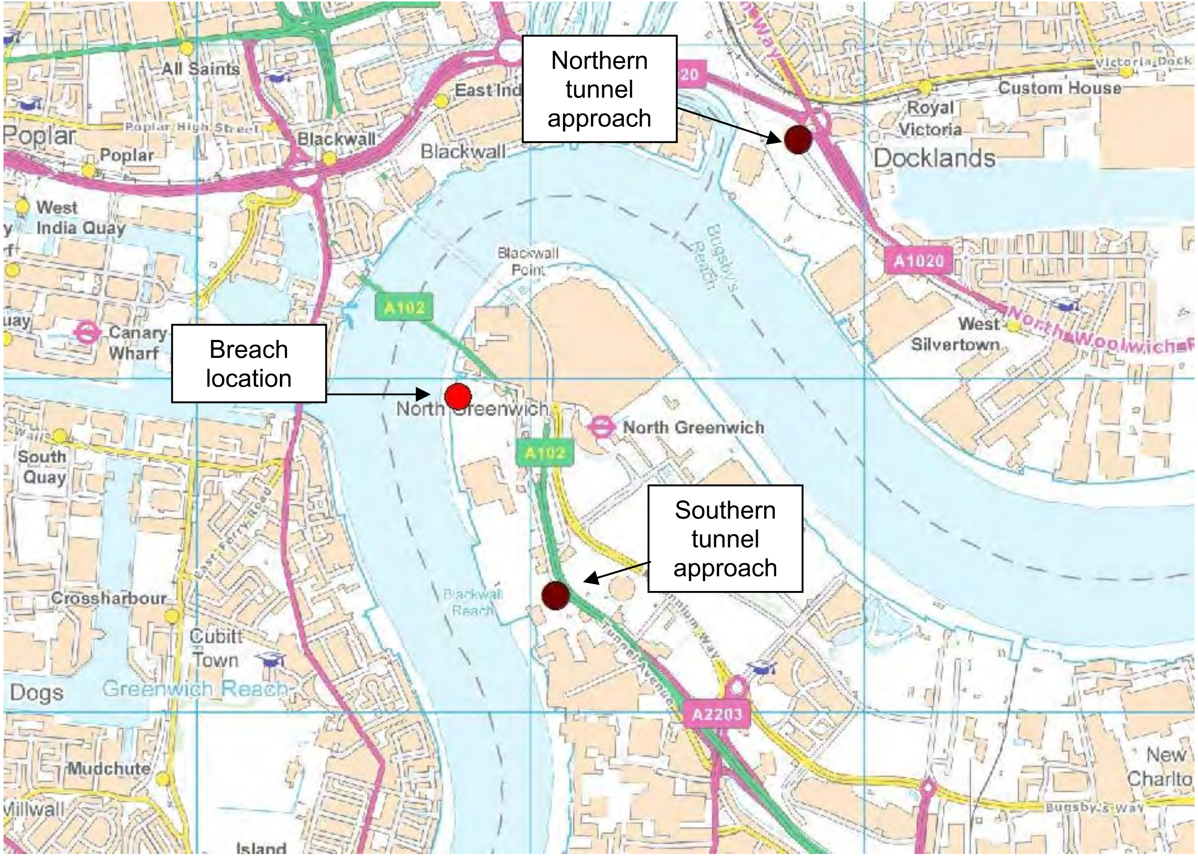
1.5.2 Southern Tunnel Approach

The Greenwich SFRA modelled breach event relevant to the southern approach at the tunnel does not include a map, but has the following text describing the breach closest to the site:

Location: *Breach seven is located near to the Millennium Dome, on the most northern point of Tunnel Avenue.*

Based on this description the breach is located as shown on Figure 1.3 below, approximately 700m north of the southern tunnel approach:

Figure 1.3 – Modelled breach location, Greenwich SFRA



Source: Contains OS Open Data

The modelled breach is for a 0.5% AEP tidal event in the present day. No climate change event was modelled. The SFRA describes the breach event as follows:

Rate of onset: *The low lying land beyond the breach location allows water to readily propagate. As such, the onset of flooding resulting from a breach at location seven is fairly rapid. The flood reaches almost full extent within 3 hours 45 minutes. Then a secondary area of shallow flooding to the south of the breach extends slightly over the next 10 hours of simulation.*

Results: *Flooding is mainly shallow, with a depth of 0-0.5 metres spreading southwards from the breach location... The flood depths are also high on Tunnel Avenue and on the A102. An area of greater depth (1-2.5 metres) is created over the A2203 and a neighbouring piece of open common land. The hazard classification is mainly Low or Significant.*

These results from the SFRA would suggest that the site of the southern tunnel approach, located very close to the 'common land' described would flood to a depth between 1-2.5m should a breach occur, and be inundated within 3 hours and 45 minutes. The modelled tidal level as reported in Table 1.1 for the 0.5% AEP (2107) event is 4.8 mAOD. Given that the ground level at the southern tunnel approach is approximately 2.2 mAOD, a depth of 2.6m could be expected.

The EA provided a breach map based on the Tidal Thames Breach Modelling 2013 that confirms that both the northern and southern tunnel approaches are at risk of flooding should a breach occur in the flood defences in the 0.5% AEP event for both the present day and 2107 climate change event.

See Appendix B for both SFRA and EA breach maps.

1.6 Surface Water Flooding

According to EA surface water rainfall maps, both the northern and southern tunnel approaches are not considered at risk from surface water flooding up to the 1 in 200 year rainfall event. The northern approach is located adjacent to an area of deeper surface water flooding in the 1 in 200 year rainfall event, which may cause access problems should this occur.

See Appendix C for surface water rainfall maps.

1.7 Emergency Planning

It is recommended that an Emergency Plan be prepared to identify how safe evacuation can be undertaken in the event of a potential flood. It is also recommended that the tunnel operators register with the Environment Agency's 'Floodline' flood warning service (tel. 0845 988 1188) and monitor flood warnings for the area, in order to receive prior warning of expected flood events in the area. In addition, it is recommended to register with the Met Office Severe Weather Warning service for South East England (http://www.metoffice.gov.uk/public/weather/warnings/.)

1.8 Conclusion

Both the northern and southern tunnel approaches are protected by regularly inspected, man-made flood defences up to the 1 in 1000 year standard of protection, with a freeboard of 330mm and 320mm, respectively. These are classified as being in Good condition by the Environment Agency.

Should a breach occur in these defences, the northern tunnel approach can expect to suffer significant depth of flooding, up to 3.1m, between 2 and 13 hours after the breach occurs. The southern tunnel approach can expect to be flooded to a depth of up to 2.6m by 3 hours and 45 minutes after the breach occurs.

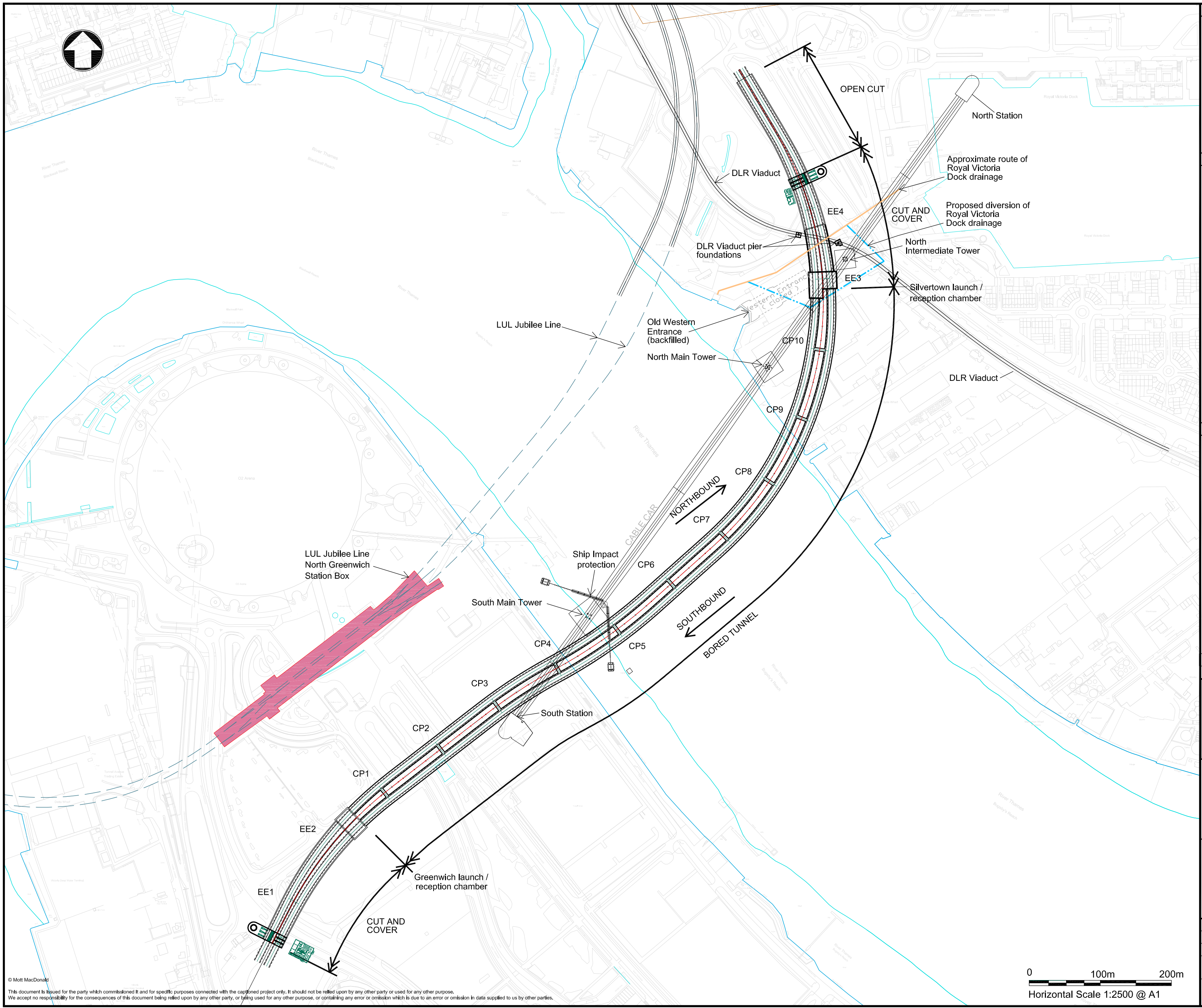
Although the likelihood of a breach combined with an extreme tidal event is very low, the consequence remains very high as shown in the Newham SFRA and Greenwich SFRA.

The proposed Silvertown Tunnel Crossing scheme will form an important part of the London transportation network connecting Greenwich to the south and Silvertown to the north, and will also provide additional capacity to the nearby Blackwall Tunnel.

Consideration has been given to providing flood gates which could be put in place in the event of flooding being predicted. However, even if such gates were provided, the tunnel could not continue to operate during a flood event. The possibility of a flood resulting from a breach in the defences has therefore been weighed against the damage that would be done to the tunnel and associated infrastructure in the case of the tunnel filling with water. Although some damage would inevitably be incurred, the tunnel itself is substantially resilient to immersion. It is therefore considered uneconomical to provide flood gates to guard against the very small risk of the Thames defences being breached.

The more important consideration is that an Emergency Plan should be prepared and put in place to address emergency evacuation of the tunnel in the event of a flood event. It is expected that such a plan would form part of the wider emergency planning for incidents that might arise with the tunnel.

Appendix A. Proposed tunnel location and alignment



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M:\267759 New Thames River Crossing\H Reports and Drawings\H.03 Outgoing Drawings\working drawings\OPTIONS 2 & 3\DWG\Option 2\267759_TUN_1001.dwg --- kni56149

Notes

Key to symbols

Reference drawings

TUNNEL ALIGNMENT FROM **des road opt 5.dwg**
RECEIVED 05/01/11

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	17/02/12	RK	Preliminary Issue	AE	ML

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Client

Transport for London

Transport for London
50 Victoria Street
London
SW1H 0TL

Title

Silvertown River Crossing
Bored Tunnel Option
Scheme Layout Plan

Designed	MAC		Eng check	NT
Drawn	CAL		Coordination	NT
Dwg check	MAC		Approved	JB
Scale at A1 1:2500		Status PRE		Rev P1

Drawing Number
MMD-298348-TUN-201

Appendix B. Environment Agency data

Product 4 (Detailed Flood Risk) for E539907, N180636 Silvertown, London
Our ref: NE34271JH
Date: 8 March 2013

Product 4 is designed for developers where Flood Risk Standing Advice FRA (Flood Risk Assessment) Guidance Note 3 Applies.

i) "all applications in Flood Zone 3, other than non-domestic extensions less than 250 sq metres; and all domestic extensions", and
ii) "all applications with a site area greater than 1 ha" in Flood Zone 2.

Product 4 includes the following information:

Ordnance Survey 1: 25 000 colour raster base mapping;
Flood Zone 2 and Flood Zone 3;
Relevant model node locations and unique identifiers (for cross referencing to the water levels, depths and flows table);
Model(s) extents;
FRA site boundary (where a suitable GIS layer is supplied);
Flood defence locations (where available/relevant) and unique identifiers; (supplied separately)
Flood Map areas benefiting from defences (where available/relevant);
Flood Map flood storage areas (where available/relevant);
Historic flood events outlines (where available/relevant, not the Historic Flood Map) and unique identifiers;
Statutory (Sealed) Main River (where available within map extents);

A table showing:
  i) model node X/Y coordinate locations, unique identifiers, levels, flows and JFLOW depths;
  ii) Flood defence locations unique identifiers and attributes; (supplied separately)
  iii) Historic flood events outlines unique identifiers and attributes; and
  iv) local flood history data (where available/relevant).

Please note:

If you will be carrying out computer modelling as part of your Flood Risk Assessment, please read the enclosed guidance which sets out our requirements and best practice for computer river modelling.

This information is based on that currently available as of the date of this letter. You may feel it is appropriate to contact our office at regular intervals, to check whether any amendments/ improvements have been made. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

This information is provided subject to the enclosed notice which you should read.

This letter is not a Flood Risk Assessment. The information supplied can be used to form part of your Flood Risk Assessment. Further advice and guidance regarding Flood Risk Assessments can be found on our website at
http://www.environment-agency.gov.uk/research/planning/82584.aspx

If you would like advice from us regarding your development proposals you can complete our pre application enquiry form which can be found at
http://www.environment-agency.gov.uk/research/planning/33580.aspx

Modelled in-channel levels

NE34271JH

Modelled water levels in the Thames for locations close to your site are shown in the tables below. All levels are provided in **metres above Ordnance Datum Newlyn (mAODN)**. In modelling the levels, three main factors were considered; the astronomical tide, the surge tide and the flow coming from the non-tidal Thames. The location, or node, closest to your site is 2.47.

Modelled River Levels (mAODN)
Location node 2.44
Grid ref: TQ 38942 78789

Year	Annual Probability of Occurrence						
	10%	5%	2%	1%	0.5%	0.2%	0.1%
2005	4.68	4.72	4.75	4.77	4.79	4.81	4.83
2055	4.75	4.76	4.77	4.78	4.79	4.79	4.80
2107	4.77	4.77	4.78	4.79	4.80	4.81	4.90

Modelled River Levels (mAODN)
Location node 2.47
Grid ref: TQ 39825 79981

Year	Annual Probability of Occurrence						
	10%	5%	2%	1%	0.5%	0.2%	0.1%
2005	4.63	4.67	4.71	4.73	4.75	4.77	4.78
2055	4.71	4.72	4.73	4.73	4.74	4.75	4.75
2107	4.73	4.73	4.74	4.75	4.75	4.77	4.86

Modelled River Levels (mAODN)
Location node 2.49
Grid ref: TQ 41357 79533

Year	Annual Probability of Occurrence						
	10%	5%	2%	1%	0.5%	0.2%	0.1%
2005	4.61	4.64	4.68	4.70	4.72	4.74	4.75
2055	4.68	4.69	4.70	4.71	4.72	4.73	4.73
2107	4.70	4.70	4.71	4.72	4.73	4.74	4.85

Model notes

NE34271JH

Model: **Tidal Thames Joint Probability Extreme Water Levels 2008**
Date of creation: **12 May 2008**

Notes:

Our water levels are created from a 2-D joint-probability computer hydraulic model. As this is a joint-probability model the confluence of different factors such as astronomical tides, tide surge and river flows have been taken into account. In summary, the calculation of extreme water levels involves two main stages:
1) Estimating a matrix of water levels at various locations (or model nodes) along the estuary 2) Calculating the statistical frequency (return period) with which a particular water level might be expected to occur at each of the model nodes.

This study modelled water levels to various annual probabilities (10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1%). Each of these probabilities have been modelled for present day (2005) and future years (2055 and 2107) taking into account DEFRA's climate change allowances as set out in the Planning Policy Statement 25 (PPS25).

Climate change allowances:

Some of the levels are lower for the more extreme probabilities when including climate change because the hydraulic model used to produce these levels takes into account the Thames Barrier closure rule (circumstances/conditions of closure) and assumes that it remains unchanged up to 2107. Increased sea levels and fresh water flows mean that the Thames Barrier closure rule will be met more often. This means that a smaller number of tides will be allowed to flow up into central London each year. The highest tides experienced upstream of the Thames Barrier occur when the circumstances are within a fine margin of meeting the closure rule, and the decision is taken not to close (a near closure event). As there will be fewer tides per year upstream of the Barrier, and the ratio of near closure levels to regular tidal levels within this smaller number of tides remains constant, the number of near closure events will decrease, and therefore so do the modelled levels.

Historic flood data

NE34271JH

Our records show that the area of your site has not been affected by tidal flooding.
Information on floods that have affected areas near your site is provided in the table below, and is shown on the attached map:

Historic Flood Events Unique ID	Flood Event Code	Flood Event Name	Start Date	End Date	Source of Flooding	Cause of Flooding
EA0619280300029	EA061928a	TTD_FEO_1928	06/01/1928	07/01/1928	Tidal River Thames	Overtopping of defences
EA0619530300005	EA061953	TTD_FEO_1953	31/01/1953	01/02/1953	Tidal River Thames	Overtopping and Breach of defence

Extra historic flood information:

The site was subject to tidal flooding on the night of the 6th and morning of the 7th January 1928. There was overtopping in the area during a storm surge (which coincided with high fresh water flows). An approximate level in the Thames at the time was 5.04m AODN.

The site was subject to tidal flooding, due to a storm surge in the North Sea, on the night of the 31st January into the morning of 1st February 1953. An approximate level in the Thames at the time was 5.26m AODN.

Please note the Environment Agency maps show flooding to land not individual properties. Floodplain extents are an indication of the geographical extent of a historic flood. They do not provide information regarding levels of individual properties, nor do they imply that a property has flooded internally.

Flood Defences

NE34271JH

General description:

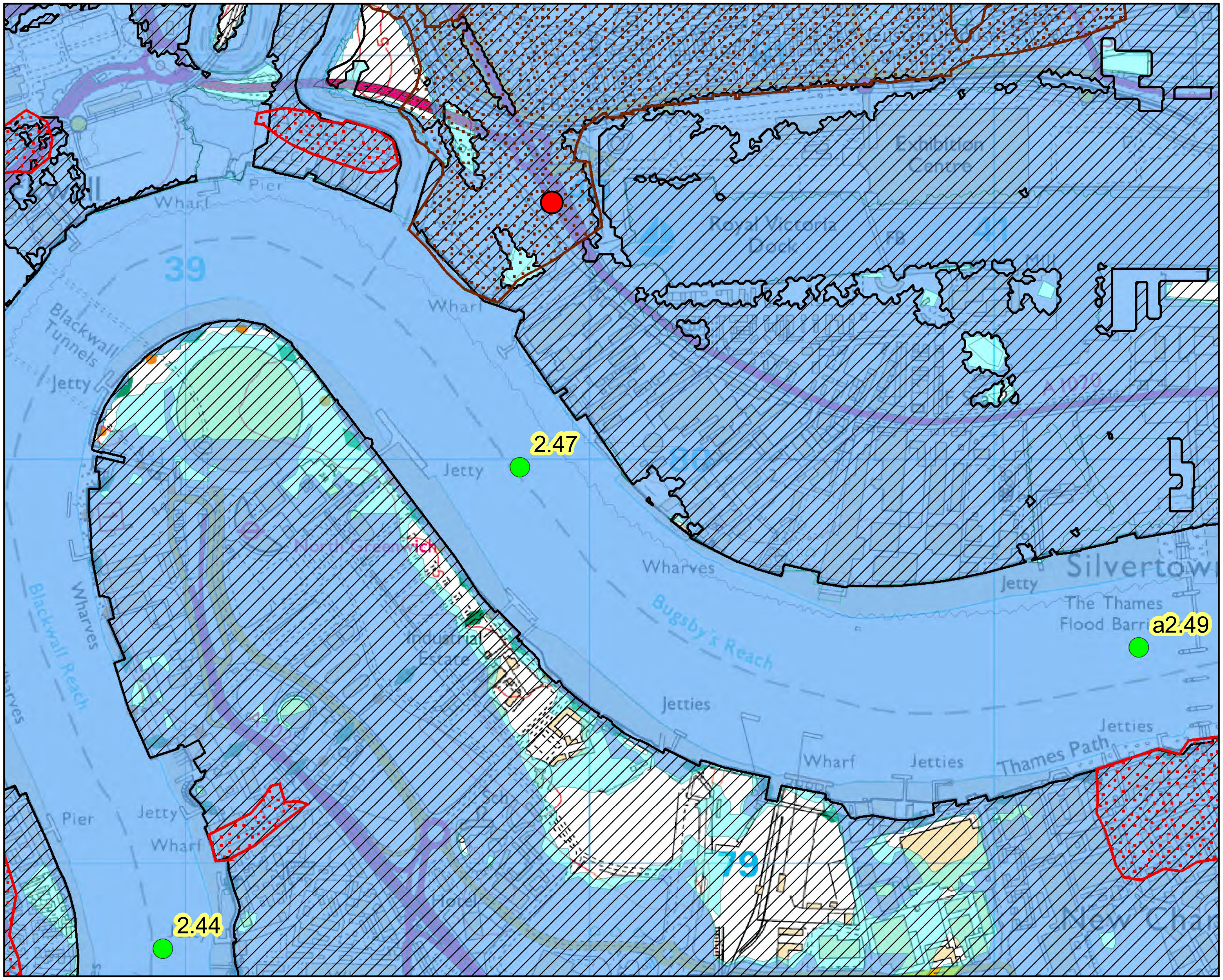
The defences along the tidal Thames in this area are all raised, man-made and privately owned. We inspect them twice a year to ensure that they remain fit for purpose. They must be maintained by their owners to a crest level of 5.18m AODN (the Statutory Flood Defence Level in this reach of the Thames). The overall condition grade for defences in the area is 2 (Good), on a scale of 1 (very good) to 5 (very poor).

Standard of protection provided by the tidal defences

The river Thames defences along this section of the river provide a standard of protection of 1 in 1000. This means that the defences protect against a tidal flooding event that has a 0.1% annual probability of occurring. This remains true up to the year 2070. After 2070 the standard of protection will decrease over time. However the Thames Estuary 2100 project has studied options to manage flood risk in the Thames estuary up to the year 2100. Public consultation of this study has finished, but you can access all the information here:
http://www.environment-agency.gov.uk/research/library/consultations/106100.aspx

Additional Notes

Detailed FRA/FCA for E539907, N180636 Silvertown, London - created 08/03/2013 - NE34271JH



Environment Agency

0 140 280 560
Meters

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Legend

- ● Site Location
- ● Model Nodes
- ▨ 1928 Flood Outline
- ▨ 1953 Flood Outline
- ▨ Areas Benefiting from Flood Defences
- 🟪 Flood Map - Flood Zone 3
- 🟦 Flood Map - Flood Zone 2

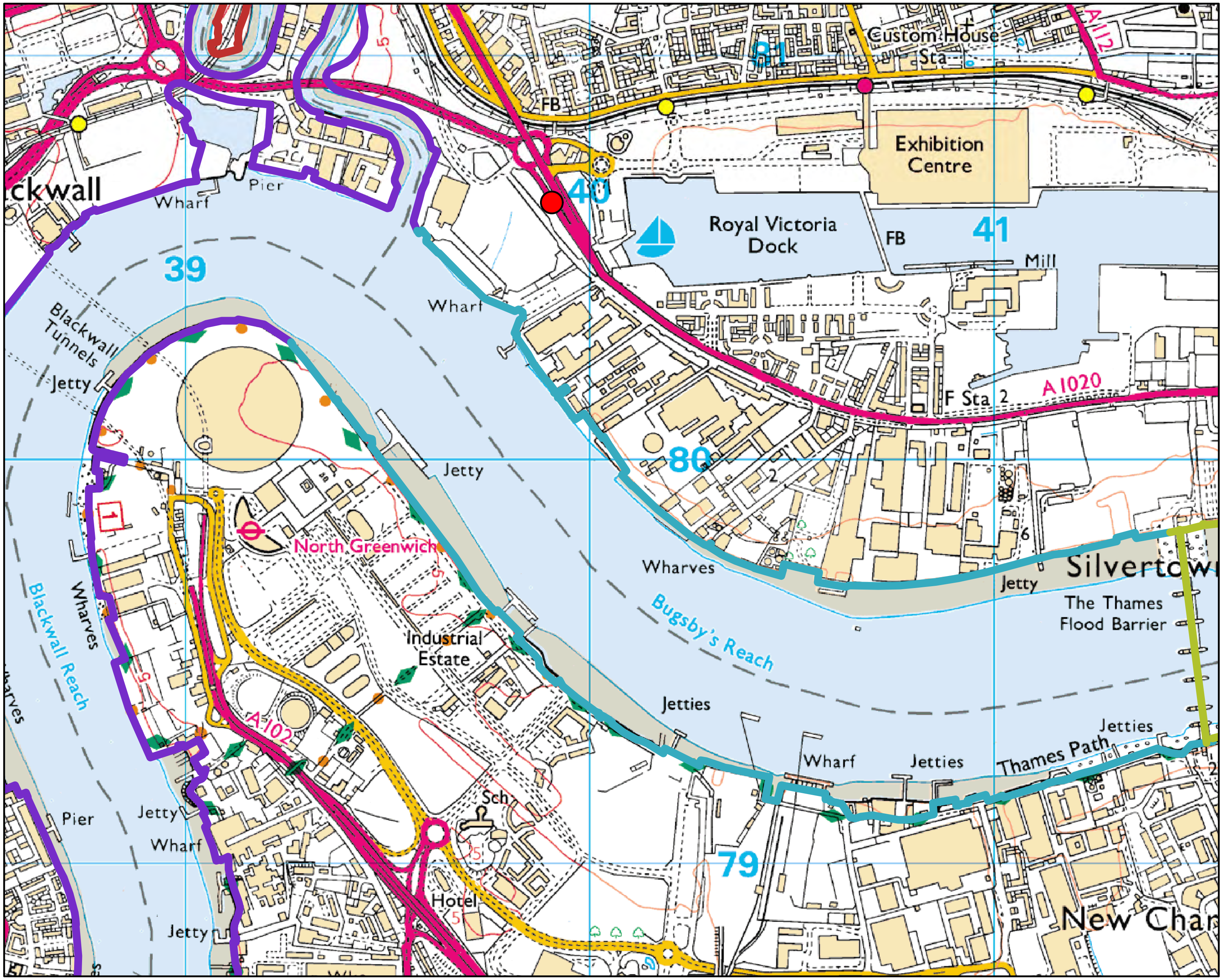
Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Detailed FRA/FCA for E539907, N180636 Silvertown, London - created 08/03/2013 - NE34271JH



Environment Agency

0 140 280 560
Meters

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Legend

● Site Location

TTD Defences SDL (mAODN)

SDL

🟦 5.18
🟪 5.23
🟥 5.28
🟩 7.2

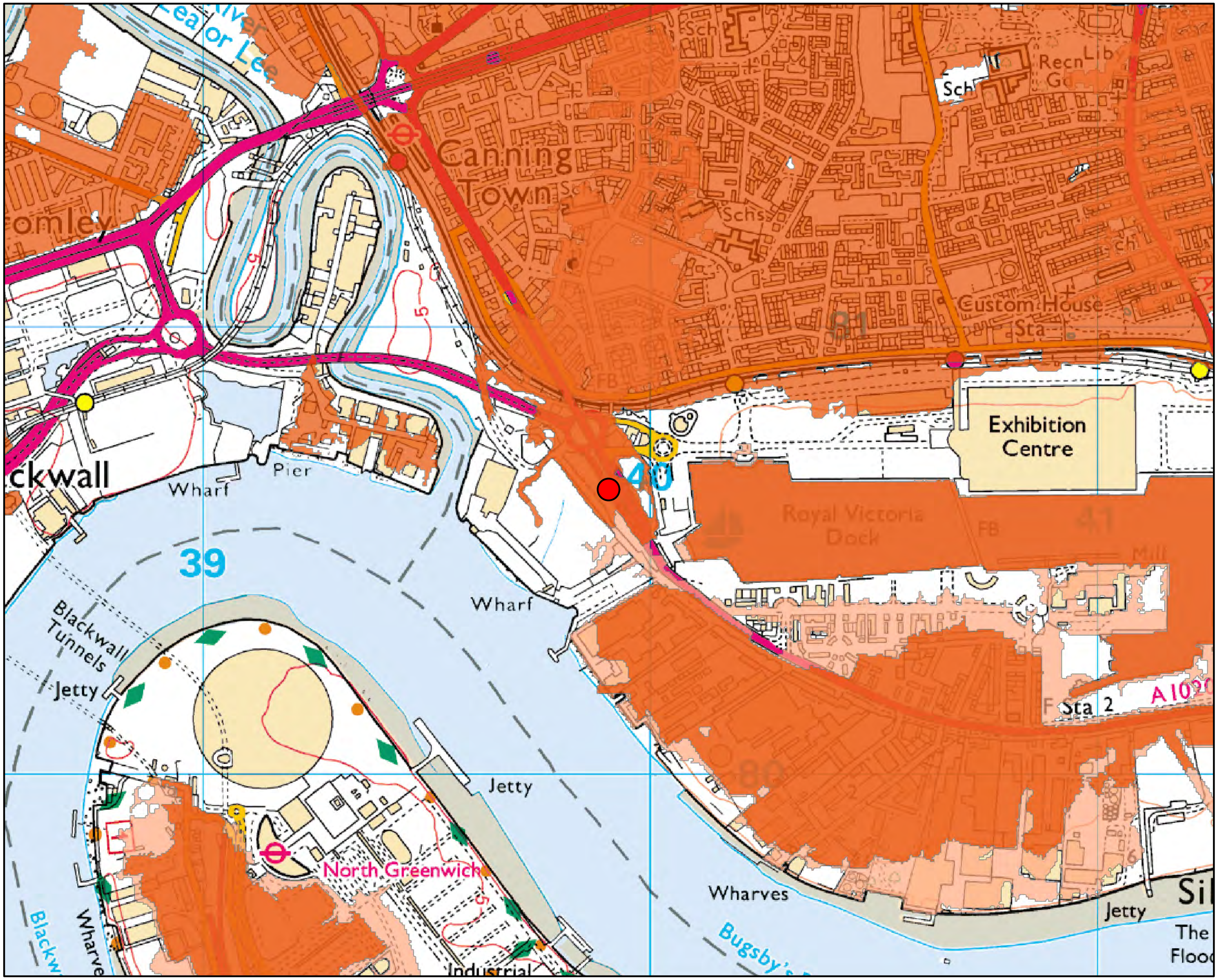
Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 0.5% or greater chance of occurring each year
- or from a river with a 1% or greater chance of occurring each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 0.1% chance of occurring each year.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Breach Modelling Map for E539907, N180636 Silvertown, London - 08/03/2013 - NE34271JH



Environment Agency

0 120 240 480
Meters

N W E S

Legend

● Site Location

Max Flood Extent

▨	0.5% AEP (1 in 200 year) 2107
■	0.5% AEP (1 in 200 year) 2005

Thames Tidal Breach Modelling 2013

A modelled representation of tidal breaches along the Thames from Teddington to the Mar Dyke and River Darent, based on low floodplain topography. For hard defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, defences are assumed to breach down to the ground level behind the defence. The modelling is based on the Extreme Water Levels 2008 (current year 2005), and includes 0.5% (1 in 200) chance in any year. In the case of breaches downstream of the Thames Barrier, the 1 in 200 year plus climate change event (2107 epoch) was also modelled.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Flood Map centred on Silvertown, London created 08/03/2013 - NE34271JH

Environment Agency

Scale 1:10,001

- **Flood Map - Defences**
- ▨ **Areas Benefiting from Flood Defences**
- ⬚ **Flood Map - Flood Storage Areas**
- 🟦 **Flood Map - Flood Zone 3**
- 🟦 **Flood Map - Flood Zone 2**

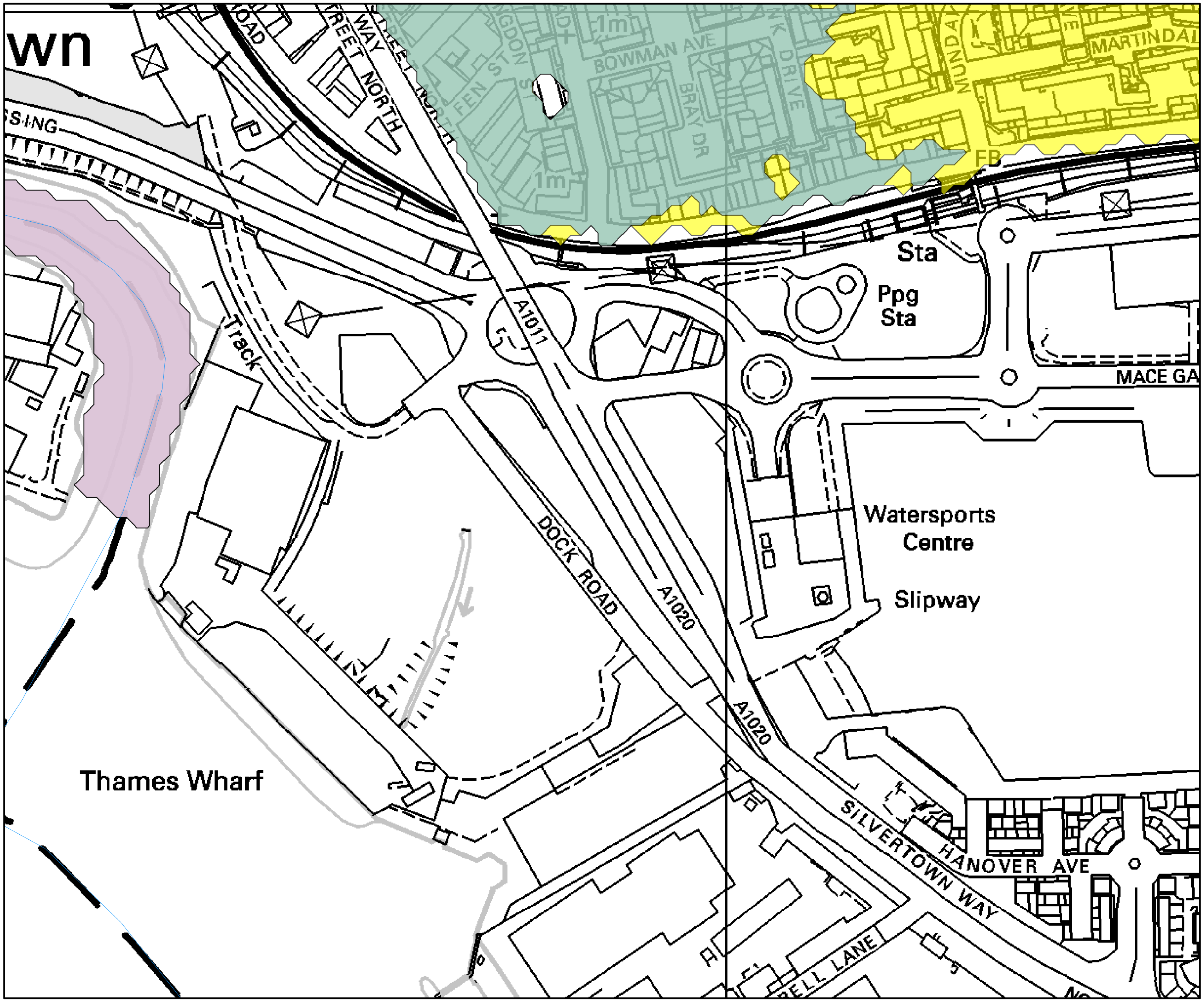
Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Detailed FRA centred on Silvertown, London created 08/03/2013 - NE34271JH



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

N
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0 50 100 200
Metres

Legend

Main Rivers

Defended Flood Outlines

🟪 1 in 100 (1%) Fluvial + 1 in 20 (5%) Tidal Defended
🟦 1 in 100 +20% (*CC) Fluvial + 1 in 20 (5%) Tidal Defended
🟨 1 in 1000 (1%) Fluvial + 1 in 20 (5%) Tidal Defended

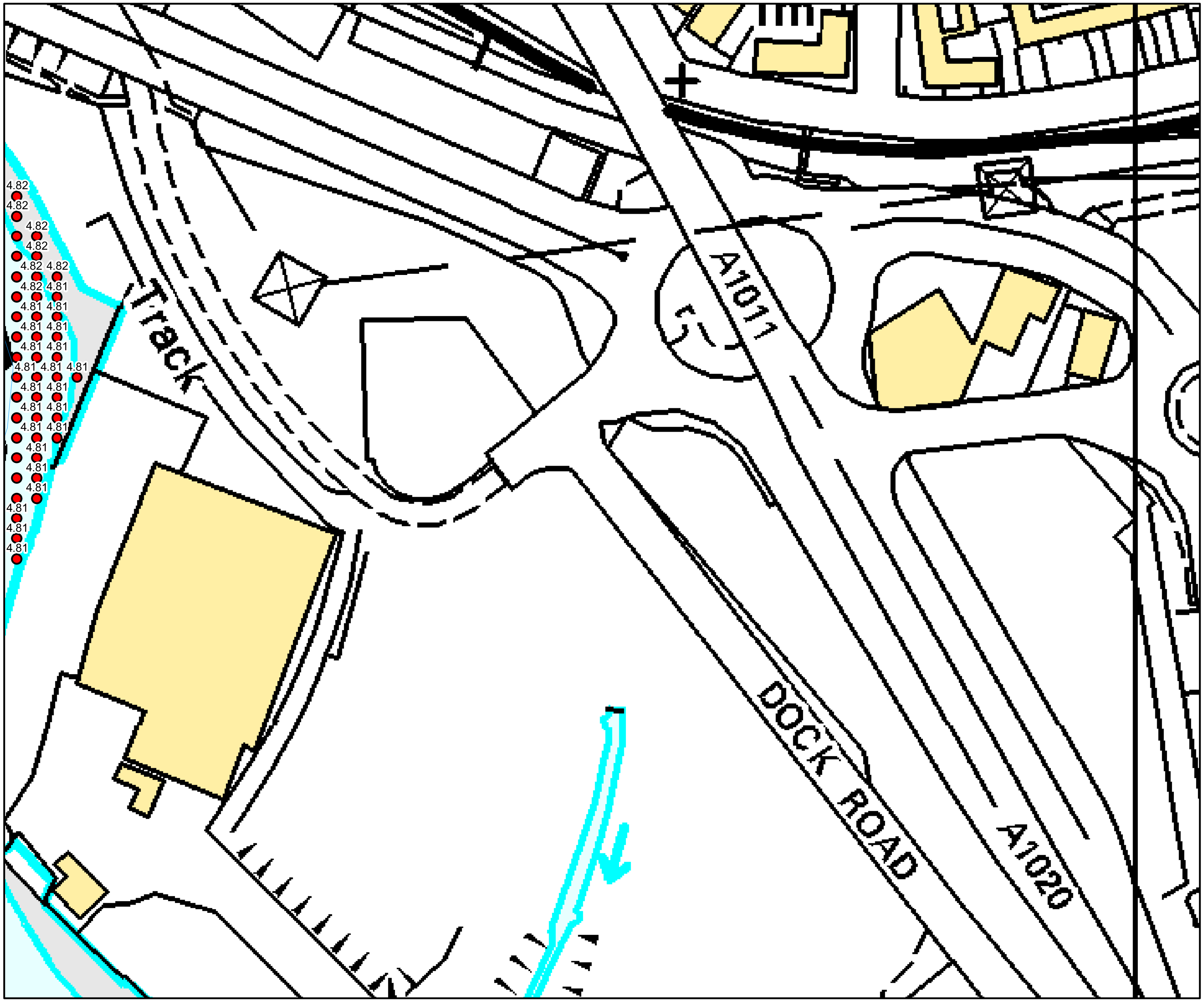
The data in this map is from the Lower Lee Valley Regeneration SFRA (Capita Symonds, 2011) This is a strategic level model and should be noted that it was not created to produce flood levels for specific development sites within the catchment.

Further refinement may be necessary for site specific developments.

Modelled outlines take into account catchment wide defences.

Produced by:
Partnerships & Strategic Overview
South East (Luton, Herts and Essex)

Detailed FRA centred on Silvertown, London created 08/03/2013 - NE34271JH



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

N
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0 25 50 100
Metres

Legend

─ Main Rivers

2D Node Results

● 1 in 100 (1%) Fluvial + 1 in 20 (5%) Tidal Defended

The data in this map is from the Lower Lee Valley Regeneration SFRA (Capita Symonds, 2011) This is a strategic level model and should be noted that it was not created to produce flood levels for specific development sites within the catchment.

Further refinement may be necessary for site specific developments.

Modelled outlines take into account catchment wide defences.

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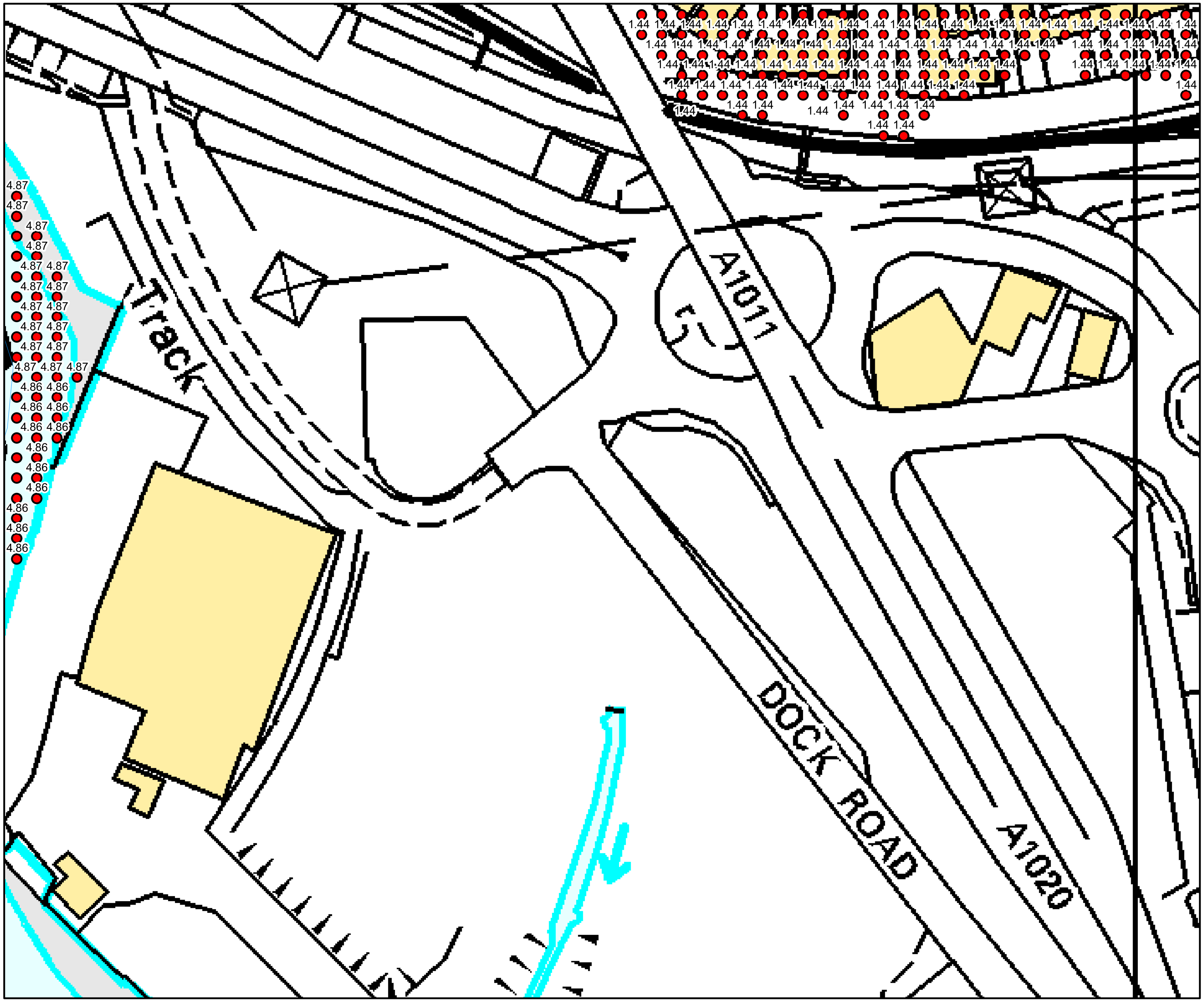
Detailed FRA centred on Silvertown, London created 08/03/2013 - NE34271JH



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

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S

0 25 50 100
Metres

Legend

Main Rivers

2D Node Results

● 1 in 100 +20% (*CC) Fluvial + 1 in 20 (5%) Tidal Defended

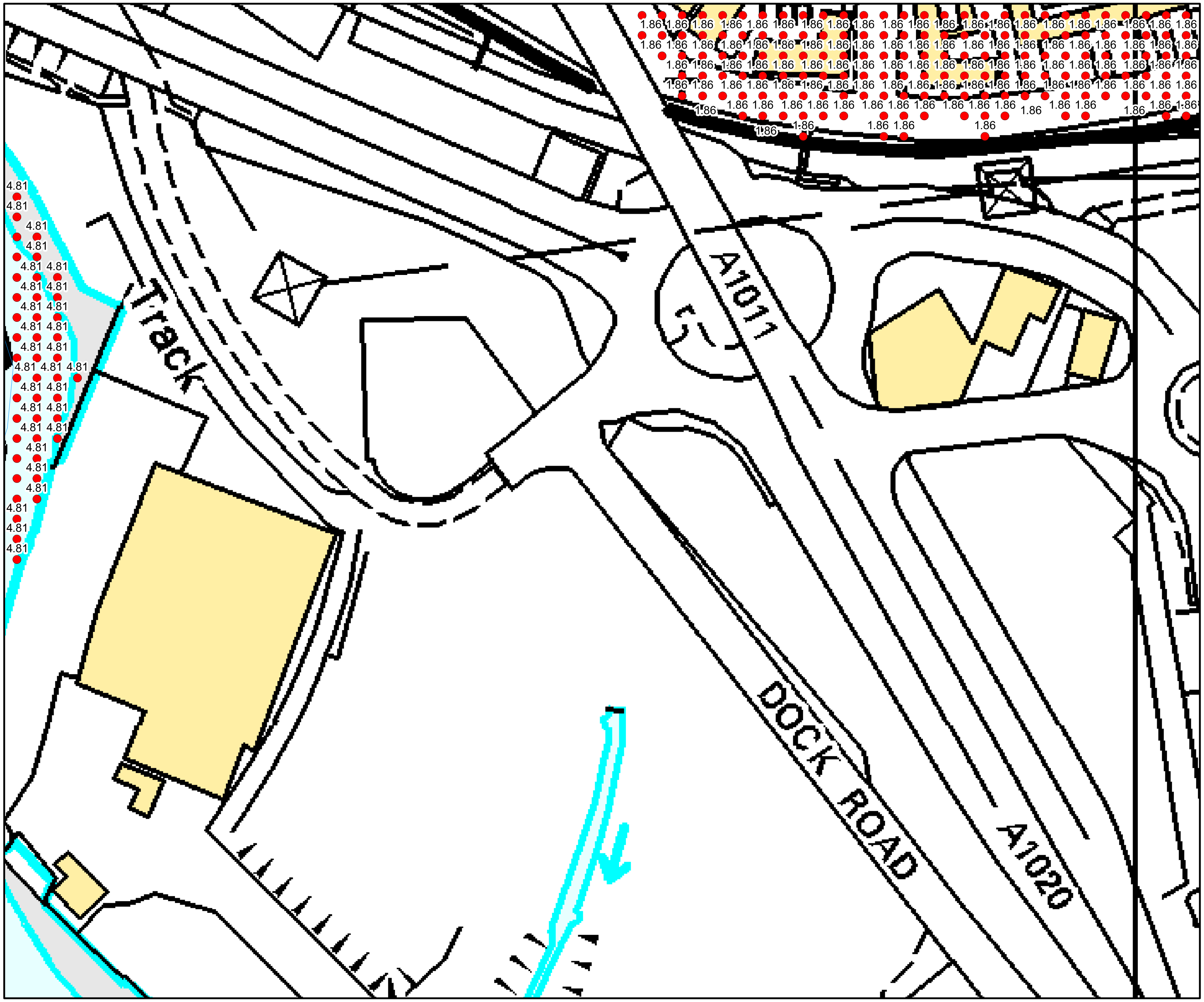
The data in this map is from the Lower Lee Valley Regeneration SFRA (Capita Symonds, 2011) This is a strategic level model and should be noted that it was not created to produce flood levels for specific development sites within the catchment.

Further refinement may be necessary for site specific developments.

Modelled outlines take into account catchment wide defences.

Produced by:
Partnerships & Strategic Overview
South East (Luton, Herts and Essex)

Detailed FRA centred on Silvertown, London created 08/03/2013 - NE34271JH



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

N
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0 25 50 100
Metres

Legend

Main Rivers

2D Node Results

● 1 in 1000 (0.1%) Fluvial + 1 in 20 (5%) Tidal Defended

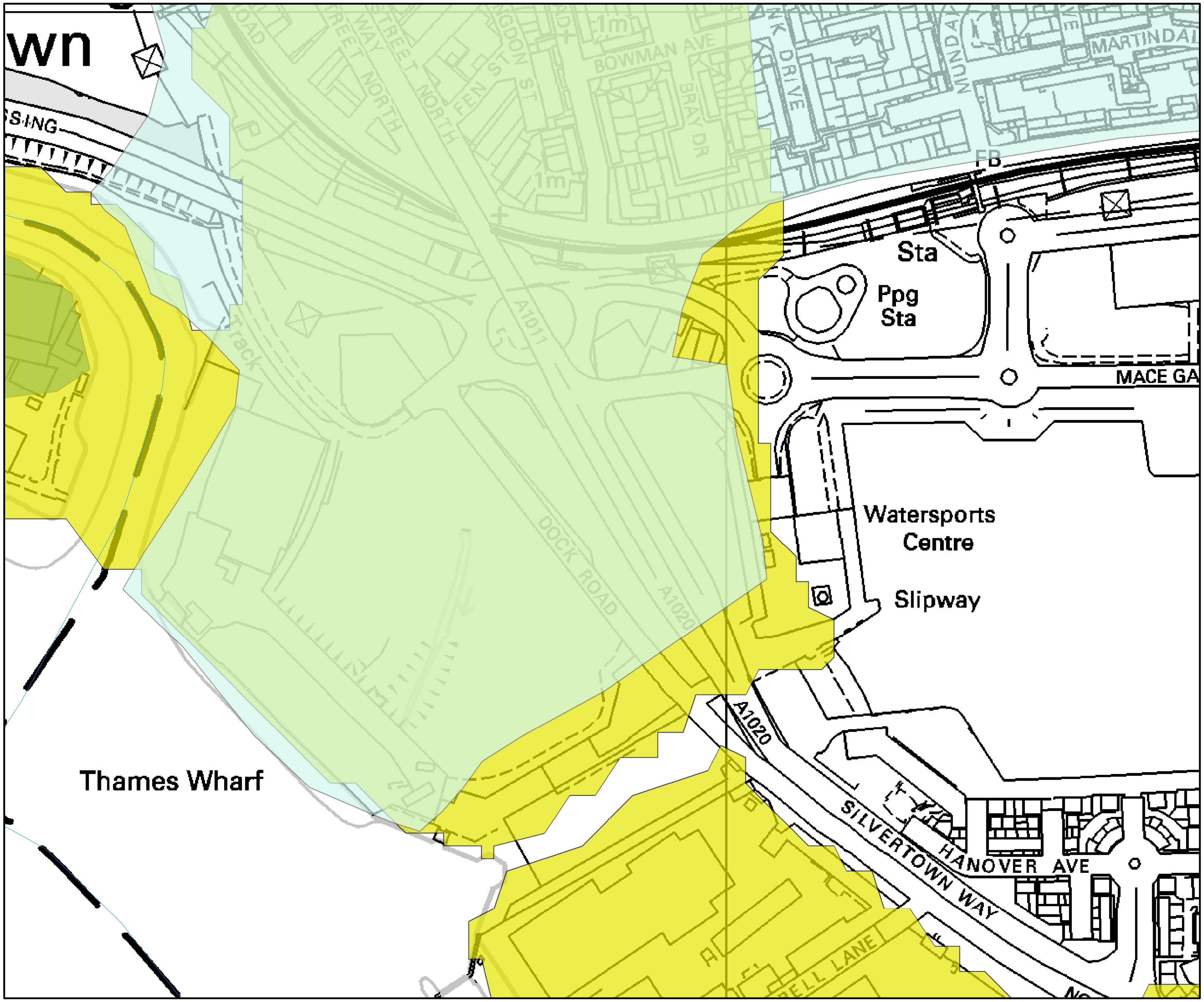
The data in this map is from the Lower Lee Valley Regeneration SFRA (Capita Symonds, 2011) This is a strategic level model and should be noted that it was not created to produce flood levels for specific development sites within the catchment.

Further refinement may be necessary for site specific developments.

Modelled outlines take into account catchment wide defences.

Produced by:
Partnerships & Strategic Overview
South East (Luton, Herts and Essex)

Historic Flood Map centred on Silvertown, London created 08/03/2013 - NE34271JH



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

N
W E
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0 50 100 200
Metres

Legend

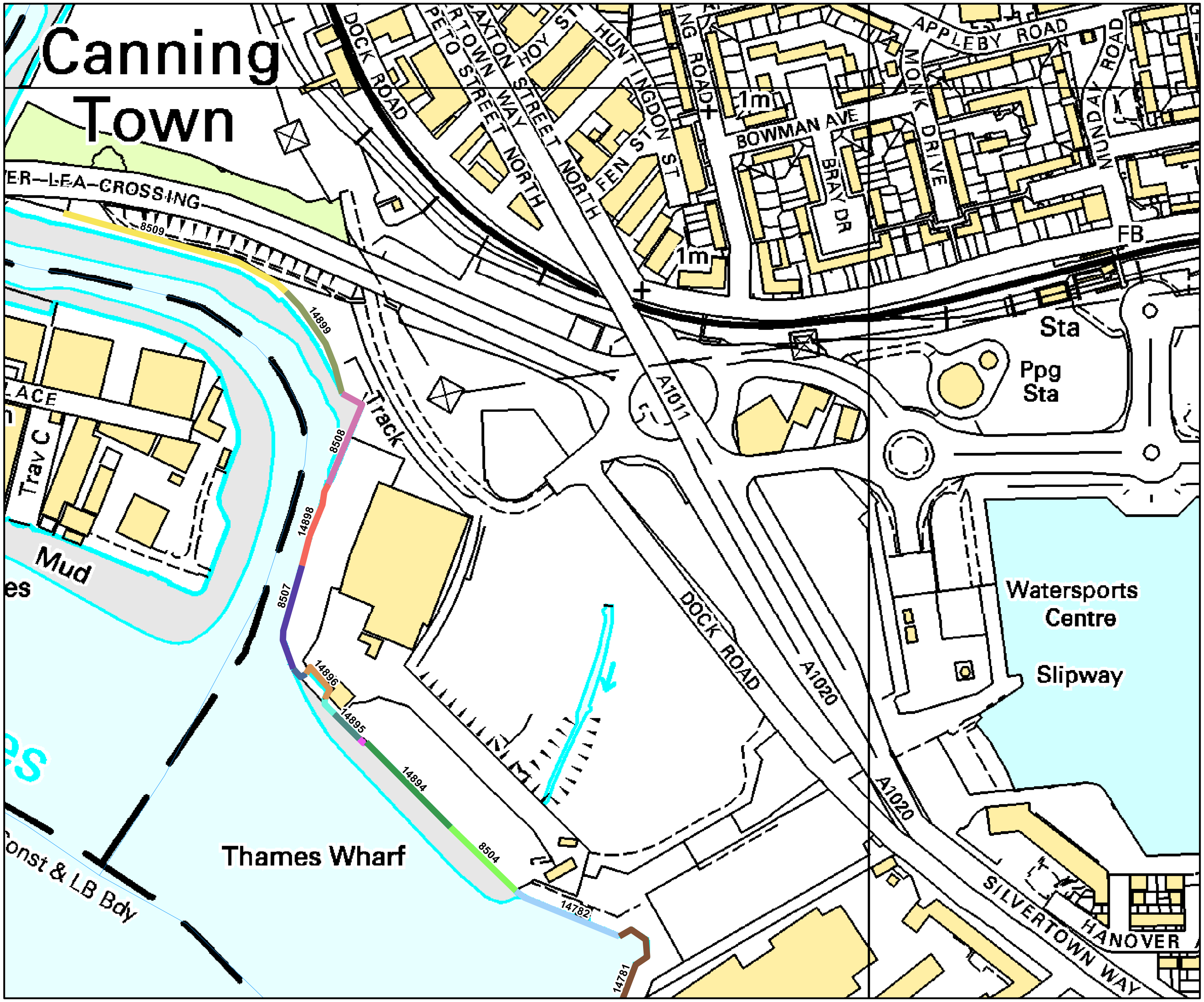
Main Rivers

Flood Event Outlines

- 🟦 1953
- 🟨 1947
- 🟦 1928

Produced by:
Partnerships & Strategic Overview
South East (Luton, Herts and Essex)

Detailed FRA centred on Silvertown, London created 08/03/2013 - NE34271JH



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

N E S W

0 62.5 125 250
Metres

Legend

— Main Rivers

Defences

Asset ID

- 🟩 8504
- 🟪 8505
- 🟦 8506
- 🟦 8507
- 🟪 8508
- 🟨 8509
- 🟫 14781
- 🟦 14782
- 🟩 14894
- 🟩 14895
- 🟧 14896
- 🟦 14897
- 🟥 14898
- 🟩 14899

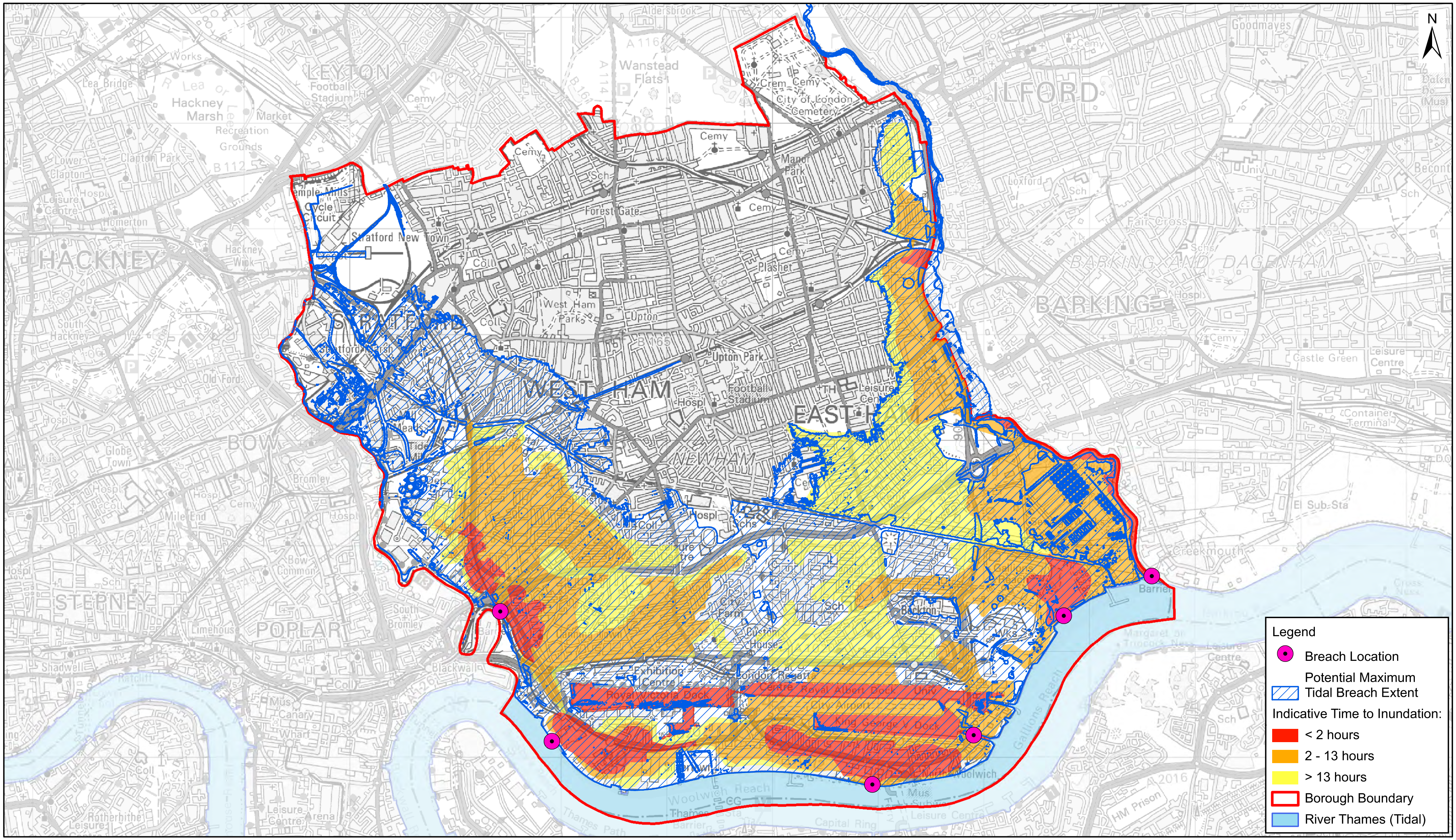
Produced by:
Partnerships & Strategic Overview
South East (Luton, Herts and Essex)

Environment Agency ref: NE34271JH

The following information on defences has been extracted from theAsset Information Management System (AIMS)

Defences

Map ID	Asset Reference	Asset Type	Asset Protection	Asset Comment	Asset Description	Asset Location	Design Upstream Crest Level (mAOD)	Design Downstream Crest Level (mAOD)	Actual Upstream Crest Level (mAOD)	Actual Downstream Crest Level (mAOD)	Design Standard of protection (years)	Grid Reference
8509	06304TH000303L05	Flood Defence Wall	Tidal	N/A	Limmo Site / Lee Crossing	Lower Lee Crossing, London, E16	5.23	5.23	6.5	6.5	1000	TQ3947980884
8507	06304TH000303L01	Flood Defence Wall	Tidal	N/A	Instones Wharf	Dock Rd, London, E16	5.23	5.23	5.68	5.68	1000	TQ3956780606
14899	06304TH000303L04	Flood Defence Wall	Tidal	N/A	Limmo Site / Lee Crossing	Lower Lee Crossing, London, E16	5.23	5.23	6.5	6.5	1000	TQ3959480811
14897	06304TH000302L39	Flood Defence Wall	Tidal	Timber clad wall.	Thames Wharf	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3957480563
14898	06304TH000303L02	Flood Defence Wall	Tidal	N/A	Instones Wharf	Dock Rd, London, E16	5.23	5.23	5.68	5.68	1000	TQ3958680674
14896	06304TH000302L38	Flood Defence Wall	Tidal	N/A	Thames Wharf	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3959380558
8506	06304TH000302L37	Flood Defence Wall	Tidal	N/A	Thames Wharf	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3959680539
8508	06304TH000303L03	Flood Defence Wall	Tidal	N/A	Instones Wharf	Dock Rd, London, E16	5.23	5.23	5.68	5.68	1000	TQ3961380743
14895	06304TH000302L36	Flood Defence Wall	Tidal	N/A	Thames Wharf	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3961180524
8505	06304TH000302L35	Flood Defence Wall	Tidal	N/A	Thames Wharf	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3962280513
14894	06304TH000302L34	Flood Defence Wall	Tidal	N/A	Thames Wharf	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3965880479
8504	06304TH000302L33	Flood Defence Wall	Tidal	N/A	Thames Wharf	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3971180426
14782	06304TH000302L32	Flood Defence Wall	Tidal	Requires subdivision.	Royal Dock Entrance	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3977280384
14781	06304TH000302L31	Flood Defence Wall	Tidal	N/A	Royal Dock Entrance	DOCK ROAD. SILVERTOWN.	5.18	5.18	5.18	5.18	1000	TQ3982680347



London Borough of Newham Strategic Flood Risk Assessment

Figure 5.11
Tidal Residual Risk
Indicative 'Time to Inundation' -
0.5% AEP (2107) Tidal Surge Event

Newham London

CAPITA SYMONDS

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A3	ISSUING OFFICE	DRAWING NUMBER	REV
AK	JR	JR	21/05/10	1:35,000	Grosvenor Gardens	CS028262/FIG5.11	-

Appendix C. Surface water flood maps

Surface Water 1 in 30 Rainfall Centered on Silvertown Created on 19 March 2013 [Ref:NE34271JH]

Environment Agency

Scale 1:10,000

N
W E
S

FMfSW - 1 in 30 chance rain

▨ **Surface Water Flooding**

■ **Deeper Surface Water Flooding**

☐ **Out of range**

Flood Map Areas (assuming no defences)

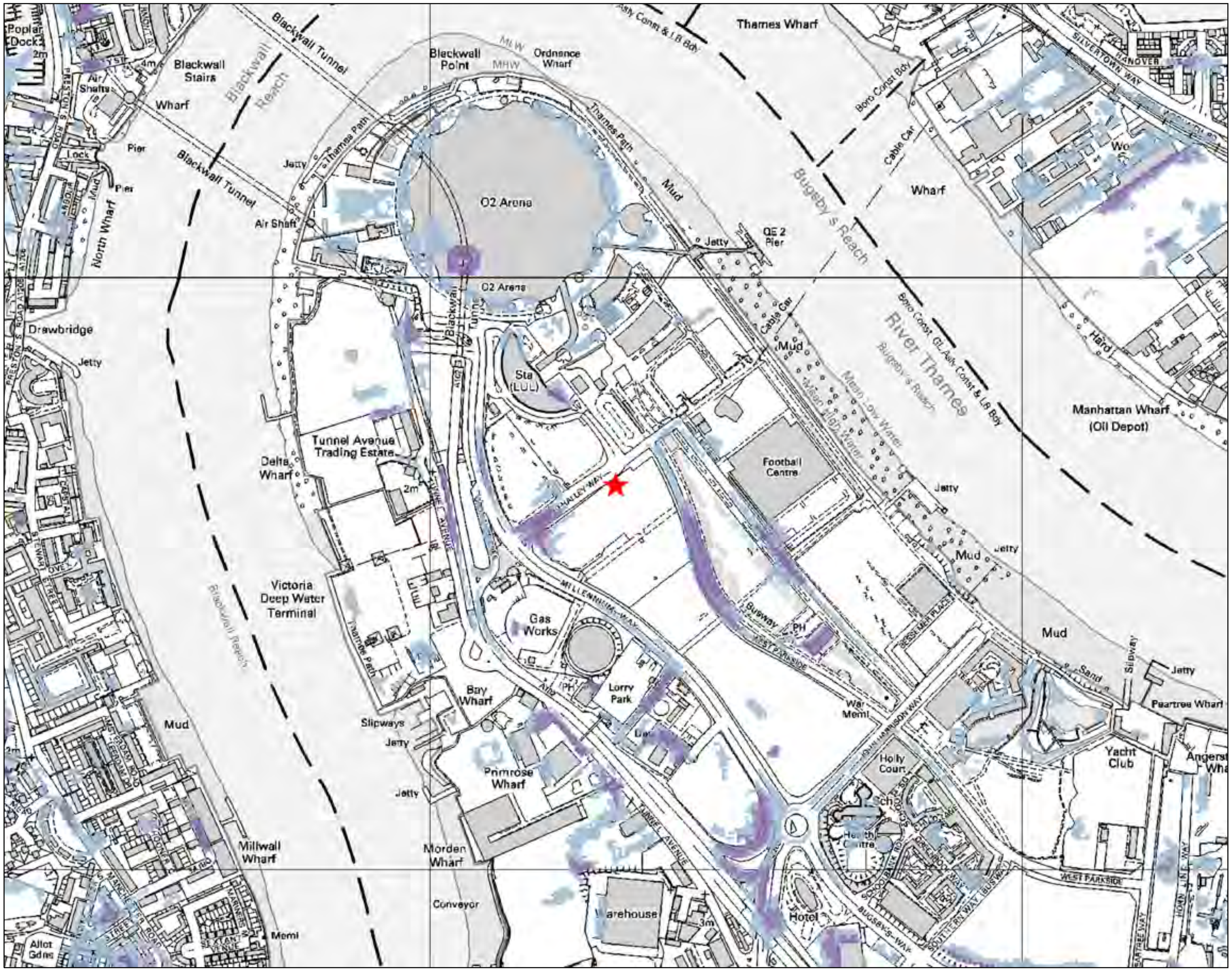
Flood Zone 3 shows the area that could be affected by flooding:

- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

Surface water 1 in 30 rainfall Centered on Greenwich site Created 19 March 2013[Ref:NE34271JH]



Scale 1:10,000

N
W E
S

FMfSW - 1 in 200 chance rain

🟦	**Surface Water Flooding**
🟪	**Deeper Surface Water Flooding**
☐	**Out of range**

Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Surface water 1 in 200 rainfall Centered on Silvertown Created 19 March 2013 [Ref:NE34271JH]

Scale 1:10,000

FMfSW - 1 in 200 chance rain

🟦	**Surface Water Flooding**
🟪	**Deeper Surface Water Flooding**
☐	**Out of range**

Flood Map Areas (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Contact Us: National Customer Contact Centre, PO Box 544, Rotherham, S60 1BY. Tel: 03708 506 506 (Mon-Fri 8-6). Email: enquiries@environment-agency.gov.uk

D.6. Outline Site Waste Management Plan

Silvertown Tunnel Crossing

Outline Site Waste Management Plan

April 2013
Transport for London

Mott MacDonald

Silvertown Tunnel Crossing

Outline Site Waste Management Plan

April 2013

Transport for London

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	12/03/2013	Anita Manns	Matt Dilling	David Dray	Draft

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Content

1. Administration and Planning

1.1 Introduction

This outline Site Waste Management Plan (SWMP) has been produced for the proposed Silvertown Tunnel project. The new Thames river crossing will provide a road link between Greenwich and Silvertown. The SWMP has been produced using the information currently available at the time of issue. This SWMP has been produced in accordance with The Site Waste Management Plan Regulations 2008 and the "Non-statutory guidance for site waste management plans", April 2008, DEFRA, to ensure that all construction waste is managed, stored and disposed of in an appropriate manner by appropriate contractors in accordance with all relevant legislation.

This document is a live document and requires updating regularly as the project progresses (refer to text in red particularly to items that are incomplete or will require review and modification). The project scope is subject to change and the SWMP will be updated to reflect any changes as necessary.

The aim of this outline SWMP is to initiate the SWMP process at an early design stage, steer the development of a detailed SWMP once the Principal Contractor has been appointed, ensure that the relevant waste legislation is implemented and incorporated from an early stage and to ensure the project reflects the waste management objectives of the Client.

Best practice suggests that the SWMP approach should be applied from the very early design stages, through the concept of Designing out Waste, and carried forward and revised throughout the project delivery process. This ensures cost savings are maximised by considering waste minimisation initiatives and identifying opportunities to reduce, reuse or recycle waste materials in the scheme and improve resource efficiency during the design stage on into construction.

1.2 Site Location

The project location is shown on the map below and illustrates the principles of how the crossing ties in to the surrounding road network.

The tunnel will run beneath the River Thames linking North Greenwich peninsular on the southern side of the River Thames with Silvertown to the north.

The southern worksite which will incorporate the approach junction and tunnel portal is located on the North Greenwich peninsular. Surrounding land-use at the time of this report includes office and commercial buildings, the O2 Arena and associated car parks, landscaped open space and residential properties and new developments. The proposed southern worksite area is currently open space and derelict land.

The northern worksite which will also involve construction of approach roads and the tunnel portal includes Thames Wharf, Alexandra Wharf and Royal Victoria Dock to the north of the Thames.

The northern side of the site is located within the London Borough of Newham and the southern side within the London Borough of Greenwich.

The Greenwich Peninsular is an area set for heavy development to high environmental standards. 10,000 homes plus offices and public spaces have been proposed.

The tunnel will link the two worksites, constructed by Tunnel Boring Machine (TBM) launched from a launch chamber forming part of the cut and cover approach at Silvertown on the northern side and passing 7-8m below the river bed predominantly within London Clay.

Figure 1 Location of Proposed Alignment (safeguarded area in red hatched area)

1.3 Development Description

The bored tunnel option is a 2-lane twin road tunnel crossing approximately 1400m long (including the cut & cover approach structures) beneath the river Thames linking Greenwich and Silvertown. The tunnels will have an internal diameter of 11.0m.

Four cross passages will be created for emergency escape purposes, three within the bored tunnel section and one within the cut and cover section on the southern side. The tunnels will be located below the River Thames and must fit within the constraints posed by the existing and proposed developments, including the cable car which crosses on a similar alignment and which includes foundations relatively close to the tunnel. The approaches include a section of cut-and-cover tunnelling adjacent to each portal, with a section of open cut construction leading to the approach roads.

1.4 Previous land use

The land on the northern side is mixed residential and recreational use around the perimeter of Royal Victoria Docks and light commercial use to the south of the elevated Silvertown Way and the Docklands Light Rail (DLR). On the south side of the River Thames, the land use is predominantly car parking with the O2 dome and commercial buildings located to the northwest and a leisure facility to the southeast.

The area located on the north side of Royal Victoria Dock is a level cobbled pedestrianised area bounded to the south by Royal Victoria Dock, to the north by Western Gateway, to the east by assorted shops and restaurants and to the west by Tidal Basin Road. It is understood that previous land uses included railway sidings.

The area located north of the River Thames is generally level and covered with hardstanding and is currently fenced off and accessible via secured locked gates. The area is bound to the northeast by Dock Road, to the south by a site occupied by Laing O'Rourke and to the southwest by a site occupied by Euromix. The site area includes the infilled Western Entrance Lock to the Royal Victoria Dock. The lock was infilled in two phases (1960's and 1980's) and is an Environment Agency Registered Landfill Site (1981).

The area to the southwest located along Dock Road has several buildings and is currently an industrial facility operated by Laing O’Rourke for storage and vehicle maintenance activities accessible via guarded gates. Surrounding land uses include the River Thames to the southwest, the Euromix site to the north and commercial buildings to the southeast. It is understood that previous land uses included manure and chemical works, oil and cake mills.

The Tunnel site, on the north side of the River Thames, it is understood to have once included a jetty for the gas works.

The area near the Greenwich site includes a private coach/car park for the O2 Arena. Surrounding land use includes roads and parking to the southwest and northwest, River Thames to the northeast and leisure (indoor football centre) to the southeast. It is understood that the southern part of the site was previously dominated by a gasworks and the area has undergone some remediation in the form of surface stripping and capping.

1.5 Geology of the site

1.5.1 Regional Geology

There is extensive made ground to the northeast and southeast of the proposed routes of the Silvertown Tunnel crossing. Superficial sediments exist around the docklands area comprising alluvial deposits of the flood plain of the Thames which rests on the flood plain gravels (Thames River Terrace Deposits). These superficial sediments overlie solid geology which comprises London Clay, the Woolwich Reading Beds and Upnor Formation of the Lambeth Group, Thanet Sand Formation and the Upper Chalk.

Made ground is also present around the perimeter of the Royal Victoria Dock, the Tidal Basin and the former Royal Victoria Dock Western Entrance. In general made ground was originally, placed to raise the level of land above the level of the marshes which were prone to regular flooding. Subsequently, made ground is likely to be associated with demolition and redevelopment of sites.

1.5.2 Geological Overview of the Greenwich Peninsula

A review of the British Geological Survey (BGS) geological mapping for the area (Sheet 256, North London) and the Geological memoir for London (BGS, 2004) indicates that the site is underlain by Alluvium which is, in turn, underlain by River Terrace Deposits, London Clay, the Lambeth Group, the Thanet Sand Formation and the Upper Chalk. In addition, made ground is likely to overlie the alluvial deposits across the majority of the site.

A generalised description of the geological succession on the Greenwich Peninsula is presented in Table 1-1. Predicted thicknesses and geological descriptions are based on information provided in the Greenwich Peninsula Environmental Method Statement (Atkins, 2005) and on data in the BGS geological memoir (BGS, 2004). A further ground investigation desk study is currently being produced by Mott MacDonald.

Table 1-1: Greenwich Peninsula Geological Succession

Geological Unit/Strata		Description	Approximate Thickness
Made Ground/ Infilled Land		Unknown	Unknown
Alluvium and peat		Soft to firm silty clay and clayey silt with locally developed beds of sand, and peat.	2-6 metres
River Terrace Gravels		Sand and fine to coarse gravel.	4-7 metres
London Clay		Stiff to very stiff silty clay.	0-15 metres
Lambeth Group	Laminated beds	Thinly interbedded sand silt and clay with scattered bivalves.	8-20 metres
	Lower Shelly Clay	Dark grey/black clay with abundant shells.	
	Lower Mottled Clay	Mottled silty clay and clay.	
	Upnor Formation	Fine to medium grained sand with well rounded flint pebbles.	
Thanet Sand		Silty fine to medium grained sand, coarsening upward.	15-20 metres
Upper Chalk		Firm to soft chalk.	Up to 60 metres

Source: (BGS, 2004) and (Atkins, 2005)

1.5.3 Geological Overview of the London Borough of Newham Silvertown Area

The British Geological Survey (BGS) England and Wales 1:50,000 Series geological drift map Sheet 257 Romford (1978) and Geology of London, Special Memoir for 1:50,000 Geological Sheets 256 (North London), 257 (Romford), 270 (South London) and 271 (Dartford) (England and Wales) (2004) indicates that the site is underlain by Alluvium which is in turn underlain by River Terrace Deposits, London Clay, the Lambeth Group, the Thanet Sand Formation and the Upper Chalk. In addition, made ground is likely to overlie the alluvial deposits across the majority of the site.

A generalised description of the geological succession in the Silvertown area is presented in Table 1-2. Predicted thicknesses are based on findings of the above investigations on nearby sites and BGS data.

Table 1-2: Silvertown Geological Succession

Geological Unit/Strata		Description	Approximate Thickness
Made ground/ Infilled land			
Alluvium		Generally silty clay and clayey silt with occasional pockets of peat.	2-7 metres
River Terrace Gravels		Sands, gravels and sandy gravelly clay.	1-4 metres
London Clay		Stiff to very stiff silty clay.	14-17 metres
Lambeth Group	Laminated beds	Thinly interbeded sand silt and clay with scattered bivalves.	15-20 metres (Greenwich Peninsula - BGS, 2004)
	Lower Shelly Clay	Dark grey/black clay with abundant shells.	
	Lower Mottled Clay	Mottled silty clay and clay.	
	Upnor Formation	Fine to medium grained sand with well rounded flint pebbles.	
Thanet Sand		Fine grained sand, coarsening upward.	12-18 metres

Geological Unit/Strata	Description	Approximate Thickness
		(Greenwich Peninsula - BGS, 2004)
Chalk	Firm to soft chalk.	-

Sources: BGS, 2004; URS, 2007; and Soils Ltd, 2002.

1.6 Project Information

This project is subject to the Site Waste Management Plan Regulations 2008, which requires the Client (or through the delegation of the appointed Principal Contractor) to produce a SWMP. Since the project is likely to exceed £500,000, additional requirements under the Regulations also apply.

Client	Transport for London
Principal Contractor	TBC
Name of person in charge of project	TBC
Author of SWMP	Anita Manns
Project title/ reference	Silvertown Tunnel Crossing
Project location	Greenwich – Silvertown, London
Project cost (estimated)	TBC
Footprint (ha)	TBC
Start date	Day X Month X Year X
Completion date	Day X Month X Year X
Description of project scope	See development description in Section 1.3. Works will involve excavation and construction.
Waste Management Champion	TBC
Person responsible for SWMP	TBC
Document Controller	TBC
Version number and date	Version 0 – 04/04/2013
Location of SWMP	Site office

1.7 Responsibilities

1.7.1 Client and Principal Contractor

A SWMP must be produced before any work in relation to the excavation and construction for this project commences on site. It is the responsibility of the Client to produce a SWMP, but usually this is undertaken in partnership with the project Designers and Principal Contractor. Mott MacDonald has been commissioned by TfL to produce this outline SWMP as part of the Further Development of Tunnel Engineering. It should be noted that some Clients initiate the SWMP process in order to steer the direction of the SWMP and influence the waste management options to be adopted by the Principal Contractor.

The Client must also give reasonable direction to any contractor to enable the Principal Contractor to comply with the Regulations. However, with this project it is appropriate for the designer to write the SWMP on behalf of the Client, with the Principal Contractor responsible for adopting it and updating it as the project progresses.

1.7.2 Construction Manager

The Construction Manager is responsible for instructing workers, overseeing and documenting results of the SWMP and monitoring the effectiveness and accuracy of the documentation during the routine site visits. Copies of the plan will be distributed to the Construction Design Management (CDM) coordinator, Client, Site Manager and each contractor. This will be undertaken every time the plan is updated.

1.7.3 Waste Co-ordinator and Waste Champion

Although the proposed scheme is currently at the pre-planning stage and has not appointed a Principal Contractor, it is important that someone is assigned responsibility for waste issues at an early stage. This could be implemented in the form of a Waste Co-ordinator within the project team, with the responsibility for overseeing the integration of the SWMP into other aspects of the project and liaising with the Principal Contractor once appointed, who will then appoint a site Waste Champion.

1.8 Proposals for minimisation

The SWMP must record any early decisions, design changes, construction methods or material specifications which have helped to minimise waste arisings on site.

Waste minimisation is at the top of the waste hierarchy and this should be continued to be a priority throughout the project, not just at the early stages.

Waste from the project will arise mainly from site clearance, excavation and any unavoidable construction waste. The proposed scheme will require specific construction materials (such as concrete, asphalt and cabling etc.) to be imported to the site. A Bill of Quantities will be provided once the planning has been approved and project is able to progress. This will be used to identify the potential types and quantities of materials produced from this project.

The person responsible for purchasing shall ensure that materials are ordered so that the timing of the delivery, the quantity delivered and the storage is not conducive to the creation of unnecessary waste.

Waste for recycling, recovery and disposal, where it cannot be re-used back in the scheme should be sent to appropriately permitted facilities. A non-exhaustive list can be found in Table 2-3 and Table 2-4. However, it is recommended that the sites are contacted prior to construction to ensure they are able to accept the waste types being removed.

Excavated materials

Excavated materials such as soils should be carefully stored in segregated piles for subsequent re-use on the site, where possible. These excavated materials should be re-used as deposition material for infilling or landscaping. Any surplus materials should be removed from site for either direct beneficial use elsewhere (such as land remediation projects) or for recycling or recovery at an appropriately permitted off-site facility. If the material is contaminated then it should be kept separate from the clean material and sent for either recycling or recovery, where appropriate, or disposal at appropriately permitted facilities.

Excavated material from tunnelling activity, the construction of portals and general construction work waste will be produced during the construction period. Excavated material from tunnelling activity will be removed from the site at which the tunnel boring machine enters the ground and from the area of the cut and cover and open cut portals located and the northern and southern ends of the tunnel at Silvertown and the Greenwich Peninsula respectively. The close proximity of the site to the River Thames and the local road network provides the opportunity to remove waste by either road or barge. If the existing infrastructure allows use of barge transportation i.e. suitable jetties and navigable depths, further consideration should be given to this method. This is the case at Silvertown where an existing jetty will form part of the worksite and all the tunnel material can be transferred to this location.

The project should examine the potential re-use and disposal options for excavated material produced as part of the scheme and in particular re-use options for London Clay. Where re-use is not possible there will be a requirement to dispose of excavated material, by licensed carriers, to licensed landfill sites and handled in accordance with the Waste Management Regulations.

Other unusable C,D&E waste materials will be collected in receptacles with mixed C&D waste materials, for subsequent separation and disposal at an off-site facility.

Vegetation

In order for construction to take place, areas of vegetation, comprising mainly of grass and shrubs will require clearance. Any vegetation removed should be sent for composting. If landscaping is part of the scheme then any vegetation could be turned into mulch or compost to be re-used back in the scheme.

If any material deemed acceptable from the enabling works is produced e.g. good quality topsoil, this should be stored and re-laid, within the project or if this is not possible should be sent for composting.

Contaminated waste

The Greenwich Peninsula was previously dominated by the Southern Metropolitan 240 acre (97ha) gasworks site which primarily produced town gas from coal and oil, but also produced coke, tar and chemicals. Site wide remediation was undertaken during the late 1990s by British Gas and English Partnerships and key sources of contamination were removed such as tar tanks and hot spots, groundwater remediation was undertaken and near surface soils were removed or cleaned prior to landscaping. However, it is understood that contaminated materials remain at depth and these could be disturbed during groundworks, potentially leading to the risk of migration of contaminants during the construction phase.

Given the nature of the works involved there is the potential for works associated with the construction of the portals to give rise to potentially contaminated material that will require remediation or appropriate disposal.

The northern side of the river has also historically been occupied by various industrial/commercial land uses which could be expected to have resulted in land contamination. There has been no widespread remediation undertaken in these locations and may give rise to contaminated material that will require remediation or appropriate disposal.

Hazardous waste

Hazardous wastes including any contaminated soil materials will be identified, removed and kept separate from other C&D waste materials in order to avoid further contamination and will be disposed of in accordance with the Hazardous Waste (England and Wales) Regulations 2005.

Asbestos based materials and other contaminants, although believed not to be present, may arise during the excavation of ground for tunnels and portals especially in areas of previously high industrial use and the historic gas works. The edge of one of the main historic gas works' buildings was located above the proposed alignment with the possibility of foundations or items of infrastructure (including asbestos sheeting) remaining underground. No records have been found detailing the demolition of these buildings. No records have been found detailing the surface remediation of the Greenwich Peninsula. Allowance will need to be made in the forecasted waste for the removal of these foundations and infrastructure.

Should asbestos or other contaminants be encountered, it should be managed by a qualified asbestos removal contractor and all asbestos should be removed off site in accordance with legislation and disposed of in a licensed tip by a licensed contractor in accordance with all appropriate regulation.

Imported material

Surplus or waste materials arise from either the materials imported to site or those generated on site. Imported materials are those which are brought on to the project for inclusion into the permanent works.

Where possible, consideration should be made for the re-use of material back into the project, however the proposed scheme will require specific materials to be imported to the site.

Any waste produced through the importation of materials needs to be monitored and included in the SWMP under construction works. Where possible, consideration should be given to the use of recycled imported material such as concrete, which has a higher recycled content. However, due to the integrity of the material required for the structure this may not be considered a suitable method.

Waste from imported material is likely to come from the packaging and spillages but these are difficult to quantify at this stage.

Fit out material

Final fit out of the tunnels and associated infrastructure should be done in conjunction with the client and not to an assumed design specification in order to reduce wastage of materials.

Construction and demolition wastes

Construction and demolition wastes typically include soils, concrete, bricks, glass, wood, plasterboard, asbestos, metals and plastics.

Two large (approximately 1.8m diameter) rising mains, forming part of the Royal Victoria Dock drainage discharge into the Thames, traverse the alignment of the tunnel in the vicinity of the DLR viaduct. It will be necessary to divert these mains, potentially producing waste from the diversion/replacement of pipes and with the reinstatement/relocation of the drainage system after completion of the tunnel works.

Excavated materials

An EPB (Earth Pressure Balance) TBM will be used rather than a slurry machine. The spoil will therefore, not come out as a slurry and require further treatment. The tunnel alignment will pass through Thames Gravel deposits at the portals, passing into London Clay and the Lambeth Group in the centre section.

Due to the size of the tunnel bores the material coming out will be a mixture of any two of these materials types at any one time, and it is expected that these materials will not be contaminated.

Soil conditioning agents (foam) will be added at the tunnel face to maintain the excavated material in the appropriate condition for control of the face and transfer through the screw, these are usually types of liquid soap - biodegraded by the time it reaches the disposal point.

If the water content of the excavated material is considered too high for transport by barge it may be necessary to add lime to reduce the water content.

The TBM is maintained underground, all oils and greases are non-mineral and biodegradable.

Spoil will be removed by conveyor, segments and materials transported from surface to underground by rubber tyred vehicles - maintenance, etc. as any site plant.

Spoil disposal and required transport infrastructure

The construction work for the Silvertown Crossing Project will generate approximately 250,000m^3 of material to be excavated from the bored tunnels. This figure equates to approximately 500,000 tonnes of spoil and an estimated 70,000 lorry movements on the roads.

There is no suitable railhead for spoil disposal so river disposal is preferred. There may be potential for the spoil to be removed by barge to be sent to Wallasea Island. Wallasea Island is currently receiving material from the Crossrail project. Early consultation is required to:

- Identify if sufficient capacity remains at Wallasea to receive further excavated material from the Silvertown tunnel project;
- Determine whether the RSPB are in willing to receive more material at Wallesea;
- The relevant planning permission is in place and any concerns of the local planning authority; and
- Consult with Natural England and other statutory organisations if Wallasea is a viable disposal site.

If Wallasea Island is not appropriate other sites should be identified an early consultation undertaken to ensure a relevant site is identified.

There will be spoil storage on site with a lime dosing plant due to the nature of the spoil to be removed and the need for it to behave as a solid when transported by ship, this may require permitting due to the change in nature of the waste material.

There are a number of possible options for treatment/disposal of hazardous, contaminated materials. These would require significant further research, however the options include removal to a hazardous waste landfill site, but the cost of disposal would be significant especially if the quantities forecasted are close to the actual quantity arising. Estimated quantities are in the region of 53,000m^3. Cost of disposal to landfill for hazardous materials is dependent on the hazardous nature of the material itself. Ranges from £30-£60/tonne for the gate fee plus £72/tonne for the landfill tax have been identified through web-based research, whereas sending it for treatment would cost between £30-£70/tonne. It should be noted that higher costs may be charged.

On-site remediation (e.g. bioremediation, chemical oxidation, soil washing, stabilisation etc. would be cheaper but would require permitting and the range of treatment methods vary depending on the type of contamination present. A list of UK soil treatment sites can be found in Table 2-5.

From the muck bin area, spoil will be transported by wheeled loader to a hopper feeding a conveyor and transported to the ship by conveyor. The muck bin will be a partially enclosed area, to protect from the elements. It will have the capacity to store seven day's excavation at a peak advance rate of 120m per week.

The spoil from diaphragm walls and piles at Silvertown after separation should be capable of being disposed of by river as should the spoil from the cut and cover box and ramp.

The past history of the Greenwich site means that all spoil is likely to need to be classified prior to removal from site and this also indicates that the best solution is likely to be road haulage.

The Silvertown site layout is determined by the need to store and then dispose of spoil and to receive, store and handle segments.

The grout mixing plant is at Silvertown for the first and second drives with a pump and re-mixer at Greenwich to receive grout from Silvertown and then supply the second drive from Greenwich.

Both sites require spoil separation plant for the diaphragm wall and appropriate office and welfare facilities. Cross passage ground treatment will be carried out from within the tunnels.

The spoil storage area is capable of taking a week of full rate TBM production to give a reserve and to ensure that external spoil management factors do not delay the TBM drive. At the peak output rates the TBM is producing 20,000 m^3 per week (after allowing bulking factor of 1.7). The storage area has a capacity of approximately 20,000m^3 with an average height of 4.5m. The area allocated for spoil storage could be increased if necessary without major re-planning of the site layout. Spoil is assumed to be removed by barge from Thames Wharf although with very minor re-planning it could be made to work with road transport.

Separation plant for the diaphragm walls is required as is the need to maintain road traffic routes and a possible spoil classification area. The remaining office, welfare and storage facilities can be arranged in a variety of ways on the available site.

1.9 Materials resource efficiency

Waste Minimisation statement	The purpose of the Site Waste Management Plan is to facilitate the principles of the waste hierarchy and to minimise the production of waste from the outset of the project. Such measures are to be incorporated into the design and implemented in the construction stages of the project. This is in addition to ensuring correct waste disposal procedures in accordance with the Waste Duty of Care provisions. This will be achieved by ensuring that wherever possible existing materials excavated for the development of Redbridge Lane are reused. Where waste cannot be re-used or recycled, it shall be disposed of in accordance with the Landfill Directive (1999/31/EC) and Waste Acceptance Criteria procedures.

Table 1-3 and Table 1-4 highlight the various objectives for minimising waste during the site works. It demonstrates the components and decisions involved in ensuring a reduction in the amount of waste and surplus materials being produced during any works on site. This has the effect of minimising the amount of material which, would traditionally be sent to landfill and to ensure a cradle to cradle approach.

Table 1-3: General Material resource efficiency measures to be considered for the proposed Silvertown Tunnel Crossing

Planning waste minimisation during construction	Waste minimisation decisions taken	Resource saving	Responsibility	Start date
Design	Enabling the purchase of materials in shape/dimension and form that minimises the creation of off-cuts/waste. Consideration should be given to the use of pre-fabricated units where possible. Specifying materials and producing the resulting Bills of Quantities that allow wastage to be minimised. Due to potential contamination, chemical testing would need to be undertaken to determine composition of the material and subsequent opportunities for re-use or remediation.	Minimal waste will be produced.	Project Manager	From the design outset
Construction methods	Sequencing the works such that re-use of materials can be undertaken.	Minimal waste produced.	Project Manager	During design and planning stages and implemented during the construction.
Materials	Assess the quantities of materials required on site. Just in time delivery (as needed basis) to prevent over supply Secure storage to minimise the generation of damaged materials/ theft. Keeping deliveries packaged until they are ready to be used. Inspection of deliveries on arrival Increase the use of recycled content; this could include traditional use of recovered material such as crushed concrete demolition waste and by procuring mainstream manufactured products with higher recycled content than their peers. Quick win areas of the project in which to implement this for could be concrete frames, flooring and brick/block work.	Prevents lost time in re-ordering of damaged equipment, reduces need for storage if over ordering takes place. An increase in the demand for such products would reduce the quantity of waste going to landfill. Recycled material use results in a reduction in demand for extraction of virgin materials and subsequently the carbon and environmental footprint.	Project Manager	During construction planning and throughout the project construction. During design and throughout the procurement/ construction stages of the project

Table 1-4: Summary of proposed and recommended minimisation measures

Summary of proposed and recommended minimisation measures		
Excavation	Proposed	Excavation is likely to be for highways, tunnels and portals and foundations. It is anticipated that any waste produced through the construction of the tunnels will be cut and fill and be reused elsewhere on site. Surplus excavated materials including soils, gravels and man-made fill can potentially generate the largest quantities of all the waste streams with significant implications on disposal costs if it cannot be reused on site. Excavated material suitable for reuse, where appropriate, will be stored for reuse as landscaping material or infilling.
Minimisation of vegetation clearance at the design phase	Recommended	As the site is potentially grass with some shrubs, clearance of vegetation has the potential to be insignificant due to the nature of the area as former industrial/gasworks. Identify, during the design phase, ways to minimise the loss of vegetation on site. Where minimisation is not possible, composting or mulching the vegetation should be considered for reuse in landscaping within the scheme.
Minimisation of contaminated land arisings	Recommended	Where possible contaminated land should be remediated and reused on site, or, if found to pose no risk to receptors (e.g. groundwater and human health) should be left undisturbed. The latter can minimise potential transport and disposal costs. This approach should be standard practice among designers and contractors.
Contractor targets	Recommended	The Principal Contractor should consider setting off-cut/surplus targets for sub-contractors with a positive incentive scheme for on-site waste champions. Good practice suggests that 3% wastage rate based on the total amount of construction material handles on site is achievable.
Avoiding over-purchasing and accurate delivery times	Recommended	Over-purchasing can lead to significant wastage and should be avoided in the first place. Ensuring materials are ordered for delivery shortly before they are used on the project would also avoid possible damage and therefore wastage.
Use of take back schemes	Recommended	Some suppliers offer a take back scheme, which should be utilised where practicable, particularly for packaging and pallets.
Monitoring and review	Recommended	The Principal Contractor should use the waste data provided from the waste removed from the project and the periodic review process (required as part of the SWMP) to their advantage to assess whether the waste objectives are being met, and if not to review procedures to steer the project towards achieving them. This will require clear responsibilities to be identified, supported with authority and incentives to act on any deviations form the SWMP.
Education and awareness	Recommended	Waste minimisation must be underpinned by education and awareness throughout all levels of the project team, from the design team to site contractors who handle the construction materials via site inductions and monthly toolbox talks which all contractors and site workers will be expected to attend.

Consideration of End of Life materials	Recommended	Consideration should be given to what will happen to the materials specified when they reach the end of their useful life. Where possible, elements should be designed for repair, modular repair, recycling at the end of life or safe disposal. The use of hazardous materials, in particular, should be minimised.

1.10 Preliminary audit of expected waste arisings

The preliminary waste audit will be carried out at a later stage once a Construction Methods report has been produced. A Bill of Quantities will be produced at a later stage, which will enable a more accurate estimation of the anticipated quantities of waste arising during the project.

The waste audit will be updated and amended in more detail as the project progresses.

1.11 Waste management

1.11.1 Segregation

It is essential that the construction and demolition work is carried out closely with the waste management contractors, in order to determine the best techniques for managing waste and ensure a high level of recovery of materials for recycling.

A specific area shall be laid out and labelled to facilitate the separation of materials, where possible, for potential recycling, salvage, reuse and return. Recycling and waste bins are to be kept clean and clearly marked in order to avoid contamination of materials. Skips for segregation of waste identified currently are:

- Mixed inert (e.g. inert plastics, concrete and rubble)
- Hazardous (e.g. asbestos, Poly Chlorinated Bi-phenols)
- Mixed non-hazardous (biodegradable waste, welfare waste, general waste)
- Metal (e.g. copper and iron)
- Wood (e.g. fencing/hoarding)
- Food (canteen waste)
- Paper and cardboard (office waste)
- WEEE: Waste Electronic and Electrical Equipment (e.g. cables, disused electrical appliances and equipment)

Successful recycling relies upon early planning, clear responsibility and space within a compound for segregation and storage. Shelter may be needed to prevent some materials such as cardboard and paper from deteriorating while being sorted or awaiting collection.

Discussions will be required between the Client and the Principal Contractor to identify space requirements within the compound to accommodate skips and storage of reusable materials.

For all waste management options on the site compound, consideration will need to be given for identifying whether waste exemptions or permits are required to enable the storage and treatment of waste materials.

Waste management options will be supported by the identification of appropriately permitted waste management and recycling facilities in close proximity to the site compound.

Colour-coded skips

Use different coloured skips (or sufficiently clear labelling) to ensure that construction workers are clear about where to put each type of waste. This reduces the levels of contamination in the skips and increases the likelihood that a load will not subsequently be rejected once the waste stream has been sent off-site for reprocessing. In cases where the load is rejected, the likely destination would be landfill (which would increase the costs of the project).

1.11.2 Contaminated land

The cost of hazardous waste treatment and disposal is significantly higher than treatment or disposal of non-hazardous or inert waste. Through identifying areas of contamination early on, the project layout and construction methods to be adopted could be amended to minimise the handling of such materials, potentially reducing the project costs. A contaminated land site investigation needs to be carried out to identify any areas that could potentially comprise of contaminated soils and gravels. Any soils removed from site during the development will be subject to a WAC (Waste Acceptance Criteria) testing to determine whether excavated soils can be returned as fill material.

1.11.3 Re-use of construction materials

Uncontaminated material will be reused where possible within the proposed improvement works for site levelling and fill. It is likely that there will be a requirement for importation of additional bulk fill materials for the project.

Any contaminated materials, which will not be re-used on-site, will be treated in accordance with all relevant legislation and best practice guidelines at the point of origin or at an alternative suitable site prior to disposal.

If applicable, surplus inert excavated materials with some engineering strength (e.g. stone, bricks, clay, rubble, rock) can be suitable for re-use in land reclamation projects, if one were proceeding at the same time as the proposed scheme. This would require compliance with the criteria and thresholds for an exemption (U1 or U11 may be applicable) or it may require a permit under the Environmental Permitting Regulations 2010 as amended. The CL:AIRE CoP may also be applicable for the reuse of this material. The material could be re-used in other schemes in the surrounding area, if one were proceeding at the same time, to avoid disposal at landfill and its associated impacts and costs, but would need to meet current legislative requirements.

1.11.4 Waste disposal characterisation

Under the Landfill (England and Wales) Regulations 2002 (as amended), waste is classified as Inert, Non-Hazardous and Hazardous.

Hazardous Waste cannot be re-used on site and may require additional treatment prior to disposal. There is a statutory requirement under the Landfill Directive (1999/31/EC as amended) to pre-treat any waste (including hazardous waste) prior to disposal off-site. Pre-treatment may reduce the cost of disposal by rendering the waste non-hazardous. Responsibility for the basic classification of waste rests with the Producer and Landfill Operator.

2. Waste Management

2.1 Forecasting and planning the reduction, reuse and recycling of waste

This section details expected waste arisings from the Silvertown Tunnel Scheme. Table 2-1 and Table 2-2 details that waste expected to arise from both the enabling/demolition and construction works (respectively) and segregates the approximate amounts of waste into different waste streams. The overall aim is to prevent cross-contamination of waste types and to maximise reuse and recycling opportunities.

Material quantities are an approximate guide for efficient waste management best practice; the contractor should independently verify the quantities of waste materials likely to be produced during the works. Waste quantities specified within the SWMP are also subject to programme and design change.

This section should be completed once quantities of waste materials across the whole project along with a greater understanding of the foundation depths have been quantified.

Estimated quantities include

- Bored tunnels – volumes 250,378m^3
- Launch chamber – excavation within secant walls - 27,00m^3. Extra over for contaminated spoil assumed 50% - 13,500m^3
- Tunnel infill – assumed that tunnel infill base section of tunnel with suitable material - 58,168m^3 (30% CSA).
- Cut and cover – Silvertown D-wall material – 3,393m^3. Excavation between diaphragm walls 73,500m^3
- Cut and cover – Greenwich, quantities taken as a proportion of Silvertown – 190/140
- Open cut – D-wall material 3,733m^3. Excavation between diaphragm walls 84,000m^3
- Cross passages – 17,928m^3
- Northern Junction – assumed contaminated materials for off-site disposal 33,077m^3
- Northern Junction – assumed unacceptable material for disposal off-site 12,139m^3
- Southern Junction – assumed contaminated materials for off-site disposal 32,915m^3
- Southern Junction – assumed unacceptable material for disposal off-site 39,171m^3

Table 2-1 and Table 2-2 comprise estimates of quantities based on present information, however, there are a few points to note:

- The quantities are solid volumes. For bulked volumes multiply by 1.6 to 1.8
- Everything has been placed under “Disposal” as the designers have not been able to identify whether any of the material is suitable for “Off-site re-use/ recycling” or “Recovery”. However, it is assumed the “natural” material will go to somewhere like Wallasey Island.
- The split for “contaminated” materials is on a percentage basis (as used in the previous cost estimate);
- Silvertown - Launch Chamber Secant Piles and excavation - 50% contaminated
- Greenwich - Reception Chamber D-walls & excavation - 85% contaminated
- Greenwich - Cut & Cover D-walls & excavation – 15% contaminated

In addition, there was found to be a shortage of chemical analysis data in the immediate vicinity of the proposed highway (north and south) so an assumption has been made that all made ground is contaminated and that the rest is to be treated as unacceptable material (although it is assumed that there is sufficient suitable material for the small volumes of required fill). The boreholes have enabled calculations for an average depth of made ground (2.2m for the southern junction and 2.7m for the northern) - the volumes shown for the Northern and Southern Junctions are based on these assumptions and include for an 800mm carriageway box construction.

Table 2-1: Estimated quantities of enabling/demolition waste

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
Inert	Unacceptable excavated material	TBC	TBC	TBC	TBC	TBC	TBC	51,310
	Concrete	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Rubble	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Tunnel	250,378	TBC	TBC	TBC	TBC	TBC	250,378
	Soils (e.g. topsoil/ natural) - Cross Passages (10No.)	3,586	TBC	TBC	TBC	TBC	TBC	3,586
	Soils (e.g. topsoil/ natural) - Silvertown - Launch Chamber Secant Piles	2,837	TBC	TBC	TBC	TBC	TBC	2,837
	Soils (e.g. topsoil/ natural) - Silvertown - Launch Chamber Excavation	13,500	TBC	TBC	TBC	TBC	TBC	13,500
	Soils (e.g. topsoil/ natural) - Silvertown - Cut & Cover D-walls	10,080	TBC	TBC	TBC	TBC	TBC	10,080
	Soils (e.g. topsoil/ natural) - Silvertown - Tension / Vent Stack Piles	3,393	TBC	TBC	TBC	TBC	TBC	3,393
	Soils (e.g. topsoil/ natural) - Silvertown - Cut & Cover Excavation	73,500	TBC	TBC	TBC	TBC	TBC	73,500
	Soils (e.g. topsoil/ natural) - Silvertown - Victoria Dock Drainage Diversion	2,700	TBC	TBC	TBC	TBC	TBC	2,700
	Soils (e.g. topsoil/ natural) - Silvertown - Open Cut D-walls (TBC by Atkins)	3,733	TBC	TBC	TBC	TBC	TBC	3,733
	Soils (e.g. topsoil/ natural) - Silvertown - Open Excavation (TBC by Atkins)	84,000	TBC	TBC	TBC	TBC	TBC	84,000
	Soils (e.g. topsoil/ natural) - Greenwich - Reception Chamber D-walls	403	TBC	TBC	TBC	TBC	TBC	403
	Soils (e.g. topsoil/ natural) - Greenwich - Reception Chamber Excavation	1,500	TBC	TBC	TBC	TBC	TBC	1,500
	Soils (e.g. topsoil/ natural) - Greenwich - Cut & Cover D-walls	11,628	TBC	TBC	TBC	TBC	TBC	11,628
	Soils (e.g. topsoil/ natural) - Greenwich - Tension / Vent Stack Piles	4,605	TBC	TBC	TBC	TBC	TBC	4,605
	Soils (e.g. topsoil/ natural) - Greenwich - Cut & Cover Excavation	84,788	TBC	TBC	TBC	TBC	TBC	84,788

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
	Soils (e.g. topsoil/ natural) - Greenwich - Open Cut D-walls (TBC by Atkins)	5,066	TBC	TBC	TBC	TBC	TBC	5,066
	Soils (e.g. topsoil/ natural) - Greenwich - Open Cut Excavation (TBC by Atkins)	114,000	TBC	TBC	TBC	TBC	TBC	114,000
Non-hazardous	Soils (moderate contamination- suitable for reuse onsite)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Bricks and Blocks	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Screed	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Green waste/ vegetation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Mixed waste	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Metal	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Timber	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Plasterboard	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Packaging	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Cable & wiring	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Glass	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Other	TBC	TBC	TBC	TBC	TBC	TBC	TBC
Hazardous	Contaminated soil – unsuitable for reuse - Silvertown - Launch Chamber Secant Piles	2,837	TBC	TBC	TBC	TBC	TBC	2,837
	Contaminated soil – unsuitable for reuse - Silvertown - Launch Chamber Excavation	13,500	TBC	TBC	TBC	TBC	TBC	13,500
	Contaminated soil – unsuitable for reuse - Greenwich - Reception Chamber D-walls	2,285	TBC	TBC	TBC	TBC	TBC	2,285
	Contaminated soil – unsuitable for reuse - Greenwich - Reception Chamber Excavation	8,500	TBC	TBC	TBC	TBC	TBC	8,500
	Contaminated soil – unsuitable for reuse - Greenwich - Cut & Cover D-walls	2,052	TBC	TBC	TBC	TBC	TBC	2,052
	Contaminated soil – unsuitable for reuse - Greenwich - Cut & Cover Excavation	14,963	TBC	TBC	TBC	TBC	TBC	14,963
	Contaminated soil – unsuitable for reuse – Northern Junction	33,077	TBC	TBC	TBC	TBC	TBC	33,077

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
	Contaminated soil – unsuitable for reuse – Southern Junction	32,915	TBC	TBC	TBC	TBC	TBC	32,915
	Toxic chemicals e.g. paint tins, line markers, mastic	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Other	TBC	TBC	TBC	TBC	TBC	TBC	TBC
TOTAL	TOTAL	713,832	0	0	0	0	0	831,134

Table 2-2: Estimated quantities of construction waste

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
Inert	Unacceptable excavated material	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Concrete	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Rubble	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Tunnel	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Cross Passages (10No.)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Launch Chamber Secant Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Launch Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Tension / Vent Stack Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Victoria Dock Drainage Diversion	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Open Cut D-walls (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Open Excavation (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Reception Chamber D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Reception Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Tension / Vent Stack Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Open Cut D-walls (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
Non-hazardous	Soils (e.g. topsoil/ natural) - Greenwich - Open Cut Excavation (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (moderate contamination- suitable for reuse onsite)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Bricks and Blocks	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Screed	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Green waste/ vegetation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Mixed waste	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Metal	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Timber	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Plasterboard	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Packaging	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Cable & wiring	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Glass	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Other	TBC	TBC	TBC	TBC	TBC	TBC	TBC
Hazardous	Contaminated soil – unsuitable for reuse - Silvertown - Launch Chamber Secant Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Silvertown - Launch Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Reception Chamber D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Reception Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Toxic chemicals e.g. paint tins, line markers, mastic	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Other	TBC	TBC	TBC	TBC	TBC	TBC	TBC
TOTAL	TOTAL	0	0	0	0	0	0	0

2.2 Disposal and treatment options

Table 2-3 highlights a number of treatment and recycling facilities within a reasonable proximity of the Silvertown Tunnel Crossing site. However, this is a guide and the appointed waste contractor for the site should contact the Environment Agency directly to determine the most appropriate waste transfer station to handle the waste material being produced. The transfer station will then send it off for final disposal at an appropriate landfill site.

The Landfill (England and Wales) Regulations 2002 require that disposal sites are classified into one of three categories dependent on the chemical composition of the material; these are hazardous, non-hazardous and inert. Prior to disposal, if material is deemed hazardous it must be pre-treated to meet the Waste Acceptance Criteria (WAC).

Table 2-3: Waste treatment sites

Site name	Site address	Material Handled		Distance from Site[1] (miles)
Brewsters Waste Management Ltd	Thames Wharf, Dock Road, Silvertown, London, E16 1AF Tel: 020 7474 3535 Email: barry@brewsterswaste.co.uk	Clay Hardcore Inert waste Metal Ferrous Cardboard Fluorescent tubes Food General office paper Glass Pallets Plastic	Rubble Subsoil Topsoil Wood Mixed plastics Paper Printers and fax cartridges Drums / containers Plastic film Tyres	0
Bywaters (Leyton) Limited	Gateway Road, Leyton, London, E10 5BY Tel: 02070016000 Email: a.kirk@bywaters.co.uk	Clay Hardcore Inert waste Metal Plasterboard Ferrous Cardboard Fluorescent tubes Food General office paper Mixed plastics Paper Printers and fax cartridges	Rubble Subsoil Topsoil Wood Asbestos sheet Cardboard Glass Pallets Plastic Plastic film Machinery / parts Tyres Drums / containers	5

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[1] The distance has been calculated from E16 1DF

Site name	Site address	Material Handled		Distance from Site1 (miles)
I.O.D Skip Hire Ltd	I.O.D House, Oasis Park, 32 Stephenson Street, Canning Town, London, E16 4ST Tel: 020 7515 4058 Email: claude@iodskips.co.uk	Clay Hardcore Inert waste Metal	Rubble Subsoil Topsoil Wood	1
McNicholas Plc	709, Old Kent Road London, SE15 1JZ Tel: 0207 7323664	Clay Hardcore Inert waste Metal	Rubble Subsoil Topsoil Wood	3
HTL Waste Management	Deptford Recycling Centre Landmann Way, Deptford, London, SE14 5RS Tel: 02086913074 Email: info@hinkcroft.co.uk	Clay Hardcore Inert waste Metal	Rubble Subsoil Topsoil Wood	3
McGrath Bros (Waste Control) Ltd	David McGrath, McGrath House, Hepscott Road, Hackney, London, E9 5HH Tel: 0208 985 8222 Email: info@mcgrathgroup.co.uk	Clay Hardcore Inert waste Metal Cardboard Glass Pallets Plastic	Rubble Subsoil Topsoil Wood Plastic film Machinery / parts Tyres	3
Docklands Waste Recycling Ltd	Thames Wharf, Dock Road, Silvertown, London, E16 1AF Tel: 020 8503 1505 Email: docklandswaste@btconnect.com	Clay Hardcore Inert waste Rubble	Subsoil Topsoil Wood	0
McGrath Bros (Waste Control) Ltd	54-58, River Road Barking, Essex, IG11 0DW Tel: 020 8507 8880	Clay Hardcore Inert waste Metal Plastic film Machinery / parts Tyres	Rubble Subsoil Topsoil Wood Cardboard Glass Pallets Plastic	4
City of Westminster	Westminster City Hall, Victoria Street, Vincent Square, London, SW1E 6QP Tel: 02076416180 Email: commercialwaste@westminster.gov.uk	Other hazardous wastes not included elsewhere	Contact operator to see if this includes soils	7

Site name	Site address	Material Handled		Distance from Site[1] (miles)
Silver Lining Industries Ltd	Unit 4, Stour Road, Bow, London, E3 2NT Tel: 0800 091 0000 Email: admin@wastecare.co.uk	Cardboard Glass Pallets Plastic Plastic film Fuel oil Lubricating oil Machinery / parts Tyres Ferrous Printers and fax cartridges	Cardboard Fluorescent tubes Food General office paper Mixed plastics Paper Other hazardous wastes not included elsewhere Drums / containers	3

Source: the Waste Directory: http://www.wastedirectory.org.uk/

NB. The ability for materials to be deposited at these sites will be dependent on the availability of void space and the conditions imposed on the sites through the relevant licence/permit. This list is not exhaustive and there may be other facilities in the vicinity of the site that can be used.

For excavated materials that are confirmed to be non-hazardous, in accordance with the WAC testing and Soil Guideline Values (SGVs), there are a number of reuse and recycling opportunities.

The excavated materials can be used as infill, bunding and landscaping on the site. Further uses could be for construction or maintenance of pavements, footings for fencing etc. Material produced could also be used in the laying of roads around the site or stored for later use, providing there are adequate storage areas and the material is adequately managed to minimise dust and run off.

If reuse or recycling on site is not possible, Table 2-4 highlights a number of possible waste disposal facilities within a reasonable proximity to the site and that also run a waste collection service.

Table 2-4: Waste disposal sites

Site name	Site address	Landfill class	Distance from Site [2](miles)
Tripcock Point Landfill Site	Facility No. 3, Tripcock Point, Off Central Way, Thamesmead, London, , SE28	A06 Landfill taking other wastes permitted to accept construction and demolition waste including canal dredgings etc.	5
Aveley Clay Pit	Aveley Landfill, Sandy Lane, Aveley, South Ockendon, Essex, RM15 4XP	A04 Dredging sites Facility permitted to accept dredgings.	13
Ayletts Farm Quarry	Warwick Lane, Rainham, Essex RM13 9XW	A04 Dredging sites Facility permitted to accept dredgings.	12
Beddington Farmlands Landfill	Beddington Lane, Croydon, Surrey CR0 4TD	A04 Dredging sites Facility permitted to accept dredgings.	15

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[2] The distance has been calculated from E16 1DF

Site name	Site address	Landfill class	Distance from Site 2(miles)
Bournewood Inert Landfill	Off A20 By-pass, Swanley, Kent, BR8 7DP	L05 – Landfill Directive Compliant Inert Landfill Facilities permitted to accept inert waste for landfill which are Landfill Directive compliant.	14
Rainham Landfill	Rainham Landfill, Wennington Marshes, Ferry Lane, Rainham, Essex, RM13 9DA	A04 Dredging sites Facility permitted to accept dredgings	11
The East Tilbury Quarry	Princess Margaret Road, East Tilbury, Essex RM18 8PH	A06 Landfill taking other wastes permitted to accept construction and demolition waste including canal dredgings etc.	24
Medebridge Road, Landfill	Area 1, Medebrdige Road, South Ockendon, Grays, Essex, RM16 5TZ	A01 Co-disposal landfill site Former landfill facility permitted to receive ranges of commercial, household and/or industrial waste which required special precautions in their handling including that which was classed as Hazardous under the Hazardous Waste Regulations (Excluding bonded asbestos) together with municipal waste which is capable of decomposition, or similar degradable wastes.	17

Source: The Environment Agency – 'What's in your backyard'

NB. The ability for materials to be deposited at these sites will be dependent on the conditions imposed on the sites through the relevant licence/permit. This list is not exhaustive and there may be other facilities in the vicinity of the site that can be used.

The facilities listed in Table 2-3 and Table 2-4 are not exhaustive and highlight a small selection of sites within reasonable distance from the point of production. It is assumed the "natural" material will go to somewhere like Wallasea Island, if possible.

Table 2-5: UK Soil Treatment Centres

Site name	Site address	Treatment method/ waste accepted
Terramundo, Port Clarence, Teeside http://www.augeanplc.com/soil-testing-treatment/default.aspx	Port Clarence Site Off Huntsman Drive Port Clarence Middlesbrough Cleveland TS2 1UE T: 01642 546836 E: landresources@augeanplc.com W: www.augeanplc.com/soil-testing-treatment/default.aspx	The soil treatment centres can tackle a broad range of contaminants. Bioremediation gives a potential 100% recovery of soils, while soil washing gives 80% recovery of sand and gravel. Soil treatment is made available for sites where on-site treatment is not a viable option, thereby promoting the clean up of contaminated land. Soil treatment can also be used as a pre-treatment to reduce contamination to acceptable levels before landfilling. Technologies used include: Soil Washing Cement Stabilisation Bioremediation
Terramundo, Kingscliffe, Northamptonshire http://www.augeanplc.com/soil-testing-treatment/default.aspx	East Northants Resource Management Facility Stamford Road Kings Cliffe PE8 6XX T: 01780 444900 E: landresources@augeanplc.com W: www.augeanplc.com/soil-testing-treatment/default.aspx	The soil treatment centres can tackle a broad range of contaminants. Bioremediation gives a potential 100% recovery of soils, while soil washing gives 80% recovery of sand and gravel. Soil treatment is made available for sites where on-site treatment is not a viable option, thereby promoting the clean up of contaminated land. Soil treatment can also be used as a pre-treatment to reduce contamination to acceptable levels before landfilling. Technologies used include: Soil Washing Cement Stabilisation Bioremediation

Site name	Site address	Treatment method/ waste accepted
Biogenie, Redhill	Redhill Soil Treatment Facility Patteson Court Landfill, Cormongers Lane, Nutfield, Redhill, Surrey RH1 4ER Tony Huke – mobile: 07969 690651 E: thuke@biogenie.co.uk W: www.biogenie.co.uk/profile	01 - Wastes resulting from exploration, mining, quarrying and physical and chemical treatment of minerals; 05 - Wastes from petroleum refineries, natural gas purification and pyrolytic treatment of coal; 13 - Oil wastes and wastes of liquid fuels (except edible oils, and those in chapters 05, 12 and 19); 16 - Waste not otherwise specified in the list; 17 - Construction and demolition wastes (including excavated soil from contaminated sites); 19 - Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intendedfor human consumption and water for industrial use; 20 - Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions.
BIFFA-Biogenie, Risley, Warrington	Risley Soil Treatment Facility Moss Side Farm, Silver Lane, Risley, Warrington Cheshire WA3 6BY Chris Woods – mobile: 07985 836219 E: cwoods@biogenie.co.uk W: www.biogenie.co.uk/profile/	01 - Wastes resulting from exploration, mining, quarrying and physical and chemical treatment of minerals; 17 - Construction and demolition wastes (including excavated soil from contaminated sites); 19 - Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use.
BIFFA-Biogenie, Meece, Staffs	Meece Soil Treatment Facility Meece Landfill Site Swynnerton, Coldmeece, Stone, Staffs ST15 0QN Jon Owens – mobile: 07764 788677 E: jowens@biogenie.co.uk W: www.biogenie.co.uk/profile/	01 - Wastes resulting from exploration, mining, quarrying and physical and chemical treatment of minerals; 05 - Wastes from petroleum refineries, natural gas purification and pyrolytic treatment of coal; 13 - Oil wastes and wastes of liquid fuels (except edible oils, and those in chapters 05, 12 and 19); 16 - Waste not otherwise specified in the list; 17 - Construction and demolition wastes (including excavated soil from contaminated sites); 19 - Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use; 20 - Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions.

Site name	Site address	Treatment method/ waste accepted
UK Remediation, Exeter, Devon	Unit 11a, Hill Barton Business Park, Sidmouth Road, Clyst St. Mary, Devon, EX5 1DR T: 01392 928028 W: www.ukremediation.com/	Our hazardous waste management license enables us to treat a range of contaminants including: Hydrocarbons – Petroleum, Kerosene, Diesel, Mineral Oil etc. Heavy metals – Lead, copper, zinc, chromium, cadmium, Arsenic etc Chlorinated solvents – PCE, DCE, TCE, Vinyl Chlorides etc Poly Aromatic Hydrocarbons (PAH's) – gasworks material Common Brownfield Contaminants Hydrocarbon Contamination Chlorinated Solvents Contamination Heavy Metal Contamination Persistant Organic Pollutants Asbestos Contamination Invasive Plants Remediation Solutions Soil vapor extraction. Solidification and Stabilization. Excavation or dredging. Permeable Reactive / Barrier Walls & Capping. Soil Segregation, Recycling and Recovery Soil Washing Ex-situ Bioremediation Steam Enhanced Remediation Aerobic In-situ Bioremediation Soil Stabilisation In-situ Chemical Reduction Ex-Situ Thermal Desorption
Connells/ER Oldham, Manchester, Waste Transfer Station	Environmental Recovery Ltd Londsdale House Blucher Street Birmingham, B1 1QU T: +44 (0)121 616 5020 E:info@environmentalrecovery.co.uk W: www.environmentalrecovery.co.uk/Service_soil_hospital.html	Contaminated soil remediation Dredge, sludge and lagoon processing Weak soil stabilisation
Cory Churngold Dudley	Churngold Group Limited St Andrews House St Andrews Road Avonmouth Bristol BS11 9DQ T 0117 900 7100 W : www.churngold-recycling.co.uk/?environmental-soil-solutions	Contaminations treated: Asbestos Contamination Chlorinated Solvents Heavy Metal Contamination Hydrocarbon Contamination Invasive Plants Persistent Organic Pollutants Remediation Techniques Physical Techniques Biological Techniques Chemical Techniques Thermal Techniques
Cory Churngold St Helens	Churngold Group Limited St Andrews House St Andrews Road Avonmouth Bristol BS11 9DQ T 0117 900 7100 W : www.churngold-recycling.co.uk/?environmental-soil-solutions	Contaminations treated: Asbestos Contamination Chlorinated Solvents Heavy Metal Contamination Hydrocarbon Contamination Invasive Plants Persistent Organic Pollutants Remediation Techniques Physical Techniques Biological Techniques Chemical Techniques Thermal Techniques

Site name	Site address	Treatment method/ waste accepted
Rem20	Elizabeth House, Duke Street, Woking, Surrey, GU21 5AS T: +44 (0)1483 346048 F: +44 (0)1604 842666 E: woking@rem20.co.uk W : www.rem20.co.uk/	The treatment technologies use one or a combination of the following methods: Physical – Wet & dry methods using differences in grain size and density of the materials to separate the different fractions. Biological – The aerobic biodegradation of contaminants by naturally occurring micro-organisms into harmless carbon dioxide and water. Chemical – Transformation by chemical treatment, destroying the contaminants or reducing their toxicity. Can accept a wide range of contaminants and offer a flexible service to suit each batch of materials which will be assessed prior to acceptance.

2.3 Waste controls and handling

2.3.1 Duty of care compliance

One aim of the SWMP Regulations is to reduce the levels of fly-tipping generated from construction projects. One requirement is to incorporate an auditable system that identifies:

- The person responsible for removing the waste from site; and
- Keeping copies of all duty of care documentation (waste transfer notes and hazardous waste consignment notes).

Table 3-1 assists with the information required to meet the duty of care requirements.

All reputable waste contractors will have systems in place to ensure that all the duty of care requirements are met prior to the waste being collected.

Various information sources are available to enable the Principal Contractor to identify local waste management facilities for both recycling, recovery and disposal.

2.3.2 Declaration

The client and principal contractor will take all reasonable steps to ensure that:

all waste from the site is dealt with in accordance with the waste duty of care in section 34 of the Environmental Protection Act 1990 and the Environmental Protection (Duty of Care) regulations 1991; and

materials will be handled efficiently and waste managed appropriately.

Signatures	Client	Principal Contractor
Date		

2.3.3 Responsibility for waste management

Table 2-6: Waste management responsibility

Site Activity/ Sub-contractor Work Package	Primary Waste Stream	Who is responsible for waste management
Demolition and site clearance	TBC	TBC
Groundworks	TBC	TBC
Foundations, Piling	TBC	TBC
Structure	TBC	TBC

Site Activity/ Sub-contractor Work Package	Primary Waste Stream	Who is responsible for waste management
Brick & Blockwork	TBC	TBC
Mechanical Electrical	TBC	TBC
Trades - (Joinery, Painting, Plastering, Rendering, Plumbing, Heating etc)	TBC	TBC
Removal of Site Offices, Temporary Works & Final Clear Away	TBC	TBC

2.3.4 Site security

Both client and principal contractor will take reasonable steps to ensure site security measures are in place to prevent illegal disposal of waste at the site.

3. Implementation of the SWMP

3.1 Register of waste carrier licences and permits

Table 3-1 gives information on the waste management contractors, their waste management licences, waste carrier licenses and exempt site licences that have been checked and verified for use on this project.

The Landfill Regulations (2002) also require that waste is described by European Waste Catalogue (EWC) codes on Transfer Notes required under the Duty of Care Regulations. The EWC categorises wastes into 20 main groups and approximately 900 codes. The EWC also identifies hazardous wastes, and these are dealt with by the Hazardous Waste Regulations.

Table 3-1: Register of waste licences and permits

EWC Waste description*	EWC[3]	Origin	Waste carrier			Disposal site	
			Name	Licence number	Expiry date	Name	Licence number/ exemption ref.
Concrete	17 01 01	From excavation of made ground known to be uncontaminated	TBC	TBC	TBC	TBC	TBC
Bricks	17 01 02	From demolished buildings and pavements					
Mixtures of concrete, bricks, tiles and ceramics other than those in 17 01 06	17 01 07	From excavation of made ground known to be uncontaminated and separation of material is not possible					
Wood	17 02 01	From construction/ demolition of buildings					
Glass	17 02 02	From construction/ demolition of buildings					
Plastic	17 02 03	From construction/ demolition of buildings					
Bituminous mixtures containing coal tar	17 03 01* (M)	From excavation of Made Ground and potential historical contamination					
Bituminous mixtures other than those in 17 03 01*	17 03 02	From excavation of Made Ground known to be uncontaminated					
Metal	17 04 07	Removal of barriers from adjacent to secondary examination shelter					

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[3] (M) mirror entry – Hazardous only if dangerous substances are present above threshold concentrations

(A) Absolute entry – Hazardous waste regardless of any threshold concentrations

EWC Waste description*	EWC3	Origin	Waste carrier			Disposal site	
			Name	Licence number	Expiry date	Name	Licence number/ exemption ref.
Cables containing oil, coal tar and other dangerous substances	17 04 10* (M)	Removal of old cables and installation of new	TBC	TBC	TBC	TBC	TBC
Cables other than those in 17 04 10*	17 04 11	Removal of old cables and installation of new	TBC	TBC	TBC	TBC	TBC
Soils and stones	17 05 04	From excavation of Made Ground					
Soils and stones other than those in 17 05 03*	17 05 04	From excavation of Made Ground known to be uncontaminated					
Other construction and demolition waste (including mixed wastes) containing dangerous substances	17 09 03* (M)	From excavation of Made Ground known to be contaminated Removal of old cables					
Mixed construction & demolition waste	17 09 04	From excavation of Made Ground known to be uncontaminated					
Paper and cardboard	20 01 01	Packaging materials					
Plastics	20 01 39	Packaging materials e.g. pallet wrap					
Wood	20 01 38	Packaging materials e.g. pallets					
Biodegradable kitchen and canteen waste	20 01 08	From canteen and mess rooms					
Mixed municipal waste	20 03 01	General site waste	TBC	TBC	TBC	TBC	TBC
Septic tank sludge	20 03 04	Welfare facilities	TBC	TBC	TBC	TBC	TBC

3.2 Training and communication

Although not a specific requirement, it would be advantageous (and in accordance with the intentions to develop a culture of promoting best practice and increasing knowledge and awareness), to maximise the opportunities available to manage waste on the site in an appropriate (and compliant) manner. All site workers should receive some form of training to enable them to identify their roles and responsibilities and educate them on the issues surrounding the site waste management plan as well as the procedures to be followed whilst handling waste on the project. This could be in the form of inductions, workshops or “tool box talks”. “Tool box talks” should be carried out every month on waste issues and all subcontractors should be expected to attend. It is hoped that these values can be transferred from this site to the next, promoting adoption of sustainable waste management practices on a wider scale.

This decision will ultimately need to be made between discussions between the Client and Principal Contractor.

3.3 Monitoring

The contractors shall complete a weekly log of all materials that come on to site, and the principal contractor will receive a waste transfer note (or consignment note if the waste is hazardous) from the waste disposal company showing the exact amount of waste materials removed from site. This sheet also identifies how much material went to landfill and how much went for recycling.

All skips need to be monitored to ensure that cross-contamination of segregated skips does not occur. The “tool box” talks shall focus on how the waste management system is working and identify the extra costs associated with contamination.

The principal contractor shall continually review the type of surplus materials being produced and change the site set up to maximise on site reuse or recycling; landfill should be the last option.

This plan should be included as an agenda item at the weekly construction meetings. In addition, the plan will be communicated to the whole team (including the client) at the monthly meetings. This shall include any updates from the last version.

3.4 Waste records

Whenever waste is removed from the site, the principal contractor must record the actions in Table 3-2, which includes documenting the name of the company removing the waste and details of the site where the waste is being transferred to for each waste type.

Table 3-2: Waste management records

Date removed	Waste type	Identity of the person removing the waste	Site the waste is being taken to and whether licensed or exempt	Waste carrier and registration number*	Confirmation of delivery*	Waste management route (reuse on/offsite, recycled on/offsite, recovery, landfill, other
TBC	TBC	TBC	TBC	TBC	TBC	TBC

*evidence of waste carrier registration and waste transfer or hazardous waste consignment notes for each removal of waste are filed and cross-reference.

3.5 SWMP implementation checklist

Table 3-3 is a checklist, which is to be filled out by the principal contractor to ensure the SWMP is fully implemented from the outset of the project. Further actions required to accompany the checklist should be identified in Table 3-4.

Table 3-3: SWMP checklist

Checks (please tick)	Y	N
Have terms and commercial rates been agreed with the waste management contractor(s)?		
Have data reporting procedures been agreed with waste management contractor(s)?		
For offsite waste management or disposal- Are all the waste destination details correct?		
Has a waste segregation/ collection area been prepared?		
Has the waste management area been adequately sign posted?		
Has the SWMP planning meeting been set?		
Has the waste management document control/ filing system been set up?		
Have all necessary staff and contractors read and signed the SWMP?		
Have all the SWMP training/ briefing requirements for staff been met?		
Have all the SWMP training/ briefing requirements for contractor(s) been met?		
Have all the waste management targets been set?		
Has the SWMP been approved by the Project Manager?		

Table 3-4: Further actions required

Comments/ Further Actions:
1. Excavated material to be tested for contamination prior to reuse and/or disposal
2. Waste Contractor to be assigned
3. Storage areas for waste to be decided upon

3.6 Updating the SWMP

The plan must be updated as often as necessary, to accurate information on progress, or at least every six months if there is little change during the project. This will help to identify which waste streams are not achieving their anticipated recycling potential so that alternative methods to handle that waste stream can be explored for the remainder of the project.

Updates to the plan will give a current picture of how work is progressing against the waste estimates contained in the plan. Therefore, for waste that is re-used or recycled on site, the SWMP should be updated to describe how much of the estimated volume or tonnage has been processed. For waste that is removed from the site the SWMP must be updated to record the identity of the person removing the waste, the type (and quantity) of waste and the site to which it has been taken.

Whenever waste is removed from the site the principal contractor must record the actions in Table 3-2. Revisions of the SWMP are recorded in Table 3-5.

If significant changes are made during the course of the project, or the plan requires substantial revision, the Regulations allow for a further plan to be produced.

Table 3-5: SWMP revisions

Nature of revision	Date of revision	Author of revision
[waste records updated]	TBC	TBC

4. Review and Audit of SWMP

4.1 Post-construction review

This section of the SWMP is a post construction review and is designed to ensure the SWMP is monitored throughout the lifetime of the project and then signed off at its closure (see Table 4-1). The aim is to:

- highlight the benefits of completing a SWMP; and
- to identify the amounts of waste reduction and resource efficiency achieved.

This is achieved by adhering to the principles outlined at the beginning of the SWMP, in addition to realising the cost benefits associated with the SWMP if it has been carried out correctly.

At the end to the project, both the Client and Principal Contractor are responsible for reviewing, revising and refining the SWMP as necessary within three months of completion to ensure legal compliance and to identify if lessons could be learned for the next time a similar project is undertaken. This review must identify and conclude the following:

- Confirmation that the SWMP has been monitored and updated within the defined timescales;
- An explanation of any deviation from the original plan;
- A comparison of the estimated quantities of each waste type against the actual quantities generated;
- An action plan to address the lessons that have been learnt from the project that could be implemented for the next project; and
- An estimation of the cost savings (if any) that have been achieved through the measures undertaken to minimise, reuse, recycle or recover waste arisings rather than just sending it to landfill.

Table 4-1: Post construction review declaration

This plan has been monitored on a regular basis to ensure that work is progressing according to the plan and has been updated to record details of the actual waste management actions and waste transfers that have taken place.		
Signatures	Client	Principal Contractor
Date		

4.2 Audit of plan

A waste audit shall be undertaken at all stages of the project using the audit plan. This will identify the amount, nature and composition of the waste generated on site. The waste audit will examine the manner in which the waste is produced and will provide opportunity for a commentary to highlight how the management and practices inherently contribute to the production of construction and demolition waste. The measured waste quantities will be used to quantify the costs of waste management and disposal in the waste audit report, which will also record lessons learned from these experiences, which can be applied to future projects.

The audit plan should be updated as the project progresses, as this will help to identify which waste streams are not achieving their anticipated recycling potential so that alternative methods to handle that waste stream can be explored for the remainder of the project. It is a requirement of the regulations to review the SWMP as often as necessary to give a current picture of how work is progressing or at least every six months if there is little change during the project.

4.3 Audit plan- estimated versus actual waste quantities

Table 4-2 and Table 4-3 illustrate how the waste materials from the enabling/demolition and construction work on the Silvertown Tunnel Corssing project will actually be managed. Table 4-4 records the deviation between those waste quantities estimated and the actual. An estimate of cost savings is also made here.

Table 4-2: Actual enabling/demolition waste quantities

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
Inert	Unacceptable excavated material	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Concrete	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Rubble	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Tunnel	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Cross Passages (10No.)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Launch Chamber Secant Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Launch Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Tension / Vent Stack Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Victoria Dock Drainage Diversion	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Open Cut D-walls (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Open Excavation (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Reception Chamber D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Reception Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Tension / Vent Stack Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Open Cut D-walls (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
Non-hazardous	Soils (e.g. topsoil/ natural) - Greenwich - Open Cut Excavation (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (moderate contamination- suitable for reuse onsite)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Bricks and Blocks	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Screed	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Green waste/ vegetation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Mixed waste	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Metal	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Timber	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Plasterboard	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Packaging	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Cable & wiring	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Glass	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Other	TBC	TBC	TBC	TBC	TBC	TBC	TBC
Hazardous	Contaminated soil – unsuitable for reuse - Silvertown - Launch Chamber Secant Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Silvertown - Launch Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Reception Chamber D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Reception Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Toxic chemicals e.g. paint tins, line markers, mastic	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Other	TBC	TBC	TBC	TBC	TBC	TBC	TBC
TOTAL	TOTAL	0	0	0	0	0	0	0

Table 4-3: Actual construction waste quantities

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
Inert	Unacceptable excavated material	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Concrete	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Rubble	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Tunnel	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Cross Passages (10No.)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Launch Chamber Secant Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Launch Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Tension / Vent Stack Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Victoria Dock Drainage Diversion	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Open Cut D-walls (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Silvertown - Open Excavation (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Reception Chamber D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Reception Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Tension / Vent Stack Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (e.g. topsoil/ natural) - Greenwich - Open Cut D-walls (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC

Type	Materials	Forecast Estimated Quantities (m3)	Trade Contractor Package	Waste Minimisation Opportunities	On-site Reuse/ recycling	Off-site reuse/ recycling	Recovery	Disposal
Non-hazardous	Soils (e.g. topsoil/ natural) - Greenwich - Open Cut Excavation (TBC by Atkins)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Soils (moderate contamination- suitable for reuse onsite)	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Bricks and Blocks	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Screed	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Green waste/ vegetation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Mixed waste	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Metal	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Timber	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Plasterboard	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Packaging	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Cable & wiring	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Glass	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Other	TBC	TBC	TBC	TBC	TBC	TBC	TBC
Hazardous	Contaminated soil – unsuitable for reuse - Silvertown - Launch Chamber Secant Piles	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Silvertown - Launch Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Reception Chamber D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Reception Chamber Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Cut & Cover D-walls	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Contaminated soil – unsuitable for reuse - Greenwich - Cut & Cover Excavation	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Toxic chemicals e.g. paint tins, line markers, mastic	TBC	TBC	TBC	TBC	TBC	TBC	TBC
	Other	TBC	TBC	TBC	TBC	TBC	TBC	TBC
TOTAL	TOTAL	0	0	0	0	0	0	0

Table 4-4: Record of deviations from SWMP

Issue	Details
[waste forecasts- exceeded]	TBC reasons
[waste forecasts- not met]	TBC reasons

4.4 Estimate of cost savings

[Enter text here]

4.5 Relevant signatures

Principal Contractor:		Date:
Client:		Date:
SWMP Author:	Anita Manns	Date: 04/04/2013

D.7. Air Quality Modelling

Silvertown Tunnel Crossing

Air Quality Technical Appendix

April 2013
TfL Planning

Mott MacDonald

Silvertown Tunnel Crossing

Air Quality Technical Appendix

April 2013

TfL Planning

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Issue and revision record

Standard

Revision	Date	Originator	Checker	Approver	Description
P1	15/04/2013	Shalini Arora	Matthew O'Brien	Matthew O'Brien	1st Draft

Content

1. Introduction

1.1 Overview

In November 2009, Mott MacDonald was commissioned to develop options for a bored tunnel road link across the river Thames to link Greenwich and Silvertown. In January 2011, further alignments were made to the preferred option, which comprised of a twin bore uni-directional 2-lane tunnel, not accessible to pedestrians or cyclists.

In February 2013, Mott MacDonald was commissioned to assist with further development of the engineering designs of the proposed Silvertown Tunnel Crossing. This report presents the air quality assessment required under the current scope of works.

1.2 Objectives

Following discussion with Transport for London (TfL), it was determined that dispersion modelling would be required to quantitatively assess the potential impacts of emissions from the tunnel on air quality in the vicinity of the project. The results of this modelling will also feed in to the design of the tunnel ventilation system through an iterative process to determine appropriate vent shaft stack dimensions and ventilation fan specifications.

The scope of air quality services under the current brief comprises the following:

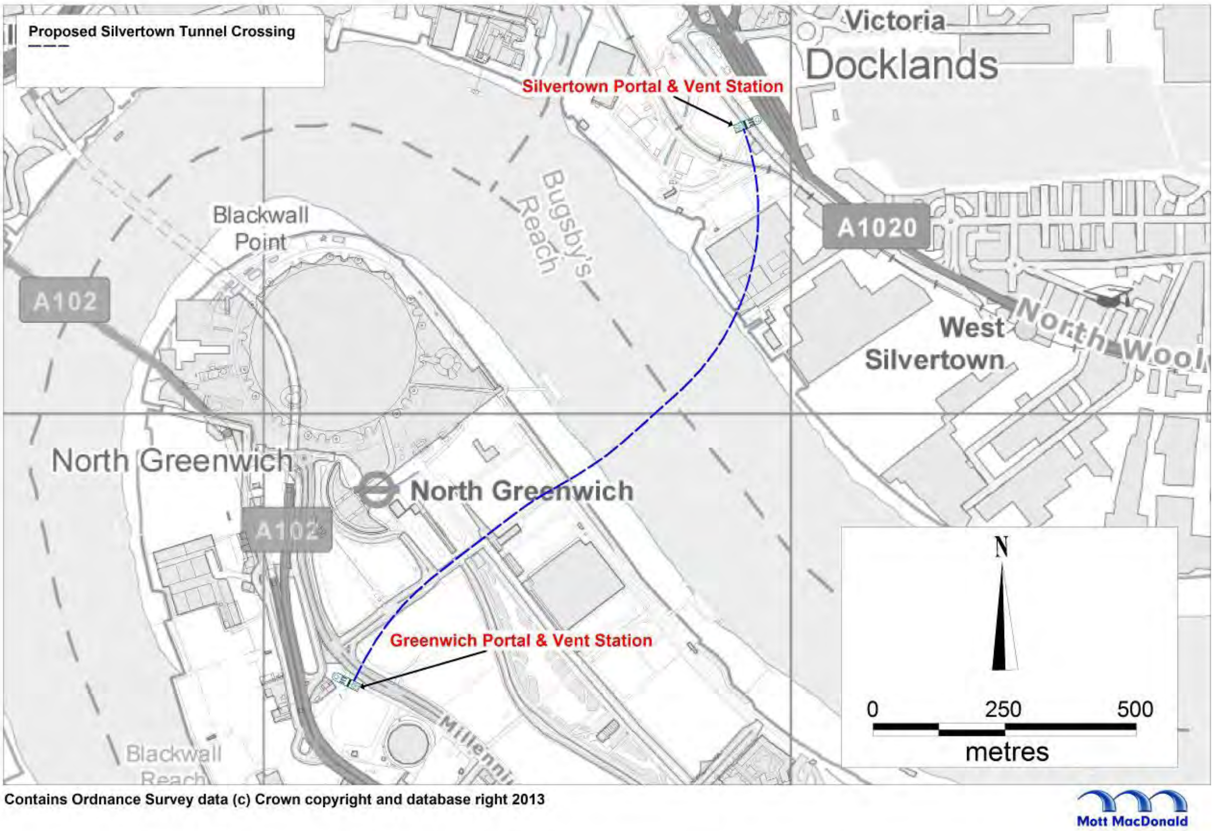
- Compile a baseline for ambient air quality conditions in the project area using existing monitoring data;
- Identify any potentially sensitive receptors nearby, such as residential buildings, schools etc.;
- Carry out atmospheric dispersion modelling of ventilation stacks and tunnel portals to quantify potential changes in ambient air quality concentrations (likely focussing on nitrogen dioxide (NO_2) and particulates (PM_{10})) at nearby receptors;
- Advise on the potential for significant emissions from the ventilation shafts and tunnel portals; and
- Feed back into the design of the ventilation system if potential impacts are identified.

1.3 Project Location

The tunnel crossing is proposed to link the Greenwich Peninsula on the south bank of the river Thames to Silvertown way on the north bank. The south portal is located within the Royal Borough of Greenwich (RBG); the north portal is situated within the London Borough of Newham (LBN).

The location of the proposed tunnel crossing is shown in Figure 1.1.

Figure 1.1: Location of proposed development



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2. Legislation and Policy

2.1 Introduction

This section summarises the relevant international and national legislation and policy in relation to ambient air quality for the Silvertown Tunnel.

2.2 Legislation

2.2.1 European Union (EU)

EU Framework Directive 96/62/EEC [Ref 1] on ambient air quality assessment and management came into force in November 1996 and had to be implemented by Member States by May 1998. This Directive aimed to protect human health and the environment by avoiding, reducing or preventing harmful concentrations of air pollutants. As a Framework Directive, it required the European Commission to propose 'Daughter' Directives which set air quality limit and target values, alert thresholds and guidance on monitoring and measurement for individual pollutants. The four Daughter Directives are as follows:

- Council Directive 1999/30/EC (the first Daughter Directive) relating to limit values for sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and oxides of nitrogen (NO_x), particulate matter (PM_{10}) and lead in ambient air;
- Directive 2000/69/EC (the second Daughter Directive) relating to limit values for benzene and carbon monoxide (CO) in ambient air;
- Directive 2002/3/EC (the third Daughter Directive) relating to ozone (O_3) in ambient air; and
- Directive 2004/107/EC (the fourth Daughter Directive) relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.

Directive 2008/50/EC on ambient air quality and cleaner air for Europe [Ref 2] was adopted in May 2008. This Directive merges the first three existing Daughter Directives and one Council Decision into a single Directive on air quality (it is anticipated that the fourth Daughter Directive will be brought within the new Directive at a later date). It also sets new standards and target dates for reducing concentrations of fine particles.

2.2.2 England

The Air Quality Standards Regulations 2010 [Ref 3] came into force in June 2010; they implement the EU's Directive 2008/50/EC on ambient air quality.

Part IV of the Environment Act 1995 [Ref 4] requires that every local authority shall periodically carry out a review of air quality within its area, including likely future air quality. As part of this review, the authority must assess whether air quality objectives are being achieved, or likely to be achieved within the relevant periods. Any parts of an authority's area where the objectives are not being achieved, or are not likely to be achieved within the relevant period must be identified and declared as an Air Quality Management Area (AQMA). Once such a declaration has been made, Authorities are under a duty to prepare an Action Plan which sets out measures to pursue the achievement of the air quality objectives within the AQMA.

The air quality objectives specifically for use by local authorities in carrying out their air quality management duties are set out in the Air Quality (England) Regulations 2000 [Ref 5] and the Air Quality (England)

(Amendment) Regulations 2002 [Ref 6]. In most cases, the air quality objectives are numerically synonymous with the limit values specified in the EU Directives although compliance dates differ.

The Environment Act also requires that the UK Government produces a national ‘Air Quality Strategy’ (AQS) containing standards, objectives and measures for improving ambient air quality and to keep these policies under review. Further details of the AQS are presented in Section 2.3.1.

2.3 Policy

2.3.1 UK Air Quality Strategy

As described above, the Environment Act 1995 requires the UK Government to produce a national AQS. The AQS establishes the UK framework for air quality improvements. Measures agreed at the national and international level are the foundations on which the strategy is based. The first Air Quality Strategy was adopted in 1997 [Ref 7] and replaced by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland published in January 2000 [Ref 8]. The 2000 Strategy has subsequently been replaced by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 [Ref 9].

The Environment Act 1995 requires that the Environment Agency has regard to the AQS in exercising its pollution control functions. Local Authorities are also required to work towards the Strategy’s objectives prescribed in regulations for that purpose. The air quality objectives in the AQS are a statement of policy intentions and policy targets. As such, there is no legal requirement to meet these objectives except in as far as they mirror any equivalent legally binding limit values in EU Directives and English Regulations.

2.4 Summary

This Section has identified the legislation and policy framework relevant to the assessment. On the basis of the above, applicable numerical environmental quality standards are summarised in Table 2.1, hereafter referred to as air quality ‘objectives’. It should be noted that these objectives only apply at locations where the members of the public might reasonably be exposed to pollutants for the respective averaging periods. Further details of this are provided in Section 3.7.

Table 2.1: Relevant Air Quality Objectives

Pollutant	Averaging Period	Air Quality Objective		Attainment Date
		Concentration	Allowance	
Nitrogen Dioxide (NO_2)	1-hour	200 µg.m^{-3}	18 per calendar year(d)	31 December 2005(a)(b) 1 January 2010 (c)
	Annual	40 µg.m^{-3}	-	31 December 2005(a)(b) 1 January 2010(c)
Particulates (PM_{10})	24-hour	50 µg.m^{-3}	35 per calendar year(e)	31 December 2004(a)(b) 1 January 2005(c)
	Annual	40 µg.m^{-3}	-	31 December 2004(a)(b) 1 January 2005 (c)

Notes: (a) Air Quality (England) Regulations 2000 as amended

(b) Air Quality Strategy 2007.

(c) EU Directive 2008/50/EEC on ambient air quality and cleaner air for Europe and The Air Quality Standards Regulations 2010

(d) Can be expressed as the 99.79th percentile of 1 hour means.

(e) Can be expressed as the 90.41st percentile of 24 hour means.

(f) Also a ‘Target’ of 15% reduction in annual mean concentrations at urban background between 2010 and 2020

3. Approach and Methodology

3.1 Introduction

This section sets out the approach that has been undertaken for the assessment of effects on air quality as a result of the proposed tunnel crossing.

3.2 Scope of Assessment

As outlined in Section 1.2, the scope of this project includes assessment of the impacts of emissions originating from within the tunnel only. Atmospheric dispersion modelling has therefore been undertaken for tunnel portals and vent shafts only; the results of this assessment are intended only for use in informing ventilation design decisions and, in-keeping with the agreed scope of works, do not constitute a detailed air quality assessment of impacts from the entire scheme.

3.3 Model Selection

The assessment uses a suite of dispersion models called Atmospheric Dispersion Modelling System (ADMS). ADMS is a PC-based model of dispersion in the atmosphere of pollutants released from industrial and road traffic sources, produced and validated by Cambridge Environmental Research Consultants (CERC). ADMS models these pollutants using point, line, area and volume sources. It is designed to allow for consideration of dispersion problems ranging from simple single isolated point sources to more complex road traffic emission sources over a large area and can include parameters such as variable meteorological conditions, complex road networks and street-canyon effects. This model is widely used by local authorities throughout the United Kingdom for Review and Assessment purposes and is one of the dispersion models recognised for modelling within the Local Air Quality Management: Technical Guidance, published in 2009 [Ref 10].

The approach taken in this assessment involved modelling the impacts from vent station stacks and tunnel portals separately; a different model from the ADMS suite was used for each of these purposes. Vent stacks were modelled as point sources using ADMS. This choice of model allowed for the inclusion of vent station structures in the model, as these are likely to affect dispersion. Portal emissions were modelled using ADMS-Roads in order to take account of the change in emissions at distances away from the portal. The different scenarios modelled are explained in more detail in Section 3.8.

3.4 Model Inputs

3.4.1 Pollutants of Concern

The pollutants considered within this assessment are those which are associated with road traffic emissions and have the potential to cause significant ambient air quality impacts. A brief description of these is provided in the following sections.

3.4.1.1 Nitrogen Oxides (NO_x)

Oxides of nitrogen is a term used to describe a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2), referred to collectively as NO_x. These are primarily formed from atmospheric and fuel nitrogen as a result of high temperature combustion. The main sources in the UK are road traffic and power generation.

During the process of combustion, atmospheric and fuel nitrogen is partially oxidised via a series of complex reactions to NO. The process is dependent on the temperature, pressure, oxygen concentration and residence time of the combustion gases in the combustion zone.

Most NO_x exhausting from a combustion process is in the form of NO, which is a colourless and tasteless gas. It is readily oxidised to NO_2, a more harmful form of NO_x, by chemical reaction with ozone and other chemicals in the atmosphere at high concentrations.

3.4.1.2 Particulate Matter (PM)

Particulate matter is a complex mixture of organic and inorganic substances present in the atmosphere. Sources are numerous and include power stations, other industrial processes, road transport, domestic coal burning and trans boundary pollution. Secondary particulate, in the form of aerosols, attrition of natural materials and, in coastal areas, the constituents of sea spray, are significant contributors to the overall atmospheric loading of particulate. In urban areas, road traffic is generally the greatest source of fine particulate matter, although localised effects are also associated with construction and demolition activity. Particulate matter is typically categorised according to particle size, for example the concentration of particles with a diameter less than 10µm is denoted as PM_{10}. $PM_{2.5}$ is a constituent of PM_{10}; the assessment of PM_{10} therefore also includes these smaller particles.

3.4.2 Ventilation Stack and Tunnel Portal Emissions

Stack and portal discharge rates and pollutant emissions have been obtained from the Mott MacDonald tunnel ventilation design team. These values were calculated using the ‘1D’ model which can simulate tunnel pollution; the model takes account of traffic flows, vehicle fleet composition, emission factors and background concentrations of NO_x and PM_{10}. Vehicle emission rates provided were based on projected vehicle fleet compositions for 2026 (the design year of the proposed tunnel crossing).

Background NO_x and PM_{10} concentrations included in the 1D model were taken from a roadside monitoring site in 2010. A roadside site was chosen for this purpose as this is considered to best represent the type of air mass being brought into the tunnels through the ventilation system. Data from 2010 was used as data from 2011 has not yet been fully ratified. Data from this monitoring site, located adjacent to the Blackwall Tunnel Approach in the London Borough of Tower Hamlets, is presented in Table 3.1 below. The site is located at grid coordinates 538290, 181452 and is operated by TfL. A sensitivity test was carried out to determine the use of annual mean or 15 minute mean pollutant concentrations. The difference in modelled impacts using these two different backgrounds in the emission calculations was small and it was concluded that the annual mean backgrounds were more representative of conditions.

Table 3.1: Continuous Monitoring Data at Blackwall

Year	Annual Mean Concentration (µg/m^3)	
	NO_x	PM_{10}
2010	173	29

Source: LAQN

The final stack and portal flowrates and pollutant emission rates used in this assessment are presented in Appendix A.

3.4.3 Meteorological Data

The most important meteorological parameters governing the atmospheric dispersion of emissions are wind direction and wind speed as described below:

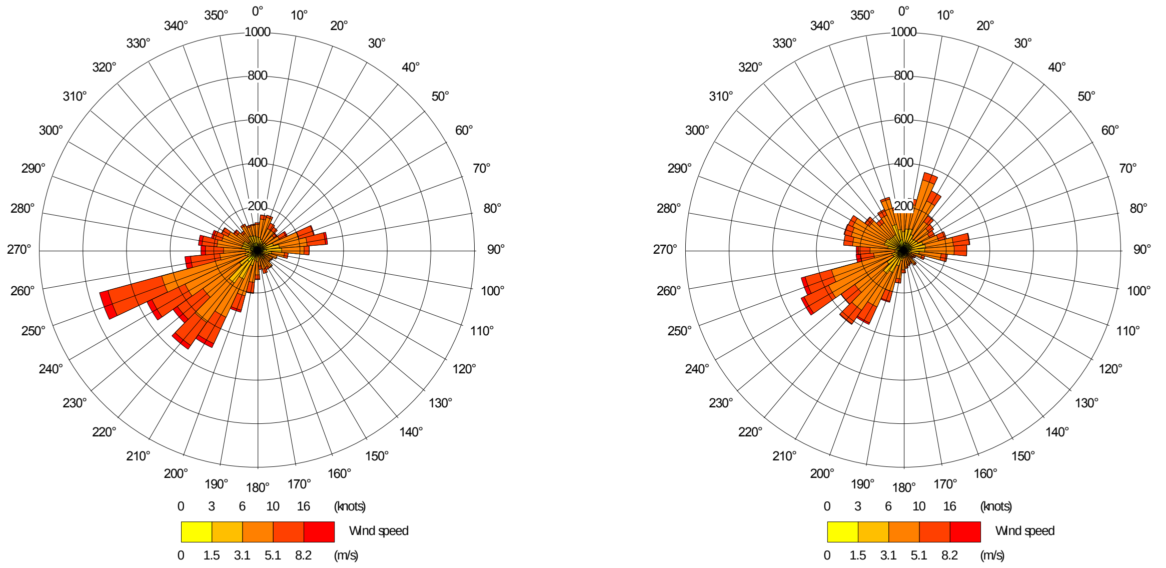
- wind direction determines the sector of the compass into which the plume is dispersed; and
- wind speed affects the distance the plume travels over time and can affect plume dispersion by increasing the initial dilution of pollutants and inhibiting plume rise.

For meteorological data to be suitable for dispersion modelling purposes, a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of sites where the required meteorological measurements are made.

Three years of meteorological data from London City Airport meteorological station (2009 to 2011) were used in the initial model assessment. The year of meteorological data that is used for a modelling assessment can have a significant effect on source contribution concentrations. 2009 was shown to consistently produce the greatest impacts at sensitive receptors. Data from this year was used for the main assessment and therefore results are likely to be conservative.

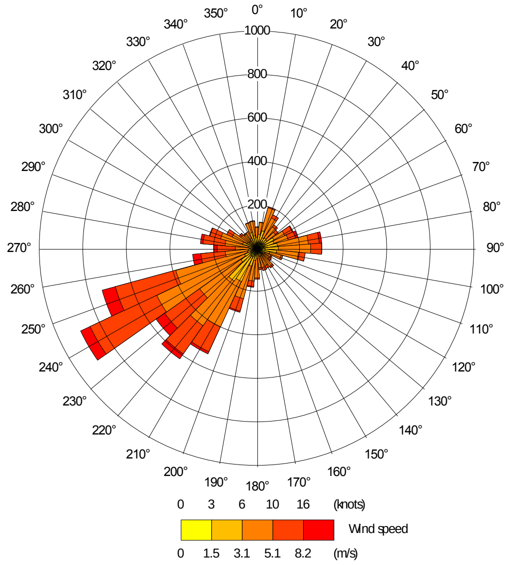
Wind roses have been constructed for each of the three years of meteorological data considered in this assessment. These show a prevailing south-westerly wind.

Figure 3.1: London City Airport Meteorological Station Windroses



2009

2010



2011

Source: London City Airport Meteorological Station

3.4.4 Background Concentrations

Only emissions directly related to the tunnel crossing (vent stacks or portals) have been explicitly included within the dispersion model. Non-tunnel related emission sources have been accounted for within the assessment by assigning appropriate ‘background’ concentrations to receptor locations. A number of information sources are available on background concentrations and these are presented, along with the choice of background data, within the Baseline section (see Section 4 below).

3.5 NO_x to NO_2 Relationship

Research undertaken on behalf of Defra has provided a spreadsheet based method to convert modelled annual mean NO_x concentrations into NO_2; the latest version of this (version 3.2) is available on the Defra AIR website [Ref 11] and has been used within this assessment.

3.6 Predicted Short Term Concentrations

For all discrete receptors assessed, annual mean concentrations of NO_2 have been presented. Research has indicated that the hourly NO_2 air quality objective of 200 µg m^{-3} (not to be exceeded more than 18 times per year) is unlikely to be exceeded at roadside locations where the annual mean concentration is less than 60 µg m^{-3} [Ref 10]. In addition to this indicator, given that NO_2 concentrations are always lower than the corresponding NO_x concentration, the short term NO_2 objective cannot be exceeded unless the maximum hourly NO_x concentration is greater than 200 µg m^{-3}.

Annual mean and 24 hour maximum concentrations of PM_{10} have been modelled; Defra’s TG(09) guidance provides the following equation which can be used to calculate the number of exceedences of the 24 hour objective using annual mean concentrations:

$$\text{No. 24-hour mean exceedences} = -18.5 + 0.00145 \times \text{annual mean}^3 + (206/\text{annual mean})$$

3.7 Receptors

The TG(09) guidance document [Ref 10] provides details of where the air quality objectives should and should not apply, as shown in Table 2.1.

Table 3.2: Example of Where Air Quality Objectives Apply

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual Mean	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as the permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the buildings façades), or any other location where public exposure is expected to be short-term.
24-Hour Mean and 8 hour Mean	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties.	Kerbside sites (as opposed to locations at the building's façade), or any other location where public exposure is expect to be short-term.
1-Hour Mean	All locations where the annual and 24 hour mean would apply. Kerbside sites (e.g. pavements of busy shopping streets). Any outdoor locations to which the public might reasonably be expected to spend 1-hour or longer.	Kerbside sites where the public would not be expected to have regular access.

Source: Local Air Quality Management Technical Guidance 2009 (LAQM TG (09) [Ref 21]

The influence of traffic on air quality is greatest close to roads. Effects decrease with distance such that the influence of a particular road is generally not detectable above background concentrations beyond 200 metres from the road [Ref 12]. Emissions from the ventilation stacks will typically result in elevated concentrations of pollutants in the direction of prevailing winds. Emissions from portals will typically result in higher concentrations in the direction of traffic flow, although dispersion may also be affected by the prevailing wind direction.

Receptors included within the model have been selected to represent locations where the greatest changes in pollutant concentrations are likely to occur and also where total concentrations are likely to be highest.

Concentrations were calculated at 26 discrete receptors, representing locations of relevant exposure (i.e. where the objectives apply). Details are presented in Table 3.3 and shown in Figure 3.2.

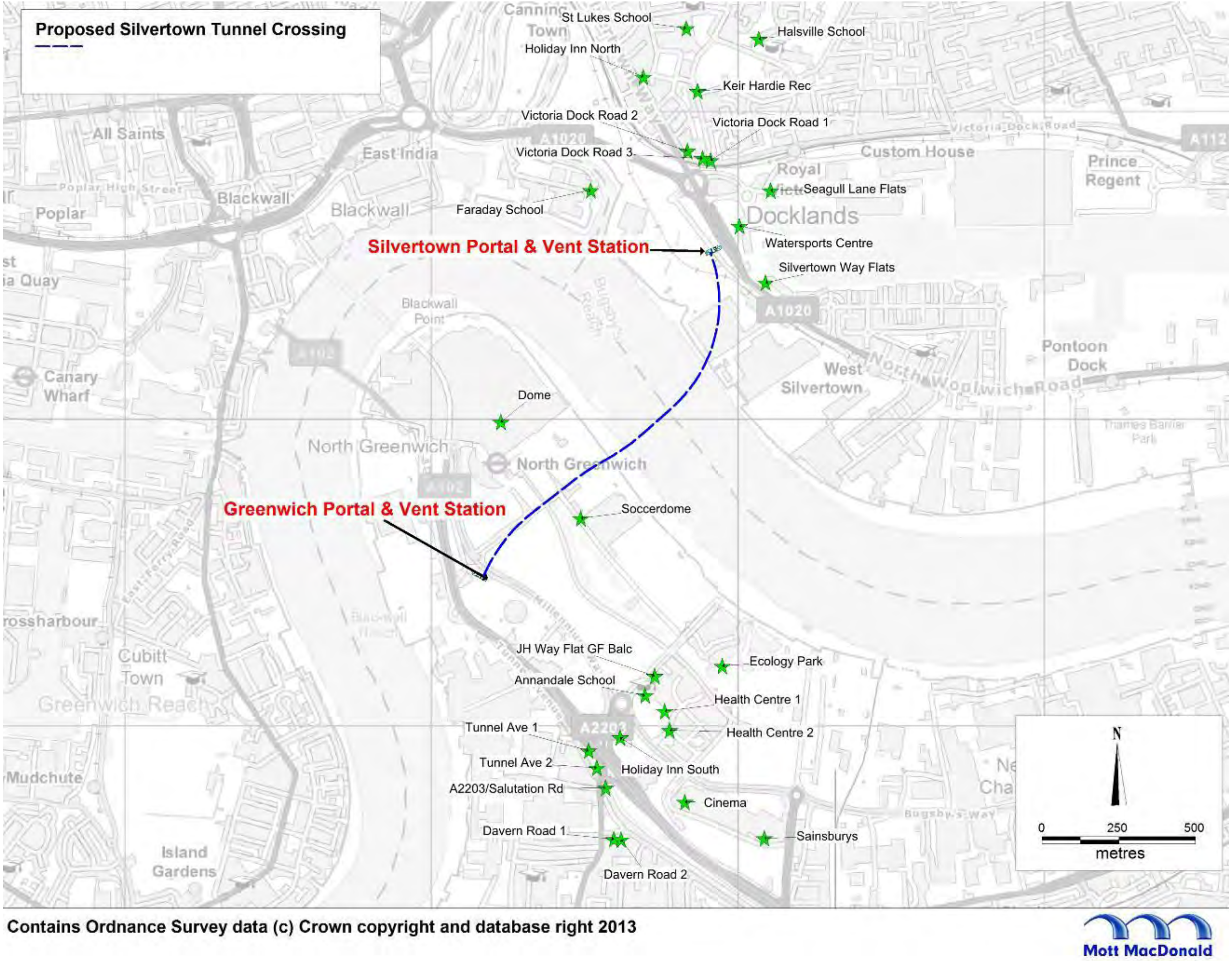
Table 3.3: Receptors included in the model

Receptor Name	Location		Height[(a)]	Applicable Objective/Standard
	X	Y	Z(m)	
Annandale School	539696	179100	2	Short Term
A2203/Salutation Rd	539567	178799	2	Long Term / Short Term
Tunnel Ave 1	539512	178920	2	Long Term / Short Term
Tunnel Ave 2	539539	178865	1	Long Term / Short Term
Davern Road 1	539594	178632	2	Long Term / Short Term

Receptor Name	Location		Height[(a)]	Applicable Objective/Standard
	X	Y	Z(m)	
Davern Road 2	539618	178631	2	Long Term / Short Term
Cinema	539826	178753	5	Short Term
Sainsburys	540085	178635	1	Short Term
Ecology Park	539948	179196	5	Short Term
Dome	539226	179990	10	Short Term
Faraday School	539519	180744	4	Short Term
Halsville School	540067	181236	1	Short Term
St Lukes School	539830	181272	2	Short Term
Keir Hardie Rec	539868	181067	1	Short Term
Holiday Inn North	539690	181113	2	Short Term
Silvertown Way Flats	540089	180444	4	Long Term / Short Term
Victoria Dock Road 2	539834	180872	3	Long Term / Short Term
Victoria Dock Road 1	539910	180842	2	Long Term / Short Term
Watersports Centre	540004	180628	2	Short Term
Seagull Lane Flats	540105	180743	3	Long Term / Short Term
Victoria Dock Road 3	539884	180848	3	Long Term / Short Term
Soccerdome	539486	179676	3	Short Term
JH Way Flat GF Balc	539727	179163	3	Long Term / Short Term
Health Centre 1	539760	179049	2	Short Term
Health Centre 2	539776	178987	1	Short Term
Holiday Inn South	539615	178963	2	Short Term

(a) Height is relative to base of stack, assumed to be approximately 2.5m above Ordnance Datum

Figure 3.2: Location of modelled receptors



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3.8 Model Approaches

3.8.1 Overview

Vehicle emissions could be released from the tunnel via two possible routes, subject to the design option chosen;

1. Via the Silvertown Portal and Greenwich Portal (‘Option 1’); or
2. Via the Silvertown Vent Station stack and Greenwich Vent Station stack (‘Option 2’)

The design options of the tunnel ventilation system currently being considered means that emissions could not be released from the portals *and* vent stations.

The specific methods and model input parameters for each of these are explained in more detail in the following sections.

3.8.2 Option 1: Pollutants Emitted from Vent Station Stack

This approach assumes that all pollution within the tunnel is discharged through ventilation stacks; there are no emissions from the tunnel portals. The current designs include a vent station located immediately above the tunnel portal at both the Greenwich and Silvertown sides.

Operational impacts from the tunnel ventilation stacks have been modelled for a range of stack heights. As shown in design drawings MMD-298348-TUN-216 and MMD-298348-TUN-217, the stacks are located within vent station buildings which have a height of 16m. The shortest stack height modelled was therefore 16m. The stack heights modelled were incrementally increased by 1m up to a maximum of 25m. The vent station buildings (dimensions: 56m(L), 16m(W) and 16m(H)) were also included in the model.

Following discussion with the tunnel ventilation design team, it was agreed that tunnel emissions would be modelled at ambient temperature. The annual mean temperature of the 2009 London City Airport meteorological data was 10^{o}C so this value was conservatively used within the model. A sensitivity analysis was carried out running the model with hourly temperature values taken from the meteorological data. Predicted concentrations were slightly lower than using a constant ambient temperature; however the constant temperature of 10^{o}C was used in order to be conservative.

Only the ‘worst case’ emissions were modelled; using the time period with the highest mass emission rates and applying this to the whole day produces conservative results..

Table 3.4: Ventilation Stack Height modelling input parameters

Property	Unit	Vent Station	
		Silvertown	Greenwich
Stack location	X, Y	539137, 179499	539937, 180557
Stack height	m	16 – 25 m	
Exit diameter	m	7	
Exit temperature	°C	10	
Volumetric flow rate	m^3/s	400	
NO_x emission	g/s	0.19	0.18
PM_{10} emission	g/s	0.03	0.04

3.8.3 Option 2: Pollutants Emitted from Tunnel Portals

3.8.3.1 Overview

Emissions from tunnel portals were modelled using two different methods as there is no general consensus on the most accurate tunnel portal modelling approach. Both methods assume there are no ventilation stacks and that all ppollutants emitted within a tunnel are released at the tunnel portal in the direction of traffic flow. Therefore, pollutants are only emitted from the northbound portal at the Silvertown side and the southbound portal at the Greenwich side.

3.8.3.2 Line Source Method

This scenario assumes that cconcentrations of pollutants will decrease with increasing distance from the portal due to increasing dispersion. The approach used in the Marina Coastal Expressway (MCE) study [Ref 13] and widely used in Australia, Asia and the United States is based on a methodology derived by

Ginzburg and Schattanek (1997) [Ref 14] —based on observations at a number of locations—which divides the plume from the tunnel portal in to three equal sections which contain 57%, 31% and 12% of the emissions respectively from the preceding tunnel section. This approach has been adopted for this method.

The plume length was estimated based on the same study. The methodology provides estimates for minimum and maximum plume length based on the prevailing wind speeds of 1, 3 and 6m/s and the average speed of the vehicles in the tunnel. For London City, the average wind speed is approximately 3.8m/s and the average speed of vehicles in the tunnel has been assumed to be 50 kph (as provided by the design team). Based on the Ginzburg and Schattanek method, the minimum and maximum portal plume lengths were estimated to be 150 and 270m in length respectively and an approximate midpoint of 210m was selected. This length also corresponded well with the distance from the tunnel portals to the points where the tunnel approach/exit roads are planned to converge with the surrounding road network. This therefore represented three 70m sections under the methodology employed in MCE. Each of these sections was modelled as a line source in ADMS-Roads, with decreasing proportions of the total portal emissions as proposed by the Ginzburg and Schattanek method.

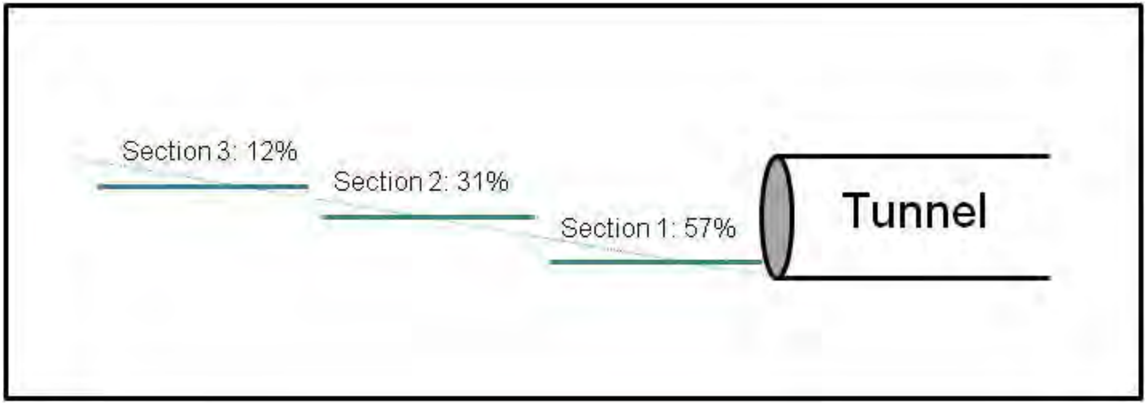
The ADMS model requires all emission rates for line sources to be presented in g/m/s. Therefore the emission rates for each section were adjusted from the values shown in Appendix A. Flowrates were also adjusted to 57%, 31% and 12% as the portal plume speed can be expected to decrease at increasing distances from the portal. To take account of the gradient of the tunnel approach/exit ramps, the three 70m sections (line sources) were input at increasing heights representing the midpoint of each 70m of ramp; Figure 3.3 shows a diagram illustrating this approach. A sensitivity analysis modelling the line sources at a constant ground level found fairly good agreement between the two methods, but it was assumed that the increasing line source height approach was more representative of the real world situation.

Model input parameters for the line source method are presented in Table 3.5.

Table 3.5: Tunnel portal model – line source method input parameters

Property	**Unit**	**Silvertown Portal Section**			**Greenwich Portal Section**		
		1	**2**	**3**	**1**	**2**	**3**
Line source height (relative to base of tunnel)	m	3.25	5.75	8.3	0.5	4.9	7.3
Line source length	m	70					
Line source width	m	11			13.5		
Exit temperature	°C	10					
Volumetric flow rate	m^3/s	169	92	35	185	101	39
NO_x emission	g/m/s	0.00142	0.00077	0.00030	0.00132	0.00072	0.00028
PM_{10} emission	g/m/s	0.00025	0.00014	0.00005	0.00027	0.00015	0.00006

Figure 3.3: Diagram showing the modelled configuration of line sources at a tunnel portal



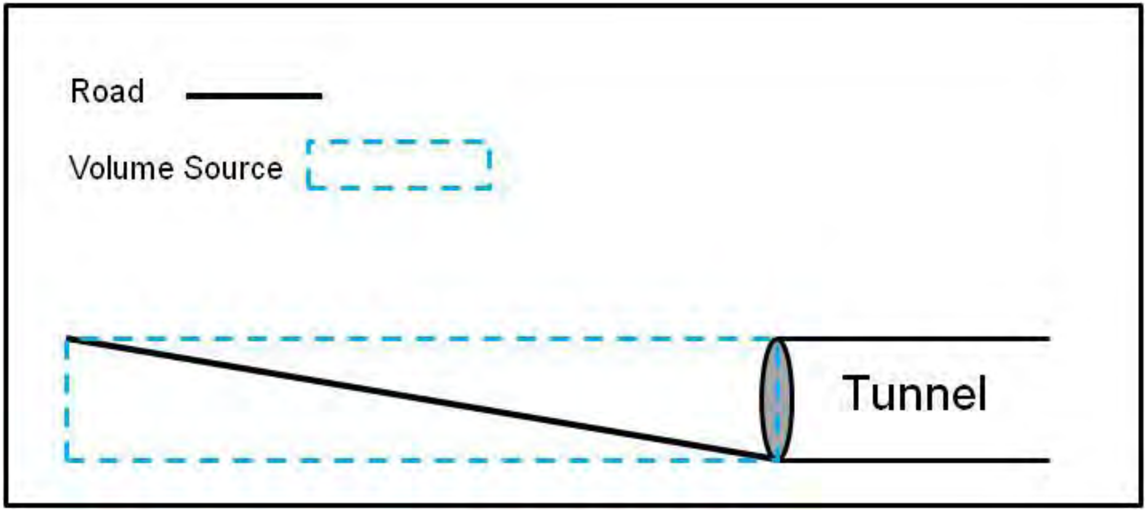
3.8.3.3 Volume Source Method

Emissions from tunnel portals were also modelled as a volume source using ADMS-Roads. This approach has previously been used by the Highways Agency for tunnel portal modelling. The volume sources representing each portal occupy the area from the tunnel portal to ground level (see Figure 3.4 below) and therefore represent a conservative approach as they assume a much larger emission area than is actually present. Emission rates were converted from g/s to g/m^3/s based on the area of the portals and the length of the volume source. The length of each volume source was measured from geo-referenced CAD files; these lengths are shorter than the plume lengths applied in the line source method in order to account for the more diffuse shape of the volume source. A summary of the input parameters is presented in Table 3.6.

Table 3.6: Tunnel portal model – volume source method input parameters

Property	Unit	Silvertown Portal	Greenwich Portal
Volume source mid-point height (relative to base of tunnel)	m	3.8	4.7
Volume source length	m	173.50	135.90
Portal area	m^2	92	100
Exit temperature	°C	10	
NO_x emission	g/m^3/s	0.0000110	0.0000120
PM_{10} emission	g/m^3/s	0.0000019	0.0000025

Figure 3.4: Diagram showing the modelled configuration of the volume source at a tunnel portal



3.9 Addressing Uncertainty

Dispersion modelling has associated with it an inherent level of uncertainty, primarily as a result of:

- Uncertainties with emissions data;
- Uncertainties with recorded meteorological data,
- Simplifications made in the model algorithms or post processing of the data that describe atmospheric dispersion or chemical reactions.

This uncertainty has been addressed within the assessment by carrying out sensitivity analyses and using conservative assumptions wherever reasonable, as described above

3.10 Significance Criteria

A number of approaches can be used to determine whether the potential air quality effects of a development are significant. However, there remains no universally recognised definition of what constitutes ‘significance’.

Guidance is available from a range of regulatory authorities and advisory bodies on how best to determine and present the significance of effects within an air quality assessment. It is generally considered good practice that, where possible, an assessment should communicate effects both numerically and descriptively.

Any description of an impact of a development is informed by numerical results. However, an element of professional judgement must also be involved. To ensure that the descriptions of effects used within this assessment are clear, consistent and in accordance with recent guidance, definitions have been adapted from the Environmental Protection UK (EPUK) Development Control: Planning for Air Quality (2010 Update) document [Ref 15]. Table 3.7 provides magnitude descriptors used for changes in NO_2 and PM_{10} concentrations as a result of the development.

Table 3.7: Definitions of Impact Magnitude for Changes in Annual Mean NO_2 and PM_{10} Concentrations

Magnitude of Change	Annual Mean
Large	Increase / decrease >10%
Medium	Increase / decrease 5-10%
Small	Increase / decrease 1-5%
Imperceptible	Increase / decrease <1%

Table 3.8 provides magnitude descriptors used for changes in the number of days in which daily PM_{10} concentrations are greater than 50 µg/m³.

Table 3.8: Definitions of Impact Magnitude for Changes in Number of Days with PM_{10} Concentration Greater than 50 µg/m³

Magnitude of Change	Number of days above 50 µg/m³
Large	Increase / decrease >4 days
Medium	Increase / decrease 2-4 days
Small	Increase / decrease 1-2 days
Imperceptible	Increase / decrease <1 day

The magnitude descriptor identified must be considered in the context of existing air quality conditions within the study area in order for the significance of that magnitude to be determined. The most important aspects to consider are whether existing concentrations are above or below the relevant air quality objective and whether existing receptors are within an AQMA.

Table 3.9 and Table 3.10 provide descriptors for the significance of air quality effects based on the magnitude descriptors. EPUK recognises that the criteria presented here are a tool to assist in interpreting results and should be supplemented by professional judgement of the air quality assessment significance.

Table 3.9: Air Quality Impact Descriptors for Changes to Annual Mean NO_2 and PM_{10} Concentrations at a Receptor

Absolute Concentrations in Relation to Objective / Limit Value	Change in Concentration (a)		
	Small	Medium	Large
	Increase with Scheme		
Above objective/limit value with scheme (>40 µg.m^{-3})	Slight adverse	Moderate adverse	Substantial adverse
Just below objective/limit value with scheme (36-40 µg.m^{-3})	Slight adverse	Moderate adverse	Moderate adverse
Below objective/limit value with scheme (30-36 µg.m^{-3})	Negligible	Slight adverse	Slight adverse
Well below objective/limit value with scheme (<30 µg.m^{-3})	Negligible	Negligible	Slight adverse

Source: EPUK Guidance [Ref15].

Note: (a) An imperceptible change would be described as 'Negligible'.

Table 3.10: Air Quality Impact Descriptors for Changes to Number of Days with PM_{10} Concentrations Greater than 50µg/m³ at a Receptor

Absolute Concentrations in Relation to Objective / Limit Value	Change in Number of Days (a)		
	Small	Medium	Large
	Increase with Scheme		
Above objective/limit value with scheme (>35 days)	Slight adverse	Moderate adverse	Substantial adverse
Just below objective/limit value with scheme (32-35 days)	Slight adverse	Moderate adverse	Moderate adverse

Absolute Concentrations in Relation to Objective / Limit Value	Change in Number of Days [(a)]		
	Small	Medium	Large
Below objective/limit value with scheme (26-32 days)	Negligible	Slight adverse	Slight adverse
Well below objective/limit value with scheme (<26 days)	Negligible	Negligible	Slight adverse

Source: EPUK Guidance [Ref 15].

Note: (a) An imperceptible change would be described as ‘Negligible’.

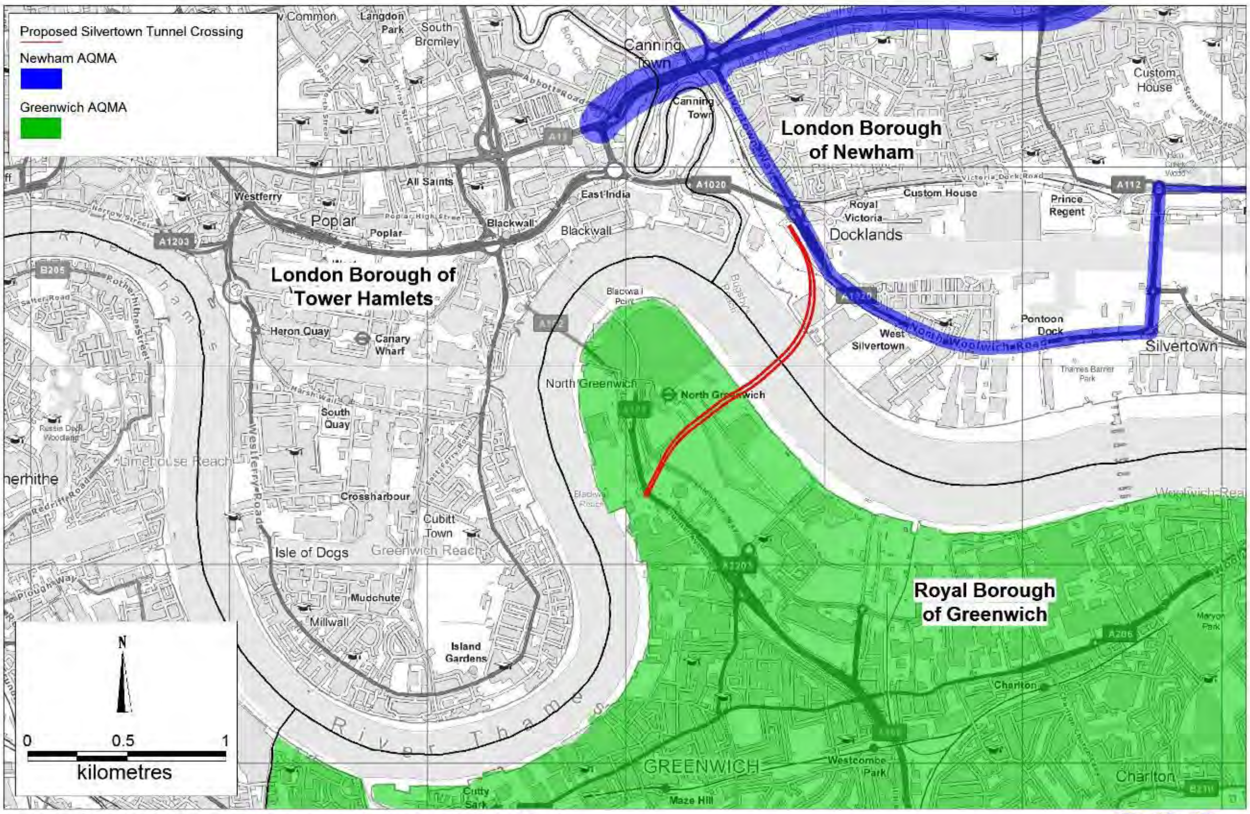
4. Baseline Air Quality

4.1 Overview

Information on air quality in the UK is available from a variety of sources including Local Authorities, national network monitoring sites and other published sources. As stated in Section 1.3, the project will be situated across two local authorities: The London Borough of Newham (LBN) and the Royal Borough of Greenwich (RBG).The primary sources examined in this assessment include the LBN and RBG Review and Assessment documents, the London Air Quality Network (LAQN) and Defra Air.

LBN’s most recent Review and Assessment document was the Updating and Screening Assessment produced in November 2012 [Ref 16]. LBN has currently declared one AQMA named the ‘Newham AQMA’; this covers main roads within the borough, including Silvertown Way. This AQMA was declared due to exceedences of the NO_2 and PM_{10} annual mean objectives, primarily as a result of road traffic emissions. As shown in Figure 4.1, the Newham AQMA covers roads that will be affected by the proposed tunnel crossing; potential impacts of the development on air quality within this AQMA have therefore be considered.

Figure 4.1: Location of the Newham and Greenwich AQMAs in relation to the proposed development.



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RBG last published an Air Quality and Action Plan Progress Report in October 2010 [Ref 17]. The report concluded that the objectives for NO_2 and PM_{10} are being exceeded at various locations across the

Borough. The whole of RGB’s administrative area is declared as an AQMA for NO_2 and PM_{10}; the area surrounding the proposed development is shown in Figure 4.1.

4.2 Local Authority Review and Assessment and LAQN Monitoring Data

Those monitoring sites considered sufficiently close to the proposed tunnel crossing to inform the baseline of ambient air quality are discussed below; their locations in relation to the proposed development are shown in Figure 4.2. Data from automatic monitors has not yet been ratified for the year 2012 so data is only presented for the years 2009 to 2011.

4.2.1 London Borough of Newham

Air quality is monitored across the LBN area through a network of monitoring sites consisting of two automatic sites and 22 diffusion tube sites. Only one of these automatic monitoring sites can be considered representative of air quality around the tunnel portal.

4.2.1.1 Automatic Monitoring

Wren Close (located at grid reference 539889, 181469) is classified as an ‘urban background’ site; it is also part of the LAQN and has been in operation since 2003. The pollutants NO_x, NO_2 and PM_{10} are monitored at this site.

Table 4.1: Continuous Monitoring Data at Wren Close (Urban Background)

Year	Annual Mean Concentration (µg/m^3)		
	NO_2	NO_x	PM_{10}
2009	38	60	24
2010	39	61	22
2011	39	55	27

Source: LAQN

Monitoring at Wren Close shows that ambient urban background concentrations are just below the annual air quality standard for NO_2 and well below the annual standard for PM_{10}.

4.2.1.2 Non Automatic Monitors

Diffusion tubes are located at 22 sites across the borough to monitor ambient NO_2 concentrations, however only four of these are considered relevant for the proposed scheme. These diffusion tube locations and their results have been presented in Table 4.2.

Table 4.2: LBN NO_2 Diffusion Tube Monitoring Results

Site Name	Site Type	X	Y	Data Capture for Monitoring Period 2011 (%)	Annual Mean NO_2 Concentration (µg/m^3)		
					2009	2010	2011
Tant Avenue E16	Background	539747	181477	100%	40	47	38
Beckton Arms, Hermit Rd	Roadside	539906	181702	92%	96	84	92
Canning Town	Kerbside	539456	181499	75%	84	81	108

Site Name	Site Type	X	Y	Data Capture for Monitoring Period 2011 (%)	Annual Mean NO_2 Concentration (µg/m^3)		
					2009	2010	2011
Roundabout							
Wren Close monitoring station	Background	539701	181459	50%	49	49	37

Source: Received directly from LNB's Air Quality Officer

Notes: Bias adjusted with local factor

4.2.2 Royal Borough of Greenwich

Air quality is monitored across the RBG area through a network of monitoring sites consisting of nine automatic sites and 43 diffusion tube sites. The locations of all RBG monitoring sites discussed below in relation to the proposed development have been presented in Figure 4.2.

4.2.2.1 Automatic Monitoring

Of the nine automatic air quality monitors currently in operation in RBG, only three can be considered close enough to the proposed development to potentially inform the baseline. This includes two roadside sites and one industrial site; there are no urban background monitors in RBG. Pollutants monitored include NO_2, PM_{10} and $PM_{2.5}$. The details of these sites and the three most recent years of ratified data are presented in Table 4.3, Table 4.4 and Table 4.5.

Table 4.3: Continuous Monitoring Data from the Millennium Village (Industrial) site located at 540169, 178999

Year	Annual Mean Concentration (µg/m^3)			
	NO_2	NO_x	PM_{10}	$PM_{2.5}$
2009	36	72	20	15
2010	36	68	22	16
2011	33	65	25	19

Source: LAQN

Table 4.4: Continuous Monitoring Data from the Woolwich Flyover (Roadside) site located at 540200, 178367

Year	Annual Mean Concentration (µg/m^3)			
	NO_2	NO_x	PM_{10}	$PM_{2.5}$
2009	82	256	37	19
2010	73	220	33	16
2011	67	212	35	17

Source: LAQN

Table 4.5: Continuous Monitoring Data from the Trafalgar Road (Roadside) site located at 538960, 177954

Year	Annual Mean Concentration (µg/m^3)		
	NO_2	NO_x	PM_{10}
2009	48	93	21
2010	47	96	22
2011	42	78	23

Source: LAQN

4.2.2.2 Non Automatic Monitors

Diffusion tubes are located at 43 sites across the borough to monitor ambient NO_2 concentrations. 8 of these are located in the vicinity of the proposed tunnel; these diffusion tube locations and their results have been presented in Table 4.2.

Table 4.6: RBG NO_2 Diffusion Tube Monitoring Results

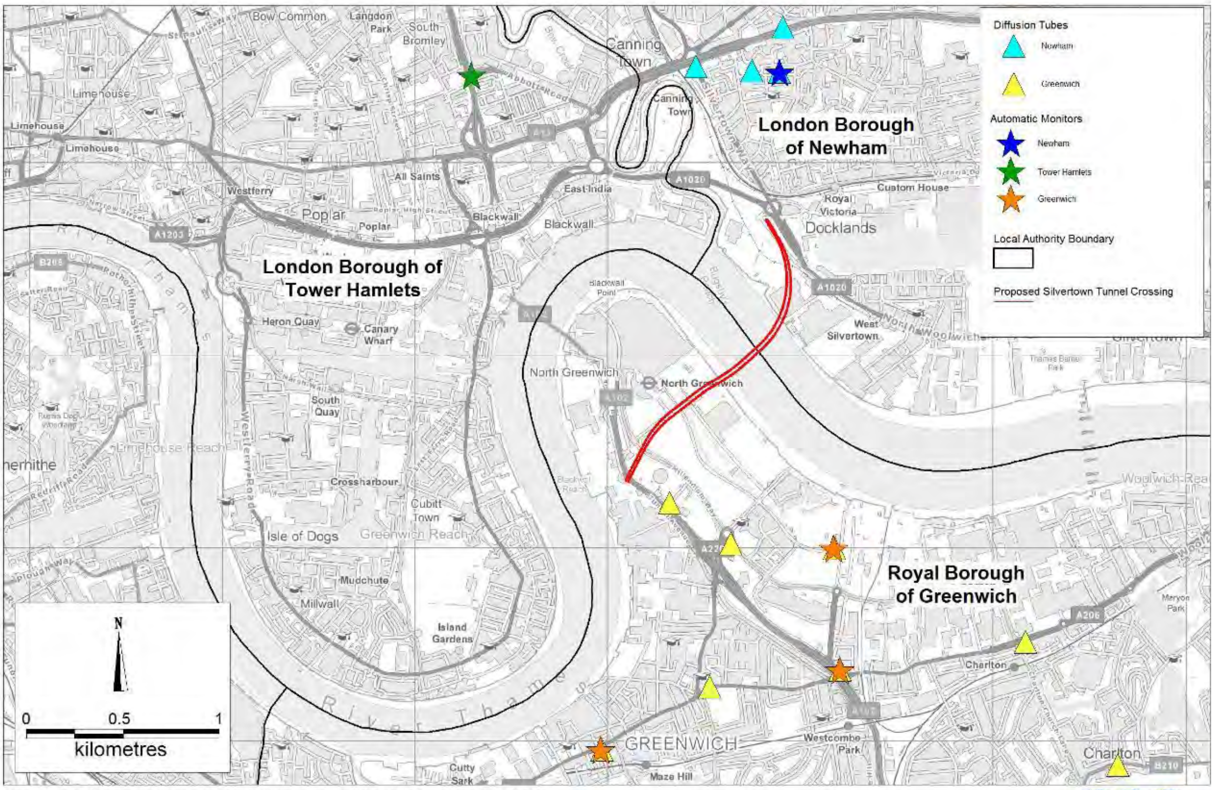
Code	Site	Type	X	Y	Annual Mean NO_2 (µg/m^3)		
					2009	2010	2011
GW27	Charlton Village	RS	541645	177874	52	57	49
GW29	Woolwich Rd Charlton	RS	541167	178512	71	67	51
GW35	Woolwich Rd Greenwich	RS	539527	178281	74	56	61
GW36	Boord St	RS	539320	179234	54	43	58
GW50	Woolwich Flyover	RS	540203	178367	75	71	64
GW50	Woolwich Flyover	RS	540203	178367	75	68	63
GW50	Woolwich Flyover	RS	540203	178367	75	74	60
GW51	Bugsbys Way	RS	539638	179024	51	49	44
GW57	Trafalgar Road Greenwich	RS	538968	177955	44	47	44
GW57	Trafalgar Road Greenwich	RS	538968	177955	44	46	41
GW57	Trafalgar Road Greenwich	RS	538968	177955	44	46	43
GW61	Millennium Village	RS	540175	179000	No data available		

Source: Direct Liaison with RGB's Air Quality Officer

Note: Bias adjusted using London wide factors for 2010 and 2011, 2011 data capture >90%

RS: Roadside

Figure 4.2: Locations of Automatic and Non-Automatic Monitors relevant to the proposed development



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4.3 Defra AIR

Defra provides estimates of pollution concentrations for NO_X, NO_2, PM_{10} and $PM_{2.5}$ across the UK for each 1 kilometre grid square for every year from 2010 to 2030, based on 2010 derived background maps. The maps include a breakdown of background concentrations by emission source, including road and industrial sources calibrated against 2010 UK monitoring data. Six grid squares were identified that cover potential receptors included within this assessment (see Section 3.7). Annual mean concentrations of NO_X, NO_2 and PM_{10} (the pollutants of concern) have been presented in Table 4.7 for the year 2011 to enable comparison with the monitoring data presented in the preceding sections.

2010 is considered to be a high pollution year due to the meteorological conditions that prevailed and as a result, the 2010 Defra background maps are generally considered to predict higher than average concentrations. This is acknowledged by Defra who have carried out analysis across the UK Automatic Urban and Rural Network (AURN) monitoring network and concluded that on average NO_X concentrations are 15% higher and NO_2 estimated to be 10% higher than other recent years. Defra highlight that if required, removal of the 2010 high pollution year can be carried out for assessments using their 'NO_2 Background Sector Tool' [Ref 18]. This accounts for the higher than average 2010 concentrations by scaling the maps. However, monitoring data presented in the above sections indicates that for these sites, 2010 concentrations were not significantly higher than other years. Therefore, in order to ensure the assessment is conservative (i.e. representing worst case conditions), this adjustment has not been applied to the predicted NO_x and NO_2 concentrations in Table 4.7.

Table 4.7: Defra Annual Mean Background Concentrations (µg/m^3) for the year 2011

Grid Square		NO_x	NO_2	PM_{10}
X	Y	(µg/m^3)	(µg/m^3)	(µg/m^3)
539500	180500	40.6	77.4	22.6
540500	180500	35.6	62.8	20.3
539500	181500	42.7	79.0	23.0
539500	179500	36.9	66.4	21.8
539500	178500	36.4	65.4	21.6
540500	178500	36.5	65.8	21.8

Source: Defra Air Website

(a) From 2001

4.4 Summary

The baseline air quality review has shown that annual mean NO_2 concentrations at roadside sites typically exceed the annual mean air quality objective. Concentrations at urban background sites tend to be close to, but just under, the annual mean NO_2 objective. PM_{10} concentrations at all monitored sites are below the relevant objectives.

As discussed in Section 3.4.4, pollution that is not explicitly included in the model is accounted for by adding modelled contributions to pollutant concentrations to the appropriate ‘background’ levels. Data for this purpose was taken from the Wren Close urban background monitoring site in LBN as this is considered the most representative of the background (ambient) air quality in the vicinity of the project.

5. Model Results

5.1 Overview

The following sections provide a brief summary of the modelling results. For further information, see the results tables in Appendix B.

5.2 Option 1: Pollutants Emitted from Vent Station Stack

A stack height of 16m is recommended, as the results of this modelling showed there was minimal improvement in concentrations at sensitive receptors with increasing stack height above this. The height of the stacks is essentially constrained by the height of the ventilation station structures, which are 16m high. The stacks therefore need to just protrude slightly from the roof of these structures.

A stack height of 16m does not lead to any exceedences of the applicable air quality standards for NO_2 or PM_{10}. Only one receptor, the Watersports Centre, was predicted to have a ‘slight adverse’ impact for NO_2. All other receptors had negligible impacts.

5.3 Option 2: Pollutants Emitted from Tunnel Portals

5.3.1 Line Source Method

The results of the line source portal modelling method showed there were no predicted exceedences at any of the modelled receptors. However, four receptors were predicted to have ‘slight adverse’ impacts from NO_2. Other receptors had ‘negligible’ impacts. All receptors had negligible impacts for PM_{10}.

5.3.2 Volume Source Method

The portal volume source modelling showed a predicted exceedence of the annual mean NO_2 objective at one receptor with relevant exposure. No exceedences of the short term NO_2, annual mean PM_{10} or 24 hour PM_{10} objectives were predicted using this method. Seven receptors were predicted to have a ‘slight adverse’ impact for NO_2 and one was ‘moderate adverse’. All other receptors had negligible impacts for NO_2 and all receptors had negligible impacts for PM_{10}.

6. Conclusion

Model results indicate that the impact on air quality at sensitive receptors would be worse if tunnel emissions were dispersed through portals rather than ventilation stacks, as the incidence of ‘slight adverse’ impacts from NO_2 was shown to increase.

Although the contributions of tunnel emissions (either through stacks or portals) to overall ambient concentrations are small compared to the background there are a number of reasons why a stack is the preferred option:

- Background concentrations are high and both tunnel portals are situated in Air Quality Management Areas (AQMAs) designated for poor air quality;
- There are many different methods for modelling tunnel portals and the sensitivity tests undertaken as part of this assessment produced varied results. Some of the methods showed modelled concentrations exceeding air quality objectives and others did not. Therefore, based on these results alone, it is not possible to say with a high level of confidence whether portal emissions are likely to cause exceedences of air quality objectives or not; and
- Road traffic on surrounding roads has not been included in the models; actual impacts of the ‘scheme’ as a whole are therefore expected to be higher than those modelled. This suggests there would be an even greater chance of portal emissions causing exceedences of air quality objectives.

A stack height determination showed that stacks need only be as high as the ventilation station structures, which have a height of 16m above ground level. Increases in stack height above 16m were shown to have a negligible effect on decreasing pollutant concentrations.

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Appendices

Appendix A. Emissions data provided by Mott Tunnels Roads model

Figure A.1: Shaft flowrate and total pollutant emissions from stack

Purpose:

Calculate emissions in g/s from the ventilation stacks. Shaft flowrate iterated to achieve reverse flow greater than 0.45m/s achieved at portals so all emissions from stack.

Background pollution level is for 2011 (MM Air Quality & Carbon Team source attached).

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Time	Direction	Pollutant	Tunnel Airspeed at Portal	Shaft Flowrate	Pollutant Density		In shaft pollution level due to vehicles			Background pollution	Emitted pollution from stack due to vehicles	Emitted pollution from stack due to background pollution	**Total emitted pollution from stack**
Source →			Roads	Roads	PIARC	PIARC	Roads	Roads	= F * H or G * I	Appendix 2	= E * J / 10^6	= K * J / 10^6	= L + M
Units →			m/s	m^3/s	g/m^3	g/m^2	ppm	$x10^{-3}m^{-1}$	ug/m^3	ug/m^3	g/s	g/s	**g/s**
AM Peak	Northbound	CO	-0.86	400	1200		0.21855877		262.3	301.0792025	0.105	0.120	**0.225**
		NOx	-0.86	400	1900		0.16310976		309.9	170.66	0.124	0.068	**0.192**
		PM	-0.86	400		0.213		0.26191562	55.7	29.23	0.022	0.012	**0.034**
	Southbound	CO	0.48	350	1200		0.25797859		309.6	301.0792025	0.108	0.105	**0.214**
		NOx	0.48	350	1900		0.15452497		293.6	170.66	0.103	0.060	**0.162**
		PM	0.48	350		0.213		0.32043648	68.2	29.23	0.024	0.010	**0.034**
Inter Peak	Northbound	CO	-0.88	400	1200		0.18954118		227.4	301.0792025	0.091	0.120	**0.211**
		NOx	-0.88	400	1900		0.15594047		296.3	170.66	0.118	0.068	**0.187**
		PM	-0.88	400		0.213		0.23506224	50.0	29.23	0.020	0.012	**0.032**
	Southbound	CO	0.51	400	1200		0.17024213		204.3	301.0792025	0.082	0.120	**0.202**
		NOx	0.51	400	1900		0.14114678		268.2	170.66	0.107	0.068	**0.176**
		PM	0.51	400		0.213		0.28222951	60.0	29.23	0.024	0.012	**0.036**
PM Peak	Northbound	CO	-0.57	250	1200		0.18314555		219.8	301.0792025	0.055	0.075	**0.130**
		NOx	-0.57	250	1900		0.09128657		173.4	170.66	0.043	0.043	**0.086**
		PM	-0.57	250		0.213		0.17861168	38.0	29.23	0.010	0.007	**0.017**
	Southbound	CO	0.49	350	1200		0.25841412		310.1	301.0792025	0.109	0.105	**0.214**
		NOx	0.49	350	1900		0.15322381		291.1	170.66	0.102	0.060	**0.162**
		PM	0.49	350		0.213		0.31765428	67.6	29.23	0.024	0.010	**0.034**

Key

green	output from MM Roads
blue	calculated
black	given data & inputs

Results are for free flowing 50km/h traffic in both directions.

Source: Tunnel Ventilation Design Team using Mott Tunnel Roads model

Figure A.2: Tunnel flowrate and total pollutant emissions from portal

Purpose:

Calculate emissions in g/s from the portals. No ventilation shafts so all emissions are from portals.

Background pollution level is for 2011 (MM Air Quality & Carbon Team source attached).

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Time	Direction	Pollutant	Tunnel Airspeed at Exit Portal	Tunnel Flowrate	Pollutant Density		In tunnel end pollution level due to vehicles			Background pollution	Emitted pollution from portal due to vehicles	Emitted pollution from portal due to background pollution	**Total emitted pollution from portal**
Source →			Roads	Roads	PIARC	PIARC	Roads	Roads	= F * H or G * I	Appendix 2	= E * J / 10^6	= E * K / 10^6	= L + M
Units →			m/s	m^3/s	g/m^3	g/m^2	ppm	x10^{-3}m^{-1}	ug/m^3	ug/m^3	g/s	g/s	**g/s**
AM Peak	Northbound	CO	3.241	297.56	1200		0.29368049		352.4	301.0792025	0.105	0.090	**0.194**
		NOx	3.241	297.56	1900		0.21917348		416.4	170.6559611	0.124	0.051	**0.175**
		PM	3.241	297.56		0.213		0.35193777	74.9	29.23252371	0.022	0.009	**0.031**
	Southbound	CO	-2.815	281.26	1200		0.32028559		384.3	301.0792025	0.108	0.085	**0.193**
		NOx	-2.815	281.26	1900		0.19185422		364.5	170.6559611	0.103	0.048	**0.151**
		PM	-2.815	281.26		0.213		0.39791954	84.7	29.23252371	0.024	0.008	**0.032**
Inter Peak	Northbound	CO	3.244	297.81	1200		0.25483522		305.8	301.0792025	0.091	0.090	**0.181**
		NOx	3.244	297.81	1900		0.20965566		398.3	170.6559611	0.119	0.051	**0.169**
		PM	3.244	297.81		0.213		0.31605962	67.2	29.23252371	0.020	0.009	**0.029**
	Southbound	CO	-3.265	326.19	1200		0.20834917		250.0	301.0792025	0.082	0.098	**0.180**
		NOx	-3.265	326.19	1900		0.17271236		328.2	170.6559611	0.107	0.056	**0.163**
		PM	-3.265	326.19		0.213		0.34553573	73.5	29.23252371	0.024	0.010	**0.034**
PM Peak	Northbound	CO	1.985	182.23	1200		0.25117722		301.4	301.0792025	0.055	0.055	**0.110**
		NOx	1.985	182.23	1900		0.12519969		237.9	170.6559611	0.043	0.031	**0.074**
		PM	1.985	182.23		0.213		0.24495177	52.1	29.23252371	0.009	0.005	**0.015**
	Southbound	CO	-2.796	279.35	1200		0.32302168		387.6	301.0792025	0.108	0.084	**0.192**
		NOx	-2.796	279.35	1900		0.19154133		363.9	170.6559611	0.102	0.048	**0.149**
		PM	-2.796	279.35		0.213		0.39716193	84.5	29.23252371	0.024	0.008	**0.032**

Key

green	output from MM Roads
blue	calculated
black	given data & inputs

Results are for free flowing 50km/h traffic in both directions.

Source: Tunnel Ventilation Design Team using Mott Tunnel Roads model

Appendix B. Model Results – Annual Mean NO_2 Data Tables

B.1. Option 1: Pollutants Emitted from Vent Station Stack

Table B.1: Annual mean NO_2 concentrations (µg/m^3) (including background (BG)) at sensitive receptors for the range of modelled stack heights

Receptor Location				Annual Mean NO_2 concentration (including background) at Stack Height (m)...									
Receptor name	X(m)	Y(m)	Z(m)	16	17	18	19	20	21	22	23	24	25
Annandale School	539696	179100	2	38.63	38.63	38.63	38.63	38.63	38.63	38.63	38.63	38.63	38.63
A2203/Salutation Rd	539567	178799	2	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62
Tunnel Ave 1	539512	178920	2	38.63	38.63	38.63	38.63	38.62	38.62	38.62	38.62	38.62	38.62
Tunnel Ave 2	539539	178865	1	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62
Davern Road 1	539594	178632	2	38.62	38.62	38.62	38.62	38.62	38.61	38.61	38.61	38.61	38.61
Davern Road 2	539618	178631	2	38.62	38.62	38.62	38.62	38.62	38.61	38.61	38.61	38.61	38.61
Cinema	539826	178753	5	38.62	38.62	38.62	38.61	38.61	38.61	38.61	38.61	38.61	38.61
Sainsburys	540085	178635	1	38.61	38.61	38.61	38.61	38.61	38.61	38.61	38.61	38.61	38.61
Ecology Park	539948	179196	5	38.63	38.63	38.63	38.63	38.63	38.63	38.62	38.62	38.62	38.62
Dome	539226	179990	10	38.67	38.67	38.66	38.66	38.66	38.66	38.66	38.66	38.66	38.66
Faraday School	539519	180744	4	38.65	38.64	38.64	38.64	38.64	38.64	38.64	38.64	38.64	38.64
Halsville School	540067	181236	1	38.64	38.64	38.64	38.64	38.64	38.64	38.64	38.64	38.64	38.64
St Lukes School	539830	181272	2	38.63	38.63	38.63	38.62	38.62	38.62	38.62	38.62	38.62	38.62
Keir Hardie Rec	539868	181067	1	38.64	38.64	38.64	38.64	38.64	38.64	38.64	38.64	38.64	38.63
Holiday Inn North	539690	181113	2	38.63	38.63	38.63	38.63	38.63	38.63	38.63	38.62	38.62	38.62
Silvertown Way Flats	540089	180444	4	38.73	38.72	38.72	38.71	38.71	38.7	38.7	38.7	38.69	38.69
Victoria Dock Road 2	539834	180872	3	38.66	38.66	38.66	38.66	38.65	38.65	38.65	38.65	38.65	38.65
Victoria Dock Road 1	539910	180842	2	38.68	38.68	38.68	38.67	38.67	38.67	38.67	38.67	38.66	38.66
Watersports Centre	540004	180628	2	39.11	39.08	39.12	39.02	38.99	38.97	38.94	38.91	38.88	38.86
Seagull Lane Flats	540105	180743	3	38.84	38.83	38.85	38.82	38.81	38.80	38.80	38.79	38.78	38.78

Receptor Location				Annual Mean NO_2 concentration (including background) at Stack Height (m)...									
Victoria Dock Road 3	539884	180848	3	38.67	38.67	38.67	38.67	38.66	38.66	38.66	38.66	38.66	38.65
Soccerdome	539486	179676	3	38.75	38.75	38.75	38.75	38.74	38.74	38.74	38.74	38.73	38.73
JH Way Flat GF Balc	539727	179163	3	38.63	38.63	38.63	38.63	38.63	38.63	38.63	38.63	38.63	38.63
Health Centre 1	539760	179049	2	38.63	38.63	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62
Health Centre 2	539776	178987	1	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62
Holiday Inn South	539615	178963	2	38.63	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62	38.62

Table B.2: Annual mean NO_2 impacts (µg/m^3) with a stack height of 16m

Receptor Name	BG Only	Stack + BG	Concentration Change	Magnitude of Change	Comparison with AQO	Significance of Change
Annandale School	38.6	38.63	0.032	Imperceptible	Just Below	Negligible
A2203/Salutation Rd	38.6	38.62	0.022	Imperceptible	Just Below	Negligible
Tunnel Ave 1	38.6	38.63	0.032	Imperceptible	Just Below	Negligible
Tunnel Ave 2	38.6	38.62	0.022	Imperceptible	Just Below	Negligible
Davern Road 1	38.6	38.62	0.022	Imperceptible	Just Below	Negligible
Davern Road 2	38.6	38.62	0.022	Imperceptible	Just Below	Negligible
Cinema	38.6	38.62	0.022	Imperceptible	Just Below	Negligible
Sainsburys	38.6	38.61	0.012	Imperceptible	Just Below	Negligible
Ecology Park	38.6	38.63	0.032	Imperceptible	Just Below	Negligible
Dome	38.6	38.67	0.072	Imperceptible	Just Below	Negligible
Faraday School	38.6	38.65	0.052	Imperceptible	Just Below	Negligible
Halsville School	38.6	38.64	0.042	Imperceptible	Just Below	Negligible
St Lukes School	38.6	38.63	0.032	Imperceptible	Just Below	Negligible
Keir Hardie Rec	38.6	38.64	0.042	Imperceptible	Just Below	Negligible
Holiday Inn North	38.6	38.63	0.032	Imperceptible	Just Below	Negligible
Silvertown Way Flats	38.6	38.73	0.132	Imperceptible	Just Below	Negligible
Victoria Dock Road 2	38.6	38.66	0.062	Imperceptible	Just Below	Negligible
Victoria Dock Road 1	38.6	38.68	0.082	Imperceptible	Just Below	Negligible
Watersports Centre	38.6	39.11	0.512	Small	Just Below	Slight Adverse
Seagull Lane Flats	38.6	38.84	0.242	Imperceptible	Just Below	Negligible

Receptor Name	BG Only	Stack + BG	Concentration Change	Magnitude of Change	Comparison with AQO	Significance of Change
Victoria Dock Road 3	38.6	38.67	0.072	Imperceptible	Just Below	Negligible
Soccerdome	38.6	38.75	0.152	Imperceptible	Just Below	Negligible
JH Way Flat GF Balc	38.6	38.63	0.032	Imperceptible	Just Below	Negligible
Health Centre 1	38.6	38.63	0.032	Imperceptible	Just Below	Negligible
Health Centre 2	38.6	38.62	0.022	Imperceptible	Just Below	Negligible
Holiday Inn South	38.6	38.63	0.032	Imperceptible	Just Below	Negligible

B.2. Option 2: Pollutants Emitted from Tunnel Portals - Line Source Method

Table B.3: Annual mean NO_2 impacts (µg/m^3) with portal emissions modelled as a line source

Receptor Name	BG Only	Portals + BG	Concentration Change	Magnitude of Change	Comparison with AQO	Significance of Change
Annandale School	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
A2203/Salutation Rd	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Tunnel Ave 1	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Tunnel Ave 2	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Davern Road 1	38.6	38.6	0.0	Imperceptible	Just Below	Negligible
Davern Road 2	38.6	38.6	0.0	Imperceptible	Just Below	Negligible
Cinema	38.6	38.6	0.0	Imperceptible	Just Below	Negligible
Sainsburys	38.6	38.6	0.0	Imperceptible	Just Below	Negligible
Ecology Park	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Dome	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Faraday School	38.6	38.8	0.2	Imperceptible	Just Below	Negligible
Halsville School	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
St Lukes School	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Keir Hardie Rec	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Holiday Inn North	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Silvertown Way Flats	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
Victoria Dock Road 2	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
Victoria Dock Road 1	38.6	39.1	0.5	Small	Just Below	Slight Adverse
Watersports Centre	38.6	39.7	1.1	Small	Just Below	Slight Adverse

Receptor Name	BG Only	Portals + BG	Concentration Change	Magnitude of Change	Comparison with AQO	Significance of Change
Seagull Lane Flats	38.6	39.0	0.4	Small	Just Below	Slight Adverse
Victoria Dock Road 3	38.6	39.0	0.4	Small	Just Below	Slight Adverse
Soccerdome	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
JH Way Flat GF Balc	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Health Centre 1	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Health Centre 2	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Holiday Inn South	38.6	38.7	0.1	Imperceptible	Just Below	Negligible

B.3. Option 2: Pollutants Emitted from Tunnel Portals - Volume Source Method

Table B.4: Annual mean NO_2 impacts (µg/m^3) with portal emissions modelled as a volume source

Receptor Name	BG Only	Portals + BG	Concentration Change	Magnitude of Change	Comparison with AQO	Significance of Change
Annandale School	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
A2203/Salutation Rd	38.6	38.8	0.2	Imperceptible	Just Below	Negligible
Tunnel Ave 1	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
Tunnel Ave 2	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
Davern Road 1	38.6	38.8	0.2	Imperceptible	Just Below	Negligible
Davern Road 2	38.6	38.8	0.2	Imperceptible	Just Below	Negligible
Cinema	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Sainsburys	38.6	38.7	0.1	Imperceptible	Just Below	Negligible
Ecology Park	38.6	38.8	0.2	Imperceptible	Just Below	Negligible
Dome	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
Faraday School	38.6	39.1	0.5	Small	Just Below	Slight Adverse
Halsville School	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
St Lukes School	38.6	38.8	0.2	Imperceptible	Just Below	Negligible
Keir Hardie Rec	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
Holiday Inn North	38.6	38.8	0.2	Imperceptible	Just Below	Negligible
Silvertown Way Flats	38.6	39.3	0.7	Small	Just Below	Slight Adverse
Victoria Dock Road 2	38.6	39.4	0.8	Small	Just Below	Slight Adverse
Victoria Dock Road 1	38.6	40.0	1.4	Small	Above Standard	Slight Adverse

Receptor Name	BG Only	Portals + BG	Concentration Change	Magnitude of Change	Comparison with AQO	Significance of Change
Watersports Centre	38.6	40.9	2.3	Medium	Above Standard	Moderate Adverse
Seagull Lane Flats	38.6	39.7	1.1	Small	Just Below	Slight Adverse
Victoria Dock Road 3	38.6	39.8	1.2	Small	Just Below	Slight Adverse
Soccerdome	38.6	39.6	1.0	Small	Just Below	Slight Adverse
JH Way Flat GF Balc	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
Health Centre 1	38.6	38.9	0.3	Imperceptible	Just Below	Negligible
Health Centre 2	38.6	38.8	0.2	Imperceptible	Just Below	Negligible
Holiday Inn South	38.6	38.9	0.3	Imperceptible	Just Below	Negligible

D.8. Tunnel Ventilation Report

Silvertown Tunnel

Tunnel Ventilation Analysis

June 2013

Mott MacDonald

Silvertown Tunnel

Tunnel Ventilation Analysis

June 2013

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1.0	19/04/13	J Bristow	D Eckford	R Hall	First issue
2.0	24/06/13	S Johnson	D Eckford	R Hall	Response to TfL Comments

Contents

Executive Summary

A new tunnel under the River Thames is proposed in East London, between Silvertown and North Greenwich. An analysis of the proposed Silvertown tunnel was performed to determine the ventilation requirements during normal, congested and incident operations.

External and internal pollution limits determined the necessary capacity for normal tunnel operations. The critical velocity determined the in-tunnel jet fan requirement for a fire scenario.

A one dimensional bulk flow analysis was used to assess the effect of the ventilation system. Normal and congested traffic operations were simulated in Mott MacDonald's Roads program. Fire scenarios were simulated in Mott MacDonald's Hotflow program.

Simulations for normal operations showed that an extraction rate of 400 m^3/s would be required to prevent any pollution emission from the portals. The tunnel was also modelled without an extraction system and pollution emissions from the portals were determined.

Congested operations simulations showed that the ventilation stacks alone could not maintain safe in tunnel pollution levels in all scenarios. Operation of jet fans was able to reduce in tunnel limits to significantly below safe recommended levels.

Fire simulations found that twenty installed jet fans per bore providing 1356 N thrust each were needed to control the movement of smoke from a design fire size of 100 MW.

1 Abbreviations

1-D	One dimensional
A.M.	Ante meridiem
CO	Carbon monoxide
CP	Cross passage
DEFRA	Department for Environment, Food & Rural Affairs
EE	Emergency Exit
HGV	Heavy goods vehicle
LDV	Light duty vehicle
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
PC	Private Car
PIARC	World Road Association
PM	Particulate matter
P.M.	Post meridiem

2 Introduction

2.1 Background

In 2012 Mott MacDonald undertook tunnel engineering design for the Silvertown tunnel crossing study. This study considered both bored and immersed tube tunnel options.

In February 2013 Mott MacDonald was commissioned to further develop the engineering design of the bored tunnel option for the proposed Silvertown Tunnel. Part of the scope of this work was the development of the mechanical and electrical design, including the tunnel ventilation systems. This report presents the tunnel ventilation analysis undertaken to size the ventilation equipment.

This report will form an appendix to the Silvertown Tunnel - Further development of Tunnel Engineering for Bored Tunnel Solution, hereafter referred to as the main report. [1]

2.2 Purpose

The purpose of this study was to size the capacity of the ventilation system for normal, congested and incident operations.

Predictions of pollution emissions from the tunnel were also required as part of the air quality modelling study (appendix D.7 of the main report). The environmental impact results from this study were used in conjunction with the ventilation modelling analysis to size the tunnel ventilation requirements for normal operations.

Predictions of in-tunnel pollution levels were used to ensure that the tunnel ventilation system was able to keep pollution levels below the minimum levels required for tunnel users' safety.

Smoke control simulations were required to determine the necessary jet fan size and locations to provide tenable conditions upstream of a fire.

2.3 Scope

This study covered the 1-D modelling of the tunnel for in tunnel pollution levels. It covered two different ventilation options. It did not cover external pollution dispersion, or the determination of the ventilation stack height, both of which are modelled as part of the air quality modelling study [2].

The smoke control modelling was performed with a 100MW fire only. This was the design fire size proposed for the Silvertown tunnel in the fire life safety section of the main report.

This study determined ventilation capacity (e.g. air flow rates) only. Plant room space proofing and fan selection will be undertaken as part of the design in the main report.

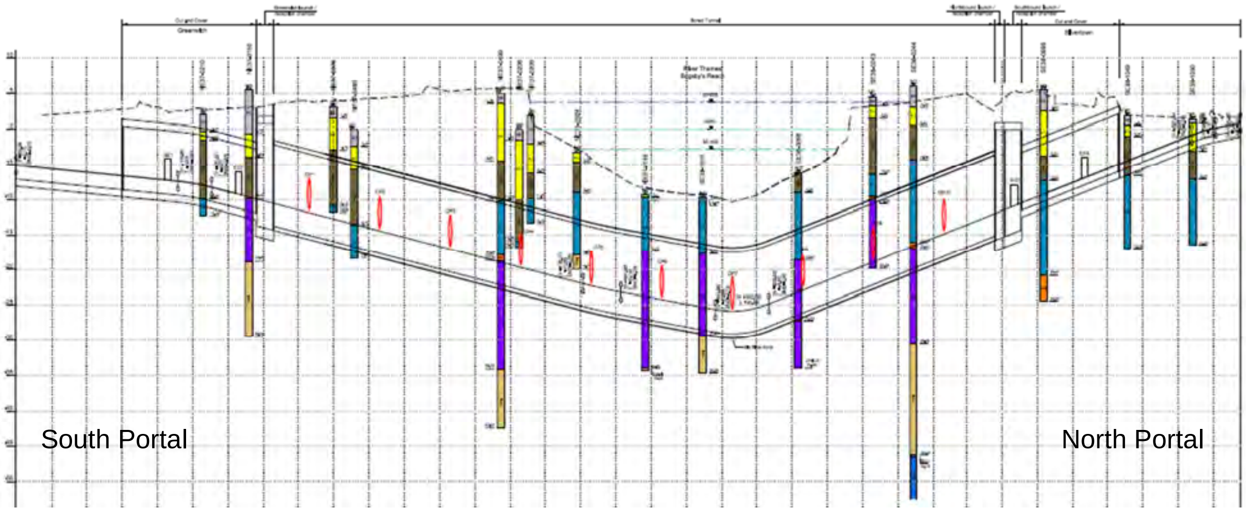
3 System description

3.1 Tunnel Geometry

The Silvertown tunnel will be a two lane twin bore tunnel under the River Thames between North Greenwich on the South side and Silvertown on the North side. The Southern end of the tunnel will consist of approximately 200m of cut and cover tunnel. A central bored section 1km in length will extend under the river. The Northern end will be a further 200m of cut and cover section. The two bores will be connected by cross passages for emergency use. These will normally be shut and only opened for evacuation in the event of a fire.

The vertical alignment of the Silvertown tunnel is shown in figure 3.1.

Figure 3.1: Vertical Alignment of the Silvertown Tunnel



Source: Appendix A of the main report [1]

The section types are described below in table 3.1. The cross section areas of the cut and cover will vary along the tunnel. All values were calculated from the drawings contained in appendix A of the main report.

Table 3.1: Tunnel section types

Location	Mean length	Mean area	Mean perimeter	Friction factor	Gradient (northbound)
	m	m^2	m	-	%
Greenwich cut & cover	100	99.9	45.4	0.0065	-1.000
	115	99.9	45.4	0.0065	-2.600
Bored section	465	64.1	31.5	0.0062	-2.600
	200	64.1	31.5	0.0062	-1.848
	360	64.1	31.5	0.0062	4.000
Silvertown cut & cover	170	91.8	41.4	0.0067	4.000

3.2 Ventilation system

3.2.1 Option 1: Ventilation stacks

An extraction system consisting of extract fans located in a ventilation stack would be located close to the exit portals. The system would provide sufficient flow to ensure inflow at the exit portals, so that all pollutants would be emitted to atmosphere from the ventilation stacks and not the portals.

3.2.2 Option 2: No ventilation stacks

The second option would involve no extraction system at the portals. In free flowing traffic pollutants would be emitted from the exit portals to atmosphere by the flow induced by the piston effect of free flowing traffic.

3.2.3 Jet fans

Both options would contain jet fans for longitudinal ventilation. These would be used to control smoke during a fire scenario, in order to provide tenable conditions upstream of a fire. They would also operate during congested traffic to reduce pollution levels in the tunnel.

4 Methodology

4.1 Tunnel Ventilation Analysis

The analysis used Mott MacDonald's in-house software to simulate performance of the ventilation system through a one dimensional (1-D) model of the tunnel. The software components are Roads and Hotflow.

The Roads program is used to calculate pollution levels throughout a tunnel network. It can calculate the air velocities in any 1-D network of tunnels by solving the unsteady compressible equations for conservation of mass and momentum. The method of characteristics is used to solve these equations through time. Traffic is added to this 1-D model as sources of momentum within the tunnel network. Pollution levels are calculated based on emission rates per vehicle at each time step. The aerodynamic part of the Roads program is identical to the rail tunnel program within Mott MacDonald's in-house tunnel software which has been extensively validated over the last thirty years.

The Hotflow software is used to calculate the effect of a fire on air and heat flow through a tunnel network using steady state methods to calculate air flows. Hotflow calculates transient heat conduction in the lining near the tunnel wall, and transient distribution of heat and combustion products in the air passing through the tunnels.

A model of the tunnel was created in the Roads software using the latest available drawings as detailed in the main report appendix A. The model included the Northbound and Southbound bores, extract flows at proposed stack locations and tunnel jet fans. Traffic flows were added to the model according to predicted traffic flow rates and predicted pollution standards for 2026. The World Road Association's (PIARC) 2012 data for emission standards from vehicles in tunnels was used to calculate each vehicle's emissions. [3]

A series of cases was set up to simulate traffic flows under normal operation. The Roads software was used to calculate the carbon monoxide, nitrogen oxides and particulate matter emissions from the vehicles. Cases both with and without forced extraction were modelled. In extraction cases the model was iterated to obtain a minimum inflow in excess of 0.5 m/s. The results were used to calculate the necessary flow rate to prevent emissions from the portals. The height of the stack will be determined by the air quality modelling analysis and has no effect on the ventilation modelling.

The Roads model was modified for use by the Hotflow program to simulate fire scenarios. The modified model included cross passages between the bores which were opened during a fire. Jet fans were modelled along the tunnel at regular intervals. Jet fans induced flow in the direction of traffic movement.

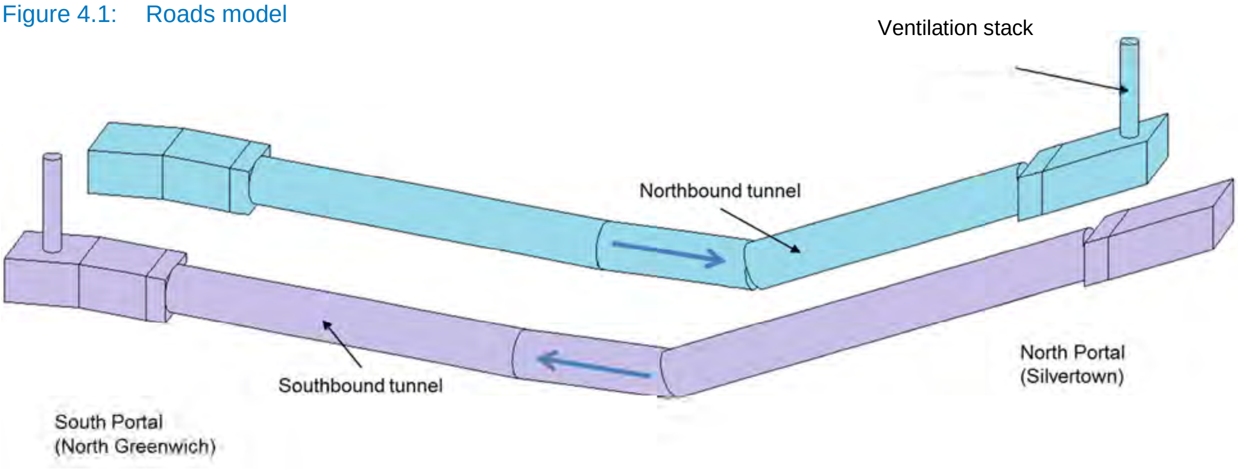
A series of cases was set up with a 100 MW fire located at different points along the tunnel. The number of jet fans and their thrust were iterated to ensure that the critical velocity was exceeded at all fire locations. The results gave the requirements and spacing of the jet fans necessary to achieve satisfactory smoke control for the design fire size.

The jet fan arrangement determined from the Hotflow model was then simulated in the Roads model during congested operation. The piston effect is reduced or non-existent when traffic is stationary. Therefore fans are required to force air through the tunnel towards the exit portal. The different cases were used to simulate the effect of the jet fans on reducing in tunnel pollution levels to confirm that pollution levels remained within accepted limits.

4.2 Roads model

The Roads model consists of two bores which are not connected. Each bore contains a ventilation stack to represent the extraction system. The Southbound bore is 20m longer than the Northbound bore due to tunnel curvature. This arrangement is shown in figure 4.1.

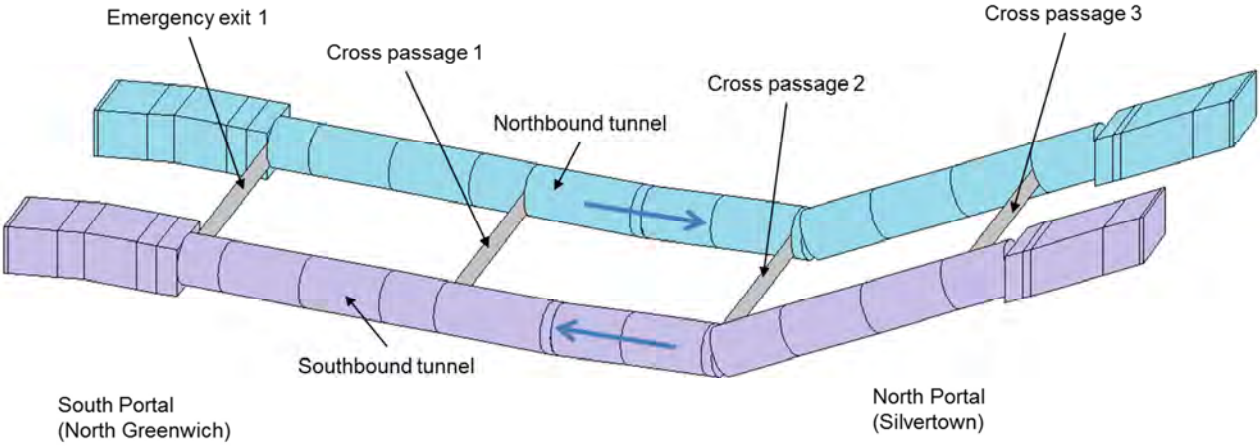
Figure 4.1: Roads model



4.3 Hotflow model

The Hotflow model consists of two bores of equal length connected by three cross passages and one emergency exit. This arrangement is shown in figure 4.2. For modelling purposes the emergency exit in the cut and cover section is treated as a cross passage. The average length of the tunnel bores in the Roads model is used as the length of each bore in the Hotflow model. This is because the Hotflow software requires the model to have compatible 3D geometry to take account of gradient. The ventilation stacks were closed during fire cases and not modelled. A 15 Pa adverse portal pressure was applied to the Silvertown end for Northbound cases and to the North Greenwich end for Southbound cases.

Figure 4.2: Hotflow model



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5 Performance Criteria

This section describes the performance criteria used to assess the simulations.

5.1 In-tunnel pollution limits

In tunnel pollution limits were defined by PIARC [3]. A case was considered unacceptable if any of the limits shown in Table 5.1 were exceeded.

Table 5.1: In tunnel pollution limits

Traffic situation		Pollutant	
	CO	NO_2	PM
	ppm	ppm	10^{-3} m^{-1}
Free flowing 50 – 100 km/h	70	1	5
Congested traffic stopped on all lanes	70	1	7
Threshold values for tunnel closure	200	1	12

Source: PIARC – Road Tunnels: Vehicle Emissions and Air Demand for Ventilation 2012, Table 3 & 2.5.3

5.2 Critical velocity

The jet fans must be able to induce sufficient flow to prevent smoke back layering. This is determined by the critical velocity, which is calculated using the Kennedy formula. [4] It was assumed that the blockage ratio due to vehicles was very low and therefore the free tunnel area was taken to be the cross section area. The critical velocities which must be exceeded at each fire location are given below in table 5.2.

Table 5.2: Critical velocities for 100 MW fire

Fire location	Critical velocity	
	Northbound	Southbound
	m/s	m/s
North Greenwich cut & cover	3.28	2.98
Bored tunnel	3.28	3.48
Silvertown cut & cover	2.98	3.40

6 Design input data and assumptions

6.1 Traffic

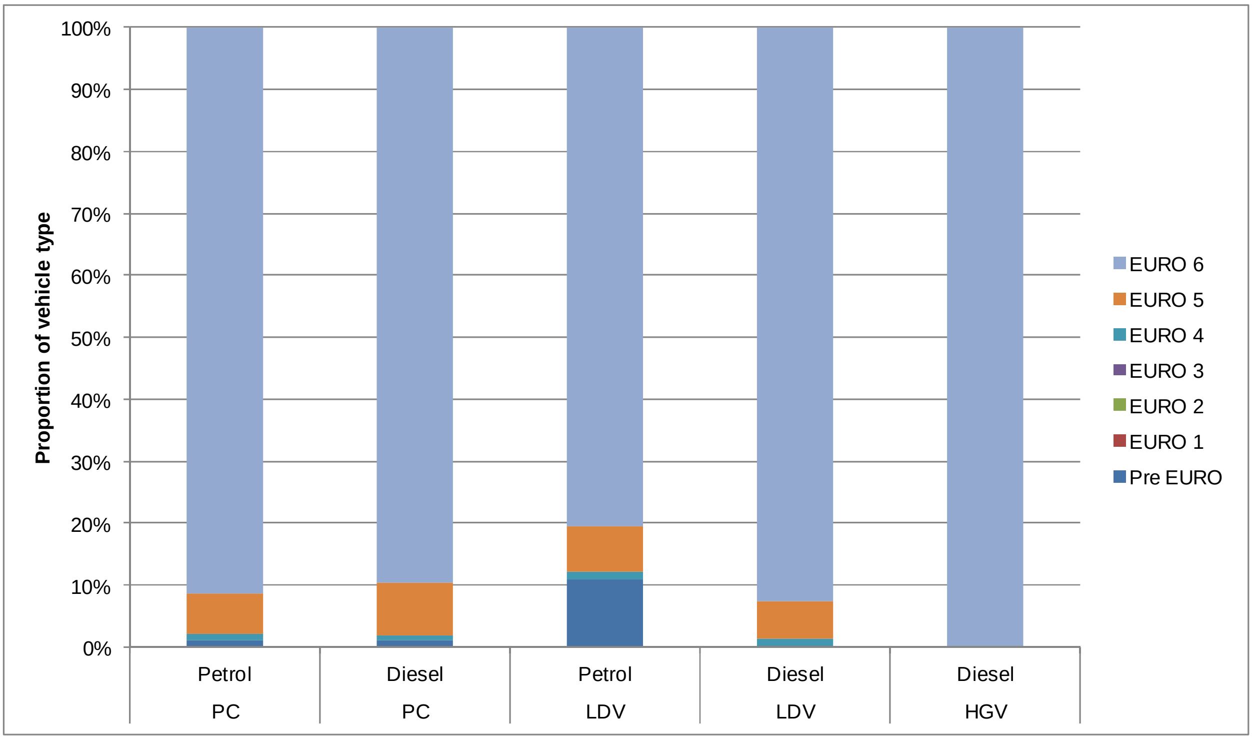
Predictions for traffic flows were made in the Network and Development Forecasting Report. [5] The £1 toll option 5b was used as the case with the largest predicted flows, which is shown in table 6.1. Four buses per hour were added to the HGV values to account for anticipated bus routes through the tunnel.

Table 6.1: Predicted number of vehicles per hour

	Predicted number of vehicles per hour					
	AM		Inter peak		PM	
Type	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
PC	1258	1551	1015	1023	708	1546
LDV	112	190	81	198	54	202
HGV	134	63	156	199	9	56
Total	1504	1804	1252	1420	771	1804

The vehicle flows were split according to EURO vehicle emissions standard. The predicted vehicle splits in 2026 were taken from data provided by the Department for Environment, Food and Rural Affairs (DEFRA) [6] and are shown in Figure 6.1. Emissions factors for each vehicle type were sourced from PIARC. [3]

Figure 6.1: Predicted EURO standard split for 2026



Source: DEFRA Emissions Factor Toolkit version 5.2c

Vehicles were split across two lanes per bore. The number of vehicles of each EURO standard was always rounded up to the nearest integer because vehicles must be added to Roads as integers. Therefore slightly more vehicles were modelled than predicted in the May 2010 report, as shown in table 6.2.

Table 6.2: Modelled number of vehicles per hour

	Modelled number of vehicles per hour					
	AM		Inter peak		PM	
Type	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
PC	1263	1554	1019	1027	712	1550
LDV	116	194	86	201	59	207
HGV	134	63	156	199	9	56
Total	1513	1811	1261	1427	780	1813

For stationary traffic a maximum vehicle density of 165 vehicles per lane per kilometre was imposed. [3] The vehicles types were split according to the proportions for free flowing traffic.

6.2 Pollution

Pollution emission rates in the PIARC report are given in grams/second of NO_X, which consists of NO and NO_2. NO by itself is not considered harmful, but NO_2 is noxious. Pollution level limits were imposed for NO_2 only. It was assumed for this study that NO_X is formed of 25% NO_2 and 75% NO. [3]

Background pollution levels were received from the air quality modelling study. [2] These are shown in Table 6.3.

Table 6.3: Background Pollution levels

Pollutant	Background level		
	ug/m^3	ppm	10^{-3} m^{-1}
Carbon monoxide	301.1	0.2509	N/A
Nitrogen oxides	170.7	0.0898	N/A
Particulate matter	29.2	N/A	0.1374

Source: Air quality Modelling Technical Appendix [2]

7 Design Cases

A description of the different Roads cases simulated is described in table 7.1.

Table 7.1: Roads simulation cases

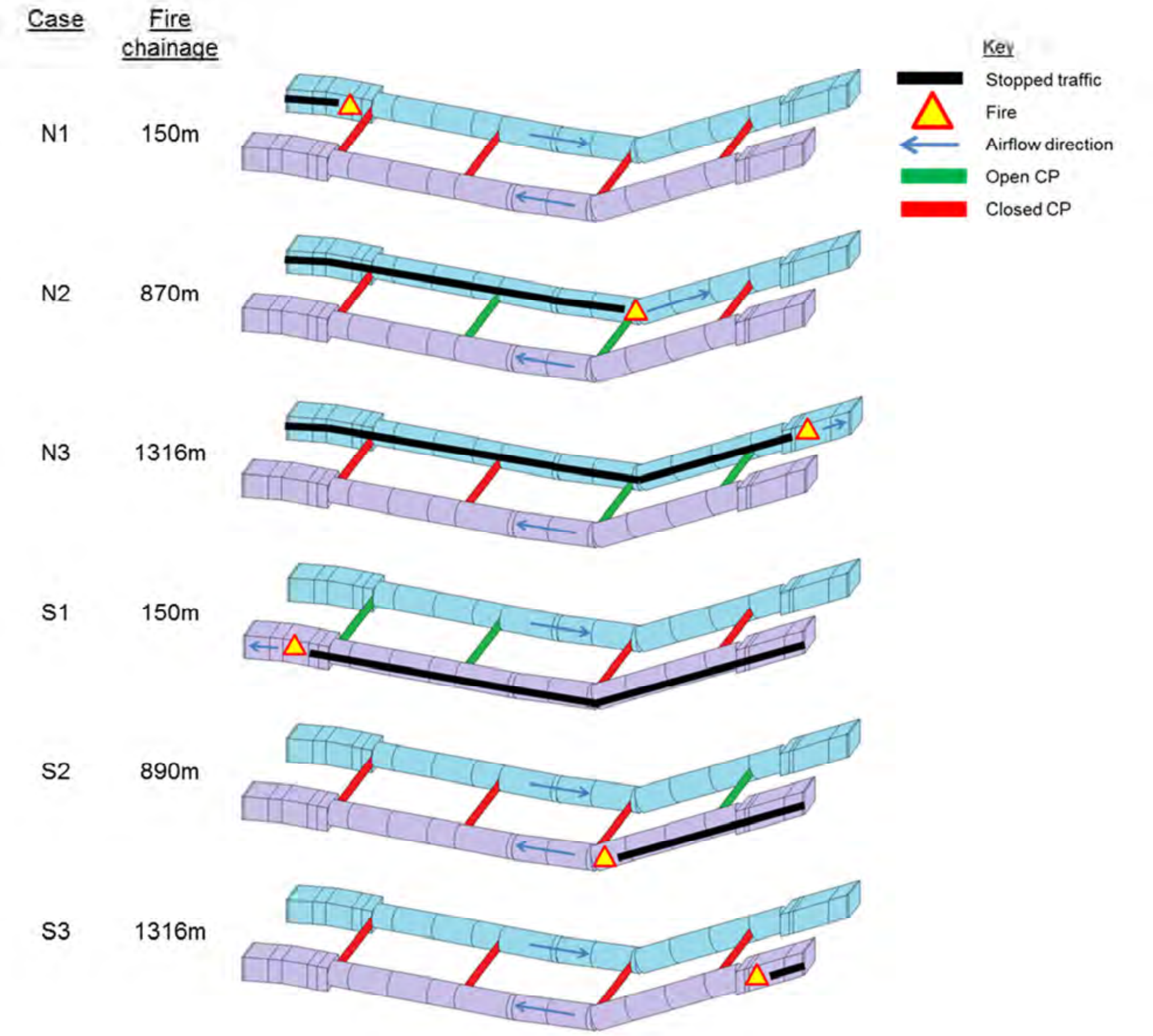
Case	Time	Stack Status	Traffic speed	Jet fans
			km/h	
C11	A.M. peak	Open	50	No
C12	Inter peak	Open	50	No
C13	P.M. peak	Open	50	No
C21	A.M. peak	Closed	50	No
C22	Inter peak	Closed	50	No
C23	P.M. peak	Closed	50	No
C31	A.M. peak	Open	0	No
C41	A.M. peak	Open	0	Yes
C51	A.M. peak	Closed	0	Yes

A description of the different Hotflow cases simulated is described in table 7.2 and shown in figure 7.1.

Table 7.2: Hotflow simulation cases

Case	Fire location		CPs open
	Bore	Chainage	
		m from South Portal	
N1	Northbound	150	None
N2	Northbound	870	CP1 & CP2
N3	Northbound	1316	CP2 & CP3
S1	Southbound	150	EE1 & CP1
S2	Southbound	890	CP3
S3	Southbound	1316	None

Figure 7.1: Fire cases



8 Results

8.1 External pollution

The results in this section were primarily for use by the air quality modelling study. [2] The pollution mass flow rate and emission velocity are shown in table 8.1 and table 8.2 for option 1 and option 2 respectively. Tunnel airspeeds are positive in the direction of traffic flow.

Table 8.1: Pollution emissions for option 1

Time	Direction	Pollutant	Portal airspeed	Stack flow rate	Stack emission
			m/s	m^3/s	g/s
A.M. Peak	Northbound	CO	-0.86	400	0.225
		NO_X	-0.86	400	0.192
		PM	-0.86	400	0.034
	Southbound	CO	-0.48	350	0.214
		NO_X	-0.48	350	0.162
		PM	-0.48	350	0.034
Inter Peak	Northbound	CO	-0.88	400	0.212
		NO_X	-0.88	400	0.187
		PM	-0.88	400	0.032
	Southbound	CO	-0.51	400	0.202
		NO_X	-0.51	400	0.176
		PM	-0.51	400	0.036
P.M. Peak	Northbound	CO	-0.57	250	0.130
		NO_X	-0.57	250	0.086
		PM	-0.57	250	0.017
	Southbound	CO	-0.49	350	0.214
		NO_X	-0.49	350	0.162
		PM	-0.49	350	0.034

The results from option 1 show that the portal extraction flow rate should be 400 m^3/s per bore. A typical fan arrangement for each stack to provide this flow would consist of five 2.5m diameter axial fans with a flow rate of 100 m^3/s and a motor rating of 121 kW. [7] One axial fan would be for redundancy.

Table 8.2: Pollution emissions for option 2

Time	Direction	Pollutant	Portal airspeed m/s	Tunnel flow rate m^3/s	Portal emission g/s
A.M. Peak	Northbound	CO	3.24	297.56	0.194
		NO_X	3.24	297.56	0.175
		PM	3.24	297.56	0.031
	Southbound	CO	2.82	281.26	0.193
		NO_X	2.82	281.26	0.151
		PM	2.82	281.26	0.032
Inter Peak	Northbound	CO	3.24	297.81	0.181
		NO_X	3.24	297.81	0.169
		PM	3.24	297.81	0.029
	Southbound	CO	3.27	326.19	0.180
		NO_X	3.27	326.19	0.163
		PM	3.27	326.19	0.034
P.M. Peak	Northbound	CO	1.99	182.23	0.110
		NO_X	1.99	182.23	0.074
		PM	1.99	182.23	0.015
	Southbound	CO	2.78	279.35	0.192
		NO_X	2.78	279.35	0.149
		PM	2.78	279.35	0.032

The results for option 2 show that without the portal extract stack there was a flow out of the tunnel in the direction of travel due to the piston effect. Therefore all of the pollution emissions flowed out at the exit portals. The mass flow rate of pollutants emitted was very similar in both options 1 and 2. The vehicles modelled within the tunnel were unchanged. The difference was due to an increased flow rate of air in option 1 due to the ventilation stack.

8.2 In-tunnel pollution

8.2.1 50 km/h free flow traffic

For 50 km/h traffic flow the jet fans did not operate. Two cases were run for each time period; one with ventilation stacks and one without. Concentration levels given include background levels. Table 8.3 shows the predicted maximum in-tunnel pollutant levels for free flowing traffic with the ventilation stack flow rates as shown in table 7.1.

Table 8.3 shows the predicted maximum in-tunnel pollutant levels for free flowing traffic.

Table 8.3: Maximum in tunnel pollutant level for 50km/h free flowing traffic, jet fans off.

Time	Stack	NO_2		CO		PM	
		Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
		ppm	ppm	ppm	ppm	x10^{-3} m^{-1}	x10^{-3} m^{-1}
Limit	-	1	1	70	70	5	5
Background	-	0.022	0.022	0.251	0.251	0.137	0.137
A.M. peak	Yes	0.074	0.068	0.529	0.558	0.471	0.519
Inter peak	Yes	0.072	0.064	0.492	0.451	0.437	0.470
P.M. peak	Yes	0.052	0.068	0.488	0.560	0.369	0.518
A.M. peak	No	0.077	0.071	0.545	0.572	0.489	0.536
Inter peak	No	0.075	0.066	0.506	0.460	0.453	0.484
P.M. peak	No	0.054	0.070	0.503	0.575	0.383	0.535

The results for free flowing traffic show that the maximum in tunnel levels were significantly below the pollution limits. They also show that the addition of the ventilation stack extraction had very little impact on the maximum pollutant level inside the tunnel. The stack flow rates were as shown in table 8.1.

8.2.2 Congested traffic

For congested cases traffic was at a standstill. Case C31 used the maximum stack extraction only. Case C41 used the maximum stack extraction and jet fans. Case C51 used the maximum number of jet fans only and all pollution was emitted at the exit portals. Concentration levels given include background levels.

Table 8.4: Maximum in tunnel pollution levels for different ventilation scenarios for AM peak congested traffic.

Case	Stack	Jet fans	NO_2		CO		PM	
			Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
			ppm	ppm	ppm	ppm	x10^{-3} m^{-1}	x10^{-3} m^{-1}
Limit	-	-	1	1	70	70	7	7
Background	-	-	0.022	0.022	0.251	0.251	0.137	0.137
C31	Yes	No	1.426	0.902	3.322	3.486	1.195	0.750
C41	Yes	Yes	0.223	0.135	0.690	0.664	0.289	0.216
C51	No	Yes	0.228	0.138	0.702	0.674	0.293	0.218

The results show that the extract stack alone was unable to keep nitrogen dioxide levels below the limit for the Northbound case. The jet fans were able to maintain in tunnel levels significantly below the limits. Depending on traffic levels a proportion of the jet fans operating would be able to maintain in tunnel pollution levels below the limits.

8.3 Fire cases

Three fire cases were assessed in each bore. The number of fans and their thrust value were iterated until the critical velocity was exceeded. The extract stack was not open during incident cases and all flow was emitted at the exit portals. Three jet fans were assumed to be inactive for the fire simulations. This was because the two closest to the fire could be damaged by the heat and one other was assumed to be unavailable due to maintenance.

It was found that there was a very large fan requirement to exceed the critical velocity in the cut and cover sections. This was because the cut and cover sections had a much larger cross sectional area than the bored section. Therefore the area of the cut and cover sections were reduced. This was achieved by reducing the width of the pavement to the minimum indicated on the drawings. In reality this could be achieved through panelling, which would maintain a near constant cross section area of the tunnel. The reduced cut and cover section area was 72.5 m^2. No other changes were made to the model.

The reduced area required for fire purposes was not observed to have a significant effect on the bulk airflow through the tunnel. The air flow rate was reduced by less than 5%. Therefore the pollution results from the Roads simulations remain valid.

Predicted tunnel air flow rates during incident scenarios (assuming the reduced cut and cover area of 72.5m^2) are shown in table 8.5.

Table 8.5: Predicted tunnel airflows for incident cases

Bore	Chainage from South Portal	CPs open	Number of jet fans operating	Jet fan thrust	Critical velocity	Velocity achieved	Margin
	m			N	m/s	m/s	m/s
Northbound	150	None	17	1356	3.28	3.64	0.36
Northbound	870	CP1 & CP2	17	1180	3.28	4.95	1.67
Northbound	1316	CP3	17	1180	2.98	3.44	0.46
Southbound	150	EE1 & CP1	17	1180	2.98	3.67	0.69
Southbound	890	CP3	17	1180	3.48	5.18	1.70
Southbound	1316	None	17	1356	3.40	3.62	0.22

In both bores the margin was smallest for a fire in the cut and cover section towards the entrance to the tunnel. This was because the fire was located at the top of a long section of tunnel with downhill gradient.

The worst case fire scenario suggests that twenty fans with a 1356 N thrust rating will be required per bore. A typical fan providing this thrust would be a 1.12m diameter fan with a 33.9 m/s outlet velocity and a 44.4 kW motor rating. [8]

9 Conclusions

Normal operations for ventilation option 1 required an extract rate of 400 m^3/s per bore at the exit portals to prevent pollutants being released from the portals. A typical fan arrangement for each stack to provide this flow would consist of five 2.5m diameter uni-directional axial fans each with a flow rate of 100 m^3/s and estimated motor rating of 121 kW. One fan would be for redundancy.

Fire simulations found that twenty installed jet fans per bore with a 1356 N thrust rating each were required to exceed critical velocity. Three fans were assumed to be out of operation. A typical fan providing this thrust would be a 1.12m diameter fan with a 33.9 m/s outlet velocity and a 44.4 kW motor rating.

During normal operations no pollution limits were exceeded in the tunnel for either option 1 or 2. During congested operations the portal extract system was not sufficient to maintain in tunnel pollution below recommended levels. The number of installed jet fans defined above was found to be more than sufficient to keep in tunnel limits at safe levels.

10 References

[1] Mott MacDonald, “Silvertown Tunnel Crossing - Further development of Tunnel Engineering for Bored Tunnel Solution 298348/MNC/TUN/002/A,” 2013.

[2] Mott MacDonald, “Silvertown Tunnel Crossing - Air Quality Technical Appendix 298348/P1/A,” 2013.

[3] PIARC, “Road Tunnels: Vehicle Emissions and Air Demand for Ventilation,” 2012.

[4] W. Kennedy, “Critical Velocity : Past, Present and Future,” in ***One Day Seminar on Smoke and Critical Velocity in Tunnels***, ITC, 1996.

[5] Mott MacDonald, “New Thames River Crossing: Network Development and Forecasting Report 265453/ITD/ITW/2/A,” 2010.

[6] Department for Environment, Food and Rural Affairs, “Emissions Factor Toolkit Version 5.2c,” [Online]. Available: http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft. [Accessed April 2013].

[7] FlaktWoods, “Fan selector,” [Online]. Available: http://fanselector.flaktwoods.com/. [Accessed April 2013].

[8] FlaktWoods, “Jetfoil - Tunnel Fans,” [Online]. Available: http://www.flaktwoods.co.uk/89988d38-eb04-455f-a4cb-5694b00f4575. [Accessed April 2013].

D.9. Utilities Report

D.9.1. Interfaces with TWUL for the Tunnel Fire Main and Fire Suppression Systems

Informal discussions have been held with Thames Water (TWUL) relating to the water supply and discharge requirements for the Silvertown tunnel. No formal application to Thames Water has been made at this early stage. Decisions relating to the type of fire suppression chosen will affect the rates required from Thames Water. The design has progressed using conservative estimates of flow rates that should, from experience be acceptable.

Tables D.9.1 and D.9.2 provide a summary of the mains water supply and wastewater discharge rates from sections 7.5 to 7.7 of the main report.

The mains water inflow rates are the proposed minimum rates. If the rates are increased then the time to refill the fire main water storage and tunnel fire suppression tanks will decrease. This will allow the tunnel to be re-opened more rapidly after an incident.

Table D.9.1: Water Supply Requirements

System	Option	Minimum Mains Water Inflow Rate – L/s	Location
Tunnel Fire Main	Indirect Supply from a Storage Tank	10	Greenwich Compound
	Direct Supply off a Water Main	42	Silvertown and Greenwich Compounds
Tunnel Fire Suppression	Deluge	20	Greenwich Compound
	Water Mist	10	Greenwich Compound

The Forward Discharge Rate in D.9.1 is a provisional rate based on the time required to remove the water from the portal sumps after a storm and the impounding sumps after a fire incident in the tunnel. The forward discharge rate is therefore an assumed rate to be discussed with TWUL. The higher the forward discharge rate then the time taken to empty the sumps and return the tunnel to normal operational service will be shorter.

The wastewater category will affect the rates charged by TWUL.

Table D.9.2: Surface and Wastewater Discharge Rates

System	Option	Forward Discharge Rate to Sewer (L/s)	Wastewater Category	Location
Portal Sumps	NA	40	Surface Water	Near the Greenwich Portal
	NA	20	Surface Water	Near the Silvertown Portal
Low Point Sump	Deluge	50 (normal duty)	Trade Effluent	Greenwich Compound
	Water Mist	70 (normal duty)	Trade Effluent	Greenwich Compound
Impounding Sumps	Deluge	40	Trade Effluent	Greenwich Compound
	Water Mist	40	Trade Effluent	Greenwich Compound

The maximum discharge rate at each location will be a summation of the portal sump and the normal low point sump discharge rate.

D.9.2. Interfaces with UK Power Networks for Power Supplies

An application has been submitted to UK Power Network (UKPN) on 16th April 2013 for two independent 11 kV electrical supplies for the Silvertown tunnel project each rated for 4500 kVA. The application has also requested UKPN to provide a budgetary cost estimate for providing these supplies. Since the previous version of this report, an initial budgetary quote has been received from UKPN for the power supply provision has been supplied. This is documented on the following pages but in summary the initial quotes are £2m for the Dock Road and £3.75m for the Millennium Way (all exclusive of VAT).

In taking this scheme into the next stages of design it would be recommended to request for a firm quotation in which UKPN carry out detail site survey and so will provide a more accurate quote. It would be expected that this work would require a design fee for UKPN.

All correspondence with UKPN is included within this appendix for reference, as well as the electrical load schedule for Silvertown tunnel. The UKPN project reference number assigned for Silvertown tunnel is 401303379.

Registered Office:
Newington House
237 Southwark Bridge Road
London SE1 6NP

Company:
UK Power Networks
(Operations) Limited

Registered in England and Wales No: 3870728

Mr R Oza
Mott MacDonald
8-10 Sydenham Road
Croydon
Surrey
CR0 2EE

9th May 2013
Our Ref: 401303379/QID170715

Dear Mr Oza

Site Address: (PTSA) Off Dock Road, London, EE3

Thank you for your recent enquiry regarding the above premises. I am writing to you on behalf of London Power Networks PLC the licensed distributor of electricity for the above address trading as UK Power Networks.

I am pleased to be able to provide you with a budget estimate for the work to provide a 4.5MVA 11kV connection.
It is important to note that this budget estimate is intended as a guide only. It may have been prepared without carrying out a site visit or system studies. No enquiry has been made as to the availability of consents or the existence of any ground conditions that may affect the works. It is not an offer to provide the connection and nor does it reserve any capacity on UK Power Networks' electricity distribution system.

1. Budget estimate

The budget estimate for this work is:
£2,000,000.00 (exclusive of VAT) if the Point Of Connection (POC) is at our Silvertown Primary Substation at Camel Road London. E16 2DD

2. Budget estimate assumptions

This budget estimate is based on the following assumptions:

- The most appropriate Point of Connection (POC) is as described above.
- A viable cable or overhead line route exists along the route we have assumed between the Point of Connection (POC) and your site.
- In cases where the Point of Connection (POC) is to be at High Voltage, that a substation can be located on your premises at or close to the position we have assumed.
- Where electric lines are to be installed in private land UK Power Networks will require an easement in perpetuity for its electric lines and in the case of electrical plant the freehold interest in the substation site, on UK Power Networks terms, without charge and before any work commences.
- You will carry out, at no charge to UK Power Networks, all the civil works within the site boundary, including substation bases, substation buildings where applicable and the excavation/reinstatement of cable trenches.

- Unless stated in your application, all loads are assumed to be of a resistive nature. Should you intend to install equipment that may cause disturbances on UK Power Networks' electricity distribution system (e.g. motors; welders; etc.) this may affect the estimate considerably.
- All UK Power Networks' work is to be carried out as a continuous programme of work that can be completed substantially within 12 months from the acceptance of the formal offer.

Please note that if any of the assumptions prove to be incorrect, this may have a significant impact on the price in any subsequent quotation. You should note also that UK Power Networks' formal connection offer may vary considerably from the budget estimate. If you place reliance upon the budget estimate for budgeting or other planning purposes, you do so at your own risk.

If you would like to proceed to a formal offer of connection then you should apply for a quotation, Please refer to our website http://www.ukpowernetworks.co.uk/internet/en/help-and-advice/documents/the_connection_process.pdf for '**The connection process'** which details our application process. To help us progress any future enquiry as quickly as possible please quote the UK Power Networks Reference Number from this letter on all correspondence.

If you have any questions about your budget estimate or need more information, please do not hesitate to contact me. The best time to call is between the hours of 9am and 4pm, Monday to Friday.

Yours sincerely

Chris Clements
Project Designer(Prelims)
Tel: 020 7055 4082
Email: christopher.clements@ukpowernetworks.co.uk

Registered Office:
Newington House
237 Southwark Bridge Road
London SE1 6NP

Company:
UK Power Networks
(Operations) Limited

Registered in England and Wales No: 3870728

Mr R Oza
Mott MacDonald
8-10 Sydenham Road
Croydon
Surrey
CRO 2EE

9th May 2013
Our Ref: 401303570/QID170808

Dear Mr Oza

Site Address: (PTSB) Off Millenium Way, London, EE1

Thank you for your recent enquiry regarding the above premises. I am writing to you on behalf of London Power Networks PLC the licensed distributor of electricity for the above address trading as UK Power Networks.

I am pleased to be able to provide you with a budget estimate to provide a 4.5MVA 11kV connection.It is important to note that this budget estimate is intended as a guide only. It may have been prepared without carrying out a site visit or system studies. No enquiry has been made as to the availability of consents or the existence of any ground conditions that may affect the works. It is not an offer to provide the connection and nor does it reserve any capacity on UK Power Networks' electricity distribution system.

1. Budget estimate

The budget estimate for this work is:
£3,750,000.00 (exclusive of VAT) if the Point Of Connection (POC) is at our Farjeon Road Primary Substation, London SE3 8SA.

2. Budget estimate assumptions

This budget estimate is based on the following assumptions:

- The most appropriate Point of Connection (POC) is as described above.
- A viable cable or overhead line route exists along the route we have assumed between the Point of Connection (POC) and your site.
- In cases where the Point of Connection (POC) is to be at High Voltage, that a substation can be located on your premises at or close to the position we have assumed.
- Where electric lines are to be installed in private land UK Power Networks will require an easement in perpetuity for its electric lines and in the case of electrical plant the freehold interest in the substation site, on UK Power Networks terms, without charge and before any work commences.
- You will carry out, at no charge to UK Power Networks, all the civil works within the site boundary, including substation bases, substation buildings where applicable and the excavation/reinstatement of cable trenches.
- Unless stated in your application, all loads are assumed to be of a resistive nature.

Should you intend to install equipment that may cause disturbances on UK Power Networks' electricity distribution system (e.g. motors; welders; etc.) this may affect the estimate considerably.

- All UK Power Networks' work is to be carried out as a continuous programme of work that can be completed substantially within 12 months from the acceptance of the formal offer.

Please note that if any of the assumptions prove to be incorrect, this may have a significant impact on the price in any subsequent quotation. You should note also that UK Power Networks' formal connection offer may vary considerably from the budget estimate. If you place reliance upon the budget estimate for budgeting or other planning purposes, you do so at your own risk.

If you would like to proceed to a formal offer of connection then you should apply for a quotation, Please refer to our website http://www.ukpowernetworks.co.uk/internet/en/help-and-advice/documents/the_connection_process.pdf for '**The connection process'** which details our application process. To help us progress any future enquiry as quickly as possible please quote the UK Power Networks Reference Number from this letter on all correspondence.

If you have any questions about your budget estimate or need more information, please do not hesitate to contact me. The best time to call is between the hours of 9am and 4pm, Monday to Friday.

Yours sincerely

Chris Clements
Project Designer (Prelims)
Tel: 020 7055 4082
Email: christopher.clements@ukpowernetworks.co.uk

APPLICATION FOR AN ELECTRICITY CONNECTION (PROJECTS)

Completing this form accurately will help us deal with your application as quickly as possible. Please complete all sections.

You can complete this form:
Online
- Download or complete the form at **www.ukpowernetworks.co.uk** (navigate to Connection Services)
- Email it to connections.projectsgateway@ukpowernetworks.co.uk

By post
- Projects Gateway, UK Power Networks, Metropolitan House, Darkes Lane, Potters Bar, Hertfordshire EN6 1AG
- Fax: 0845 650 0248

Safety note: before you allow anyone to start digging or building near to any overhead or underground electricity cables, please get a copy of our cable records for your site from our plan provision team on **0800 056 5866**. Sometimes there's a charge for this service.

Please complete this application form for:
- Any development requiring more than four connections
- Any development with a power requirement of more than 70kVA
- Any commercial development requiring more than one single or three phase connection
- The diversion of existing electricity assets, e.g. cables, substations, overhead lines
- Alterations to an existing electricity connection of more than 70kVA.

For enquiries that involve the connection of generation please visit **www.ukpowernetworks.co.uk** (navigate to Connection Services) to see our application process.

This isn't the correct application form if you require:
- Alterations to your existing electricity connection including bracket moves and earthing up to 70kVA
- Up to four new domestic electricity connections
- Single commercial supplies including temporary builders supplies up to 70kVA
- Upgrades up to 70kVA.

If any of these apply to your application, please call **0845 234 0040** (select option 3) and ask for a small services application form, or visit **www.ukpowernetworks.co.uk** (navigate to Connection Services).

Any questions? Call 08701 964 599

Monday to Friday 8.30am to 5pm

UK Power Networks

Section A: Your details

A1. **Details of the person making this application and to whom we will issue a budget estimate or quotation** (we will consider you to be the Applicant). The Applicant will also receive any payments due under our guaranteed standards of performance during the 'estimate and quotation' stage of your application. The Applicant **must** also sign and complete Section I.

Title: Mr. Name: Rakesh Oza Company name: Mott MacDonald

Address: 8-10 Sydenham Road

Croydon, Surrey

Postcode: CR0 2EE

Telephone: 0208 774 2598 Mobile: 07817 588 233

Email: Rakesh.Oza@mottmac.com

A2. Site address (where the work is taking place)

Address:

1) Off Millennium Way, London EE1 (Refer attached map)

2) Off Dock Road, London EE3 (Refer attached map) Postcode:

A3. How would you prefer to be contacted by us during the application process? ☑ Email ☐ Phone ☐ Letter

A4. Your authorised representative's details (to allow someone to act on your behalf during this application). If you complete this, we will deal with this person's instructions as if they are your own

Contact name: Company name:

Relationship to you (e.g. developer, consultant):

Address:

Postcode:

Telephone: Mobile:

Email:

Section B: Quotation requirements

B1. Did you know you can seek competitive quotations from an Independent Connection Provider for many elements of the work involved in getting an electricity connection? Please indicate if you:

☑ Want UK Power Networks to complete all of the work

☐ Are intending to use or are acting as an Independent Connection Provider (ICP).

☐ Are intending to use or are acting as an Independent Distribution Networks Operator (IDNO).

More information can be found in our helpsheet 'Did you know you have a choice?' found at www.ukpowernetworks.co.uk

Independent Connections Provider (ICP)
is an accredited company that is entitled to build electricity networks to the specification and quality required for them to be owned by UK Power Networks

Independent Distribution Network Operator (IDNO)
an IDNO has a wider scope than an ICP; after building the local network, it will continue to own the local network and provide maintenance and 24 hour fault repairs.

B2. Please tick which you require (tick only one box):

☑ Budget estimate
This is based on a desktop assessment only without any site specific conditions being taken into account. It may vary considerably from a formal connection offer. It is not capable of acceptance and does not secure any network capacity.

☐ Quotation
This is a connection offer which is made following an assessment of your requirements. It is capable of acceptance and is normally valid for 90 days from the date issued. Please note that by requesting a quotation you are confirming that you are in a position to accept our offer within 90 days of issue. If this is not the case then please request a budget estimate.

B3. Please confirm that you would like your Budget Estimate or Quotation issued by: [✓ Email] Letter
(we will use the details provided in A1)

B4. Have you had a budget estimate or quotation from us before for this site address? ☐ Yes ☑ No
If yes, please state your previous UK Power Networks reference number (this will be a nine digit number starting with 40 or 30)

Section C: Your requirements

C1. What is your required date for the connection(s) to be provided? (we call this the 'power on' date) March 2018

C2. Does your project require notification under the Construction (Design and Management) (CDM) Regulations 2007?

☑ Yes ☐ No

For guidance on CDM please go to **www.hse.gov.uk**

If yes, please provide contact details below for your CDM Coordinator and Principal Contractor:

CDM Coordinator

Name: To be confirmed (Initial Inquiry only) Company name:

Address:

Postcode:

Telephone: Mobile:

Email:

Principal Contractor

Name: To be confirmed (Initial Inquiry only) Company name:

Address:

Postcode:

Telephone: Mobile:

Email:

C3. Please tick which service(s) you require:

Office use only (project ref no):

☑ New connection

Total number of connections required: TWO

Please complete C4.

☐ Upgrade of an existing connection

Existing service capacity: kVA/ kW

Existing 13-digit Meter Point Administration Number MPAN):
(this can be found on your electricity bill and will start with 19, 10 or 12)

Please complete C4.

☐ Temporary connection

Capacity required for the temporary connection kVA

☐ single phase ☐ three phase

Please complete C4.

☐ Diversion work (this is an alteration or diversion of electricity cables, overhead lines or substations)
Please complete section F.

C4. Will any of these connections power any motors or welders? ☑ Yes ☐ No

If yes, please note that you will need to provide further details in Section E

Section D: Site and load details

Depending on your project, there may be a requirement to install a substation on your site. Our design team will discuss this with you in more detail but it would be helpful at this stage if you could indicate a preferred location on a plan (explained in section H).

D1. Please complete the section(s) which best match your project:

i. Domestic

a. Please complete this table:

Type of property (e.g. house or flat)	No. of bedrooms	No. of properties	Load required per property
	Please select		kVA
	Please select		kVA
	Please select		kVA
	Please select		kVA
	Please select		kVA

b. How will the property be heated? ☐ Gas ☐ Electric ☐ Other ________

If electric, please provide the space or water heating demand per property

____

c. Are landlord connections required? ☐ Yes ☐ No please complete D2

How many landlord's are required? ________ If you require more than one landlord supply please supply full details in section G

Capacity required for the landlord's connection: ________ kVA

The landlord's connection is: ☐ single phase ☐ three phase

Please complete D2.

ii. Commercial/Industrial

a. Please complete this table:

Type of property (e.g. office, industrial, warehouse unit)	No. of metering points	Load required per metering point
Substation bldgs for new Road Tunnel	Two	4500 (Refer attached sheet for detail) kVA
		kVA
		kVA
		kVA
		kVA

b. Maximum power required (after diversity): 4500 kVA kVA/ kW

Please complete D2.

D2. Will any new street lights be required? ☐ Yes ☑ No

If known, how many? ________

(if yes please mark the proposed location on the plan that you send to us, in section H)

Section E: Motors/welders or other disturbing loads

E1. Some types of load can disturb our electricity network. Please provide details of any air conditioning, fuel or heat pumps, lifts, motors, refrigeration, welders or other industrial machinery. If the electrical characteristics are unknown please refer to the manufacturer or the equipment installer.

Please use the following conversions as a guide: **4 amps = 1 kilowatt or 1 kilowatt = 1.1kVA**

Type of appliance (e.g. motor, welder, heat pump, wind turbine)	Rating of appliance	How often will the appliance be started in one hour?	Single or three phase?	Starting method (Star Delta, Direct On Line, Soft start)	Starting current
Motors. (20x 45 kW)	900 kW	1	three phase	Star Delta	350 amps
Motors- Fire Pump (4x220)	880 kW	0.1	three phase	Star Delta	715 amps
Motors - HVAC	60 kW	1	three phase	Star Delta	85 amps
	kW		Please select	Please select	amps

Section F: Diversion works

F1. If applying for diversion work please provide a full description of the work that you propose to carry out.

- Please detail whether you require the diversion of electricity cables, overhead lines or substations.
- Please send us detailed plans of your works to allow us to identify the impact on our electricity assets.

F2. What is the planned start date for your work? ____________________

Section G: Additional information

Please provide any additional information that you think will help us process your application. For example, any details of land ownership, planning constraints, site hazards or areas of contamination.

The project is a new road tunnel in the East London, called Silvertown tunnel with two bores each with two lanes and 1.4 km long tunnel.

Inside the tunnel main equipment will be Tunnel ventilation fans, drainage pumps, tunnel lighting and various other communication equipment such as CCTV, Lane control signs etc. The equipment inside the tunnel will be served by a substation at each end where 11 kV power supplies would be required.

In accordance with the power supply standards for the road tunnels and critical nature of a tunnel, 11 kV supplies at both locations shall be derived from an independent 132 kV grids, however both the substations will be interlinked to improve reliability of power supplies and shall be capable to supply the whole tunnel. The Substation building also house other equipment which will be built by the Owner. Refer attached Load Schedule and Electrical Schematic drawing for further detail.

As these substations are new built, the post code is not available but attached map shows the location of both the sites.

Section H: Checklist of what to send us

Before you submit your application, please ensure that you have enclosed the following information which will allow us to process your application as quickly as possible:

☐ 1. Plan showing the site location (an example is shown on page 7)

☐ 2. Plan showing the site layout (an example is shown on page 7)

Section I: Signature of the Applicant

The applicant must sign this section (the person named in A1).

Signature of applicant:

Date: 16/04/2013

Print name: RAKESH OZA

Acting on behalf of company name (from section A1):

1. Plan showing the site location

What is this?
A map showing us where your site is so we can accurately assess your requirements.

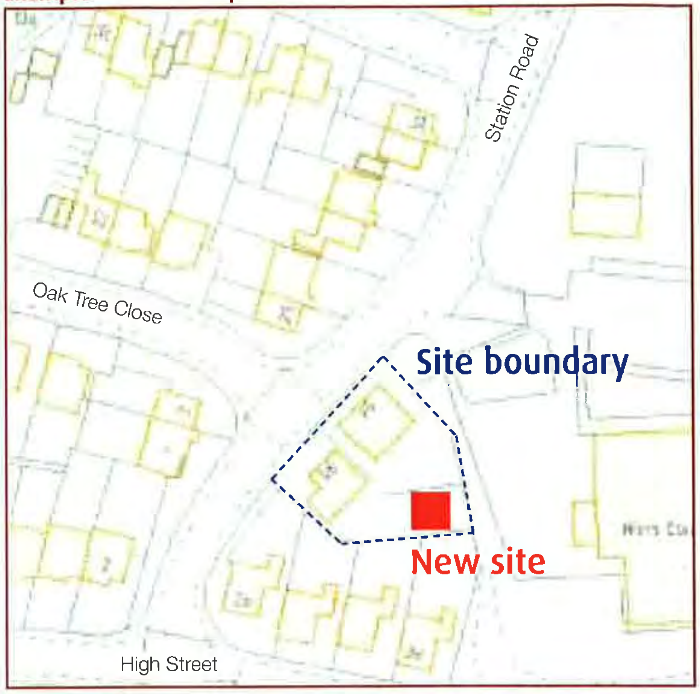
What should the map show?

- the site location in relation to the surrounding area
- which roads are closest to the site
- the site boundary

Where to find one
Location plans can be found by using street maps or via internet sites such as:

- Googlemaps
- Ordnance Survey
- Multimap

Example site location plan



2. Plan showing the site layout

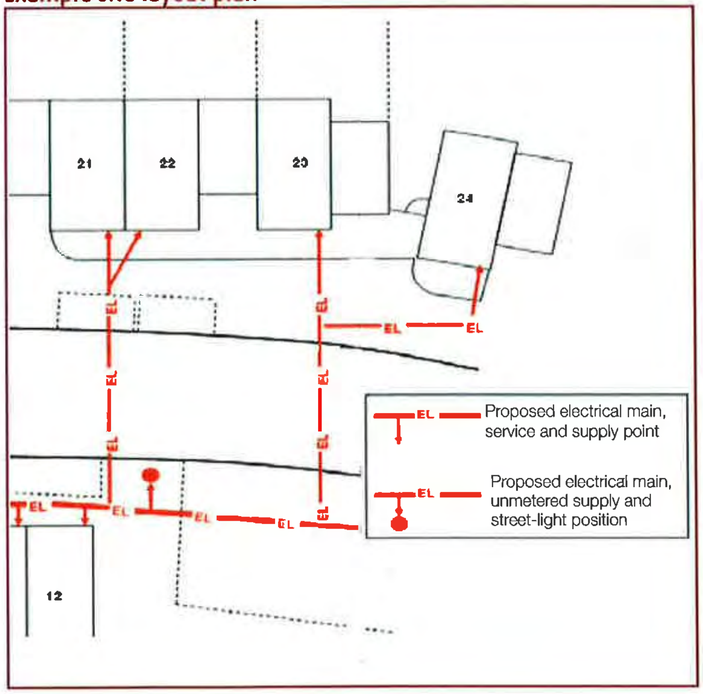
What is this?
A scaled plan showing us the layout of the site and the ground floor layout of any buildings. Please make sure you provide us with an appropriate sized plan.
The size we require will depend on the size of your development but it should be no smaller than A3.

Where to find one
If you have an architect working on your project, they will be able to provide this. If you haven't an architect please send a detailed location plan showing the details (below).

What should the plan show?

- the layout of the development
- any footpaths, roads or access routes
- where you'd prefer the electricity cable entering the building
- your proposed duct and cable route
- any existing service routes (if known)
- where you'd like the electricity meter positioned (internal or external)
- the site boundary
- any buildings that will be demolished
- proposed location of any new street-lights
- depending on your project, there may be a requirement to install a substation on your site. Our design team will discuss this with you in more detail but it would be helpful at this stage if you could indicate a preferred location on a plan.

Example site layout plan



Can I send these documents electronically? Yes, we accept most file types such as PDF, JPG, DWG or GIF.

Completing this form accurately will help us deal with your application as quickly as possible. Please complete all sections.

Email the form to us

Clicking this will create a new email and automatically attach your completed form. Please remember to attach the maps asked for in section H.

You can complete this form:

Online

- Download or complete the form at **www.ukpowernetworks.co.uk** (navigate to Connection Services)
- Email it to connections.projectsgateway@ukpowernetworks.co.uk

By post

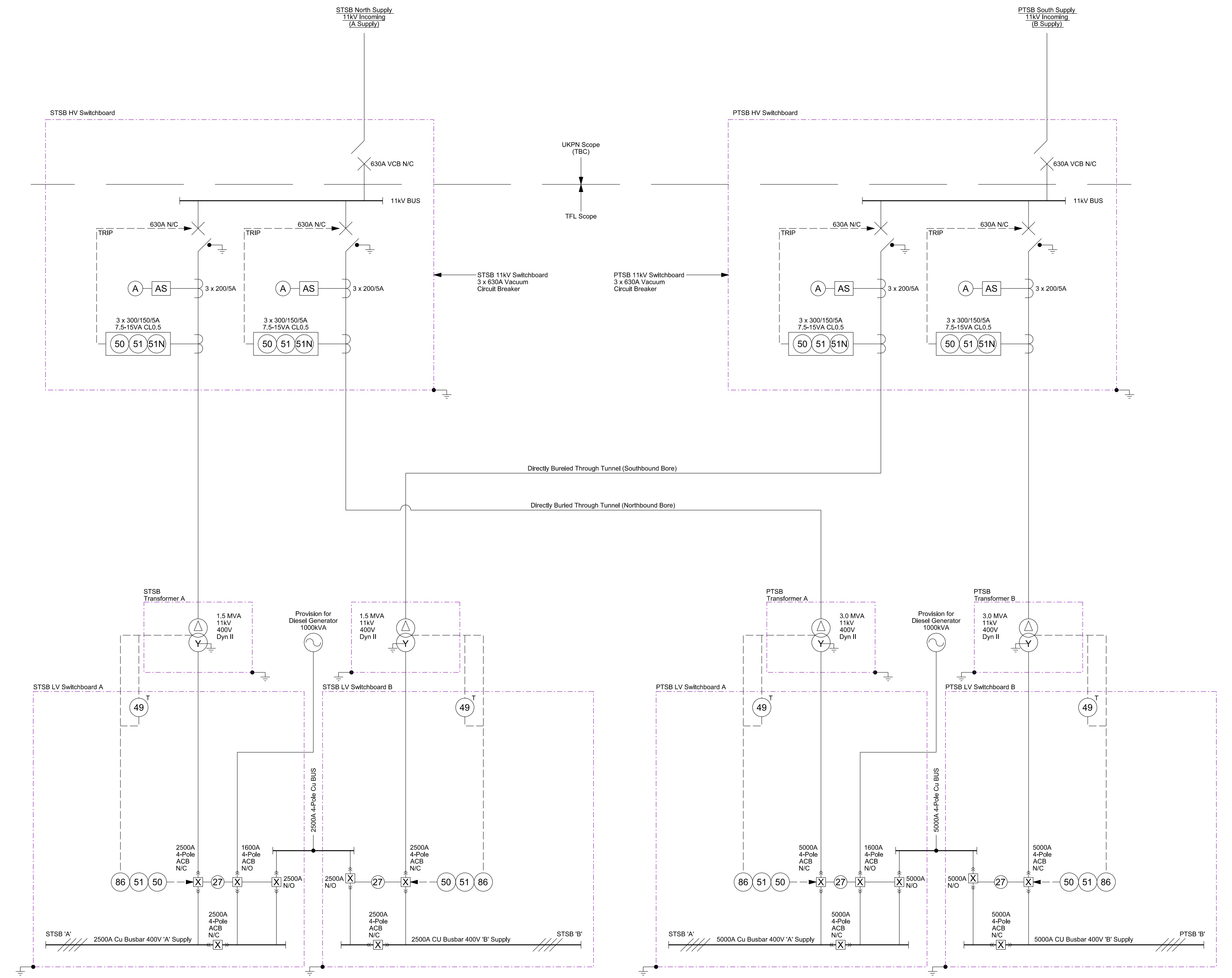
- Projects Gateway, UK Power Networks, Metropolitan House, Darkes Lane, Potters Bar, Hertfordshire EN6 1AG
- Fax: 0845 650 0248

Any questions? Call 08701 964 599

Monday to Friday 8.30am to 5pm

UK Power Networks (Operations) Limited
Registered office: Newington House, 237 Southwark Bridge Road, London SE1 6NP
Registered number: 3870728 registered in England and Wales

UK Power Networks



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We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

Notes

1. All dimensions in millimetres unless otherwise stated.
2. Do not scale this drawing.

Key to symbols

A	Ammeter
AS	Ammeter Selector Switch
V	Voltmeter
VS	Voltmeter Selector Switch
N/C	Normally Closed
N/O	Normally Open
STSB	Secondary Tunnel Services Building
PTSB	Primary Tunnel Services Building
MET	Main Earth Terminal
M	REC Metering located remotely from swtitchboard
27	Undervoltage Relay
49	Transformer Thermal Ray
50	Instantaneous Overcurrent
51	IDMTL Overcurrent Relay
51N	Earth Fault Relay IDMTL
86	Locking-out Relay
△ Y	11/0.40kV, 2000kVA, Dy n II
X	Air Circuit Breaker (ACB) 4 Pole
	Current Transformer
	Fuse
	Circuit Breaker
	Earth Switch

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	16/04/2013	ZZG	PRELIMINARY ISSUE	MZ	RCH

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Client

Transport for London

Transport for London
50 Victoria Street
London
SW1H 0TL

Title

Silvertown River Crossing
Bored Tunnel Option
Electrical Systems
High Voltage Electrical Schematic
Single Line Diagram

Designed	R. Oza	Eng check	M. Zbucki
Drawn	Z. Zuberi	Coordination	S. Johnson
Dwg check	R. Oza	Approved	R. Hall

Scale at A1 NTS
Status PRE
Rev P1

Drawing Number
MMD-298348-E-DR-00-ZZ-1001

To see all the details that are visible on the screen, use the Print link next to the map.

Preliminary Tunnel Service Building (PTSB)

To see all the details that are visible on the screen, use the Print link next to the map.

Secondary Tunnel Service Building (STSB).

Silvertown Road Tunnel - Summary of Electrical Load

LV Switchboards	Connected Load (kW)	Maximum Demand (kVA)	Operating Load (Amps)	25% Spare capacity (kVA)	Proposed Equipment Rating (kVA)
Primary unnel Service Building (PTSB)	3368.50	2497	3604	3121.35	
Secondary Tunnel Service Building (NTSB)	3129.50	1069	1543	1336.36	
UPS - (PTSB)	142.31	142	205	177.89	220
UPS - (STSB)	111.05	111	160	138.82	220
Transformer at STSB South Portal	3511	2639	3810	3299.24	3500
Transformer at NTSB North Portal	3241	1180	1703	1475.18	1500
DG Set (PTSB)		677	978	846.73	1000
DG Set (STSB)		573	827	716.18	1000
Total BSP Load	**6751**	**3820**	**5513**		

400 V., 50Hz. 3 phase & neutral, 4 wire
TN-C-S Earthing System assumed.
External Impedance (Ze) to be advised by DNO

Consumer	Location	Qty	Unit Load (kW)	Connected Load (kW) (STSB)	Connected Load (kW) (PTSB)	Diversity	PF	Efficiency (%)	Total load at PTSB (kVA)	Total load at STSB (kVA)	PTSB UPS (kVA)	STSB UPS (kVA)	DG Sizing PTSB	DG Sizing STSB
Jet Fans														
South Tunnel Jet Fans	Tunnel	20.00	45.00	900.00		0.60	0.90	85.00	705.88				352.94	
North Tunnel Jet Fans	Tunnel	20.00	45.00		900.00	0.60	0.90	85.00		705.88				352.94
South Portal Vent Fans	Tunnel	4.00	130.00	520.00			0.90	85.00						
North Portal Vent Fans	Tunnel	4.00	130.00		520.00		0.90	85.00						
Fire Suppression System - Estimated Load														
STSB - Intensifier pumps		1.00	5.50	5.50	5.50	0.90	0.90	89.00	6.18					
STSB - Supply pump 1 & 2		2.00	18.50	37.00	37.00	0.90	0.90	89.00	41.57					
STSB - Sprinkler pump set 1		3.00	216.00	648.00	648.00	0.90	0.90	89.00	728.09					
STSB - Sprinkler pump set 2		2.00	216.00	432.00	432.00	0.90	0.90	89.00	485.39					
STSB Control panels		4.00	0.70	2.80	2.80	0.90	0.90	89.00	3.15					
STSB Control valves		2.00	0.70	1.40	1.40	0.90	0.90	89.00	1.57					
STSB Trace Heating (m)		180.00	0.03	4.50	4.50	0.90	0.90	89.00	5.06					
PTSB - Intensifier pumps		1.00	5.50	5.50	5.50	0.90	0.90	89.00	6.18					
PTSB - Supply pump 3		1.00	18.50	18.50	18.50	0.90	0.90	89.00	20.79					
PTSB Control panels		3.00	0.70	2.10	2.10	0.90	0.90	89.00	2.36					
PTSB Control valves		1.00	0.70	0.70	0.70	0.90	0.90	89.00	0.79					
PTSB Trace Heating (m)		180.00	0.03	4.50	4.50	0.90	0.90	89.00	5.06					
Tunnel Lighting														
EDP01-A/A	CP-16	1.00	50.00		50.00	0.90	0.95	100.00		47.37				
EDP01-A/B	CP-16	1.00	50.00		50.00	0.90	0.95	100.00		47.37				
EDP02-A/A	CP-15	1.00	50.00		50.00	0.90	0.95	100.00		47.37				
EDP02-A/B	CP-15	1.00	40.00		40.00	0.90	0.95	100.00		37.89				
EDP03-A/A	CP-14	1.00	40.00		40.00	0.90	0.95	100.00		37.89				
EDP03-A/B	CP-14	1.00	20.00		20.00	0.90	0.95	100.00		18.95				
EDP04-A/A	CP-13	1.00	20.00		20.00	0.90	0.95	100.00		18.95				
EDP04-A/B	CP-13	1.00	10.00		10.00	0.90	0.95	100.00		9.47				
EDP05-A/A	CP-12	1.00	15.00		15.00	0.90	0.95	100.00		14.21				
EDP05-A/B	CP-12	1.00	15.00		15.00	0.90	0.95	100.00		14.21				
						0.90								
EDP01-B/A	CP-01	1.00	50.00	50.00		0.90	0.95	100.00	47.37					
EDP01-B/B	CP-01	1.00	50.00	50.00		0.90	0.95	100.00	47.37					
EDP02-B/A	CP-02	1.00	50.00	50.00		0.90	0.95	100.00	47.37					
EDP02-B/B	CP-02	1.00	40.00	40.00		0.90	0.95	100.00	37.89					
EDP03-B/A	CP-03	1.00	40.00	40.00		0.90	0.95	100.00	37.89					
EDP03-B/B	CP-03	1.00	20.00	20.00		0.90	0.95	100.00	18.95					
EDP04-B/A	CP-04	1.00	20.00	20.00		0.90	0.95	100.00	18.95					
EDP04-B/B	CP-04	1.00	10.00	10.00		0.90	0.95	100.00	9.47					
EDP05-B/A	CP-05	1.00	15.00	15.00		0.90	0.95	100.00	14.21					
EDP05-B/B	CP-05	1.00	15.00	15.00		0.90	0.95	100.00	14.21					

Consumer	Location	Qty	Unit Load (kW)	Connected Load (kW) (STSB)	Connected Load (kW) (PTSB)	Diversity	PF	Efficiency (%)	Total load at PTSB (kVA)	Total load at STSB (kVA)	PTSB UPS (kVA)	STSB UPS (kVA)	DG Sizing PTSB	DG Sizing STSB
EDP01-A/UPS	CP-16	1.00	20.00		20.00	1.00	0.95	100.00				21.05		
EDP02-A/UPS	CP-15	1.00	15.00		15.00	1.00	0.95	100.00				15.79		
EDP03-A/UPS	CP-14	1.00	15.00		15.00	1.00	0.95	100.00				15.79		
EDP04-A/UPS	CP-13	1.00	15.00		15.00	1.00	0.95	100.00				15.79		
EDP05-A/UPS	CP-12	1.00	10.00		10.00	1.00	0.95	100.00				10.53		
EDP01-B/UPS	CP-01	1.00	20.00	20.00		1.00	0.95	100.00			21.05			
EDP02-B/UPS	CP-02	1.00	15.00	15.00		1.00	0.95	100.00			15.79			
EDP03-B/UPS	CP-03	1.00	15.00	15.00		1.00	0.95	100.00			15.79			
EDP04-B/UPS	CP-04	1.00	15.00	15.00		1.00	0.95	100.00			15.79			
EDP05-B/UPS	CP-05	1.00	10.00	10.00		1.00	0.95	100.00			10.53			
Cross Passages Lighting														
X Passage Ltg (1-5)		Load Inculded in the CP-EDP Load												
Cross Passages Small Power														
Small Power (1-5)		Load Inculded in the CP-EDP Load												
Fire Alarm and Fire Protection														
Fire Alarm		Load Inculded in the CP-EDP Load												
Fire Protection														
Fire Main Equipment														
STSB Fire Pumps No. 1 Main	STSB	1.00	90.00	90.00		1.00	0.90		100.00				100.00	
STSB Fire Pumps No. 2 Standby	STSB	1.00	90.00	90.00			0.90							
STSB Fire Pumps No. 3 Jockey	STSB	1.00	4.00	4.00		1.00	0.90		4.44				4.44	
Communication Equipment in each Cross Passage														
		Load Inculded in the CP-EDP Load												
Communication Equipment in each Bored Tunnel														
		Load Inculded in the CP-EDP Load												
Preliminary Tunnel Service Building														
HVAC Panel		1.00	60.00	60.00		0.50	0.85	0.90	39.22					
DB-1 Lighting and Small Power		1.00	20.00	20.00		0.50	0.85	0.90	13.07					
DB-2: Lighting & Small Power		1.00	25.00	25.00		0.50	0.90	1.00			13.89			
DB-Comms Equipment Room		1.00	30.00	30.00		0.75	0.95	1.00			23.68			
DB- Radio Equipment Room		1.00	30.00	30.00		0.75	0.95	1.00			23.68			
Low point sump Panel		1.00	50.00	50.00		0.50	0.85	0.85	34.60					
Fire Alarm Panel		1.00	2.00	2.00		1.00	0.95	1.00			2.11			
Control centre equipment at comms/Radio room														
		Load Inculded in the CP-EDP Load												

Consumer	Location	Qty	Unit Load (kW)	Connected Load (kW) (STSB)	Connected Load (kW) (PTSB)	Diversity	PF	Efficiency (%)	Total load at PTSB (kVA)	Total load at STSB (kVA)	PTSB UPS (kVA)	STSB UPS (kVA)	DG Sizing PTSB	DG Sizing STSB
Secondary Tunnel Service Building														
HVAC Panel		1.00	50.00		50.00	0.50	0.85	0.90		32.68				
Low point sump panel		1.00	50.00		50.00	0.50	0.95	1.00		26.32				
DB-1 Lighting and Small Power		1.00	20.00		20.00	0.50	0.95	1.00		10.53				
DB - Lighting and Small Power		1.00	10.00		10.00	0.60	0.95	1.00				6.32		
DB-Radio Equipment Room		1.00	15.00		15.00	0.75	0.95	1.00				11.84		
DB-Comms Equipment Room		1.00	15.00		15.00	0.75	0.95	1.00				11.84		
Fire Alarm Panel		1.00	2.00		2.00	1.00	0.95	1.00				2.11		
Control centre equipment at communications room														
		Load Inculded in the CP-EDP Load												
Control centre equipment at radio room														
		Load Inculded in the CP-EDP Load												
Control centre equipment at operations room														
		Load Inculded in the CP-EDP Load												
Total Load (kW)				**3368.50**	**3129.50**			**Total (kVA) :**	**2497.08**	**1069.09**	**142.31**	**111.05**	**457.39**	**352.94**

Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon
CR0 2EE

Alison Ashby
Tel: 0870 1964599

Our Ref / LPN / 401303379
Your Ref: 1517606
For Attention Of: Mr Rakesh Oza

Date 19/04/2013

Dear Mr Oza

Re: Silvertown Tunnel Project, Off Dock Road, London, CR0 2EE
Project Reference Number: 401303379

Thank you for your recent enquiry regarding the above project.

Your enquiry has been allocated to our Prelims Team who will work with you to arrange for the development of your electrical design requirements. If you have requested a budget estimate this will normally be provided to you free of charge.

Safety reminder
I would like to take this opportunity to remind you of an important safety issue if you have already started, or intend to start work on site in the near future.

In the interest of safety to personnel, equipment, and UK Power Networks apparatus, it is imperative that the approximate position of the underground cables is established before any excavation is commenced. The positions are to be obtained by the use of electronic cable locators and to then be confirmed by careful trial holing, using hand held tools. UK Power Networks CANNOT UNDERTAKE THIS WORK FOR CONTRACTORS. UK Power Networks Plan Provision team will be able to advise you in this respect and they can be contacted on free phone 0800 056 5866

It will be helpful if you can quote your project reference number on any future correspondence.

If you are applying for a formal offer for a new or upgraded connection, UK Power Networks has an obligation to issue you with a quotation as soon as is reasonably practicable and certainly within three months. This measurement begins as soon as we receive from you all the information necessary to provide you with a formal quotation. It may be reset on the receipt of updated information from you which is likely to affect the quotation. For all other types of enquiry (for example budget estimates) the same obligation does not apply, but we are still committed to providing a high level of service & will respond to your request as quickly as possible.

Yours sincerely

Alison Ashby

Business Support Assistant

UK Power Networks, Connections, Potters Bar. Metropolitan House, Darkes Lane, Potters Bar, Herts. EN6 1AG.
Tel: Number: 0870 1964599   Fax No.: 0845 6500248   Email: alison.ashby@ukpowernetworks.co.uk

D.10. Paper on form of tunnel approach ramps

Memorandum

Mott MacDonald

To	From	Our reference
David Fielder, TfL	Jonathan Baber	298348
Office	**Date**	**Your Reference**
-	27.03.13	-

Subject Silvertown Tunnel - Form of Tunnel Approaches

Further to the coordination meeting held on 25 March 2013 it was agreed that Mott MacDonald would set out the rationale for determining the form of the tunnel approaches for the Silvertown Tunnel – whether they should be retained approaches or open earthworks cuttings. This paper provides discussion on the various issues to be considered and provides a recommendation.

Introduction

The study report prepared by Mott MacDonald in July 2012 recommended retained approach ramps to the tunnel on both the Silvertown and Greenwich approaches. They were envisaged to be diaphragm wall construction with possible use of secant pile walls at selected areas, and an insitu floor slab spanning between the walls. A secondary lining would be installed to provide a drainage void for any water seepage through the diaphragm/secant pile walls.

At the time there was no knowledge of the highway layout and geometry of the main carriageway or slip roads. Atkins has subsequently prepared conceptual designs for the approach roads and have used a working assumption of open cuttings in the approach. It is necessary to undertake an evaluation of the two solutions to determine a preferred strategy.

Volumes of excavation

Clearly the volume of excavation will be less for the retained solution compared to the open cut solution. The volume will be significantly increased but it should be recognised that it is still a small volume in comparison to the tunnelling and cut and cover tunnel quantities (total spoil disposal was estimated as 544,000m^3 in the previous study stage, so it is expected to be in the order of a 15% increase).

The cost associated with additional excavation is outweighed by the structural works and the structural solution will remain a more expensive solution (though it is noted they are <10% of total scheme cost).

The additional excavation will, however, have an impact on the number of truck movements or river movements required to remove the material.

Contaminated land

There are two aspects to the influence on contaminated land:

i) Volumes of material requiring disposal
ii) Breaching existing barrier systems from previous remediation works

As noted in the preceding section on volumes of excavation there will be a greater volume of contaminated material to be removed. A working assumption of 10% contaminated material was made in the previous study phase for pricing the disposal of materials. However this will need to be verified by GI at the next stage of design. Volumes are not expected to be high but they should be minimised and a retained solution helps to mitigate this.

On the Greenwich approach it is known that the gas works area had a degree of remediation and surface contaminated materials were removed and replaced and materials at depth were capped. The depth of excavation required for the ramps means the previous barrier systems will be breached and further remediation work will be required, replacing or adjusting the existing systems. This will be necessary to avoid contamination of the groundwater of the secondary aquifer and the River Thames. Minimising the footprint of the excavation works is beneficial in this respect and therefore a retained approach ramp is preferred.

Ground water seepage

The approaches to the tunnel are constructed through ground that comprises made ground overlying alluvium overlying Terrace Deposits (sands and gravels) overlying London Clay. It is anticipated that the underside of the road slab would be founded in the Terrace Deposits for the majority of its length.

An issue was identified in the previous study report that hydraulic continuity through the Terrace Deposits along the line of the tunnel approaches might be undesirable and that cut-off measures may be necessary. It is noted that the Terrace Deposits continue to and beneath the River Thames and there is therefore a hydraulic gradient in this layer that would be expected to cause continual seepage.

Without any ground water cut off measure the seepage of water will occur through the earthworks leading to slope saturation and a risk of instability. To prevent this either a structural cut-off or a cut-off within the ground such as a slurry wall, placed cohesive material or a buried membrane is needed. To allow seepage to occur would be a highly unusual approach and is recommended against.

Seepage and contamination

A further issue that exists with open earthworks cuttings in the approaches is a combination of seepage and contamination issues. Surface water will percolate through the surface deposits and may travel through the ground into the drainage system surrounding the approach ramps, to be carried into the portal sumps. The land surrounding the site is known to be contaminated, particularly on the Greenwich approach. There is therefore a risk that the percolating water is washing through contaminated ground and carrying contaminants into the portal sump.

Whilst a degree or remediation has been carried out on the Peninsular this may not be fully effective or cover the whole surrounding area so this risk cannot be ruled out.

This may result in health and safety issues regarding maintenance personnel who maintain the pumping equipment and periodically clean the sumps, and it may also impact on the treatment requirements for water prior to its discharge. We would recommend a retained ramp solution that avoids these risks altogether.

Drainage

Open cuttings will have no means to prevent water seeping to the surface. To protect the slopes and road construction drains will need to be installed. Drains will be needed to each side of the road and potentially drains within the earthworks will also be necessary. These will feed into the drainage system that collects surface water run-off from rainfall.

Pumping tests would be needed to establish the expected water ingress rate and the consequential sump size and drainage pumps. If a significant inflow of ground water occurs this could lead to a permanent pumping requirement. This is generally avoided in new-build tunnels because of the power demand and the continuous maintenance regime associated with such a system. This would not be our recommended approach.

At this stage of study the water ingress cannot be determined and further GI would be necessary to form a final view on this issue.

Dewatering for construction

In order to construct the approaches in the dry either the area has to be dewatered by an arrangement of pumping wells or a groundwater cut-off measure will need to be installed to allow dewatering and excavation to create a dry environment for construction.

The retained solution is based on a diaphragm wall or secant pile wall that would extend down into the London Clay which provides a natural cut-off layer. This allows excavation between the walls without further water ingress into the excavated area. Dewatering, if needed at all, would be localised to the structure.

An open cut solution will require wells around the perimeter of the site and within the site to keep the ground water level below the base of the excavations. The extent, nature and cost of such a dewatering system will depend on the ground water flow through the Terrace Gravels. This is unknown at this time and would have to be determined from pumping tests.

A dewatering solution might be feasible or it may be that the ground water flow is large and the solution becomes very expensive or unfeasible.

The impact of a dewatering scheme will need to be considered on surrounding infrastructure as it may cause ground movement or settlement of adjacent buildings or infrastructure. The buildings and structures that will need to be considered are those identified in the stage 1 PDA report. The zone of influence is likely to extend beyond that assumed in the stage 1 assessment as this assumes retaining solutions, so the risks are likely to increase. Large scale dewatering schemes are generally avoided in urban areas because of the risk to surrounding buildings and infrastructure and so a retained solution is recommended,

Land use around portal areas

Retained ramps clearly offer a greater opportunity to utilise the land surrounding the tunnel approaches. On the Silvertown approach there is no particular demand for tunnel plant buildings or maintenance facilities alongside the ramp that is currently known of, although there may be requests forthcoming later from emergency services for parcels of land to be available for managing incidents in the tunnel. These may include parking for emergency vehicles, triage areas, breakdown recovery areas etc.

On the Greenwich approach the decision is already taken to retain the cutting alongside the gas holder site for this reason.

Greater land would be available in the construction stage also by using retained approaches. This is of greatest benefit on the Silvertown approach but could also be helpful on the Greenwich side.

Highway alignment

It is understood that the highways design remains valid for either an open cutting or a retained cutting solution. Therefore there is no perceived advantage or disadvantage for either solution in this respect.

Construction programme

Although sequencing will be different it is not expected that there will be any overall difference to the construction programme. The open cuttings allow greater freedom but this is a small benefit compared to some of the other issues.

D-walls or secant walls are necessary in any case for the cut and cover tunnels so plant will be mobilised and the contractor will be set up for this type of work. There is therefore no particular cost or programme penalty for extending this work through to the approach ramps.

Recommendation

Taking into account the issues described we recommend that retained ramps should be adopted. They offer:

- Control of ground water seepage
- Avoidance of large scale dewatering for construction
- Minimising ground movement impacts to surrounding infrastructure and buildings
- Minimising contaminated land being excavated and disposed of
- Maximising future land use around the tunnel approach areas
- Minimum risk of contaminated ground water entering drainage system
- Minimum risk of ground water contamination
- Lowest operational and maintenance cost associated with pumping

The likelihood of open cuttings being feasible is considered to be low and there are a number of risks attached to taking such an approach, notably those described in association with contaminated land, drainage, construction stage dewatering and ground water seepage.