5 Consideration of Alternatives

5.1 Introduction

5.1.1 *Rule 11 (1.d)* of the *Transport and Works (Applications and Objections Procedure) (England and Wales) Rules (2006)* requires that an ES should include *an outline of the main alternatives to the proposed works studied by the applicant and an indication of the main reason for his choice, taking into account the environmental effects*.

5.1.2 This chapter begins by presenting an historical overview of the Bank Station Capacity Upgrade (BSCU), including identifying project objectives and requirements. It then presents an outline of the main alternatives considered at various stages of the project design. This includes alternative tunnel alignments, station entrances and work sites. A summary of the consultation undertaken, and how this has influenced the design, is also provided.

5.2 Historical overview

5.2.1 The Bank Monument Station Complex is one of the busiest interchanges on the London Underground Network with over 337,000 passengers currently boarding, alighting or interchanging at the station daily.

5.2.2 The station is already highly congested, and passenger forecasts show an increase, exacerbating operational and safety risks. Key constraints of, and challenges to, the current Bank Monument Station Complex include:

- high levels of congestion and lack of capacity;
- limited step-free access for Passengers of Reduced Mobility (PRM);
- complex and indirect routes within the station complex;
- lack of resilience to wider network disruptions and train faults;
- limited facility for routine maintenance and refurbishment activities given other constraints;
- lack of strong visual presence or identity at street level; and
- need to enhance fire and evacuation protection measures.

5.2.3 Recent and planned improvements on the network will only increase pressure on the station, for example:

- Docklands Light Railway (DLR) 3-Car service upgrade, delivered in 2010; and

- Northern Line upgrades, which will significantly boost capacity on the line in a two phase project scheduled for completion in 2022.

5.2.4 The Northern Line platforms currently suffer the worst crowding. Passageways to the DLR, Central Line and station exits also experience congestion and queues, particularly in the peak periods.

5.2.5 London Underground Limited (LUL) has recognised that major improvements are essential at Bank Station. In the early 2000s increased demand forecast for this pivotal station within the City of London highlighted existing concerns about constraints to passenger interchange, conflicting passenger flows, unclear way-finding and access to street level.

5.2.6 In 2003 a masterplan was developed by LUL identifying a suite of options to enhance and upgrade the station. This included a series of operational interventions to manage congestion using measures such as trains not stopping at Bank, one-way pedestrian flow and direction via alternative (above ground) routes. This was not deemed to be a suitable long term solution to provide sufficient pedestrian capacity improvement.

5.2.7 Other options in the masterplan considered improvements to the Central, District and Circle Lines, but in isolation these would not alleviate congestion and evacuation constraints. An integrated approach for the station, with capacity improvements targeting the Northern Line, DLR and interchange between other lines was considered to represent the most effective long term solution to improving congestion relief at Bank Monument Station Complex, while also providing step free access and fire evacuation to the Northern Line and DLR.

5.2.8 The Bloomberg Place project at Walbrook, which is currently under construction, will address problems of congestion, evacuation and step free access to the Waterloo and City Line by providing a new entrance to Bank Station on Walbrook. This is being delivered as a separate project outside of the BSCU and is due to be completed by in 2017.

5.3 Key Project Requirements

5.3.1 To address the constraints identified in 5.2.2, and in response to the challenges identified in the *Mayor's Transport Strategy* (Greater London Authority, 2010), the overarching aim of the BSCU is to ensure that TfL continues to provide a fit-for-purpose public transport station complex to support the City of London. It shall do this by:

- increasing the capacity of Bank Station so that it is able to handle present and forecast demand, and thereby support the economic growth of the city;

- minimising passenger journey time through the station, and thereby reduce crowding;
- improving the quality of access, interchange and ambience, including the provision of step-free access routes from street level to Northern Line trains and provide step-free interchange between Northern Line and Docklands Light Railway (DLR) trains; and
- improving emergency fire and evacuation protection measures.

5.3.2 In addition to these requirements, the project should seek to minimise the disruption to existing services, passengers and third parties during construction.

5.4 Feasibility Development (2002 - 2011)

5.4.1 Options were considered for enhancing the station, specifically to address the existing and forecast constraint to interchange capacity between the Northern Line and DLR. Different platform, interchange and running tunnel alignments, as well as new station entrances, were considered for feasibility including their anticipated benefits, cost, constructability, and environmental effects.

5.4.2 The main options considered are presented below under the headings:

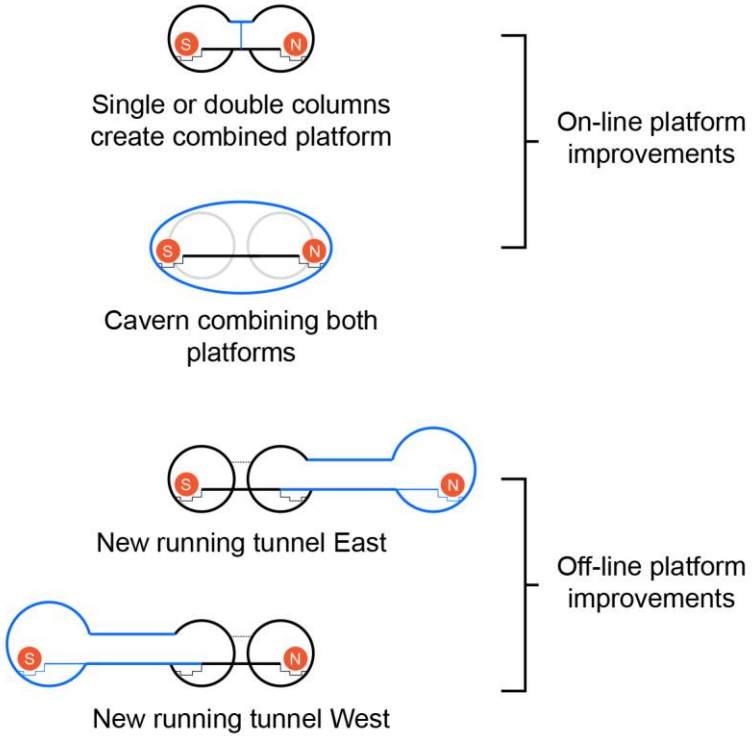
- congestion relief;
- station entrance;
- interchange; and
- step-free access and improved fire evacuation.

Congestion Relief

5.4.3 It was considered that capacity on the Northern Line platforms required improvement. Variations of on-line (enhancing the existing platform layout) and off-line (providing a new passenger platform linked by a new railway tunnel) were explored (See Figure 5.1).

5.4.4 To reduce congestion, options were considered which provided more circulation space and increased interchange capacity to remove people from the platforms. Platform clearance would help to alleviate immediate congestion for disembarking passengers, and would provide wider congestion relief in the station removing conflicting flows and clustering of passengers at existing stairs and escalators, especially between the DLR and the Northern Line.

Figure 5.1: Northern Line Tunnel Alignment Options



S = southbound tunnel; N = northbound tunnel

5.4.5 The two on-line options of enlarging the existing platforms, either by opening more passenger space between the platforms, or by expanding the existing tunnels to realign the tracks to provide a larger platform cavern would not provide sufficient congestion relief. Construction of the on-line options would require substantial closure of the station and lengthy disruption to the Northern Line service. This was identified as an unacceptable operational risk to Bank Station and with wider secondary impacts to the network.

5.4.6 It was concluded that construction of a new tunnel that bypassed the existing infrastructure would limit potential disruption and risk to existing services. Transforming one of the existing platform tunnels into a new concourse would increase passenger capacity sufficiently.

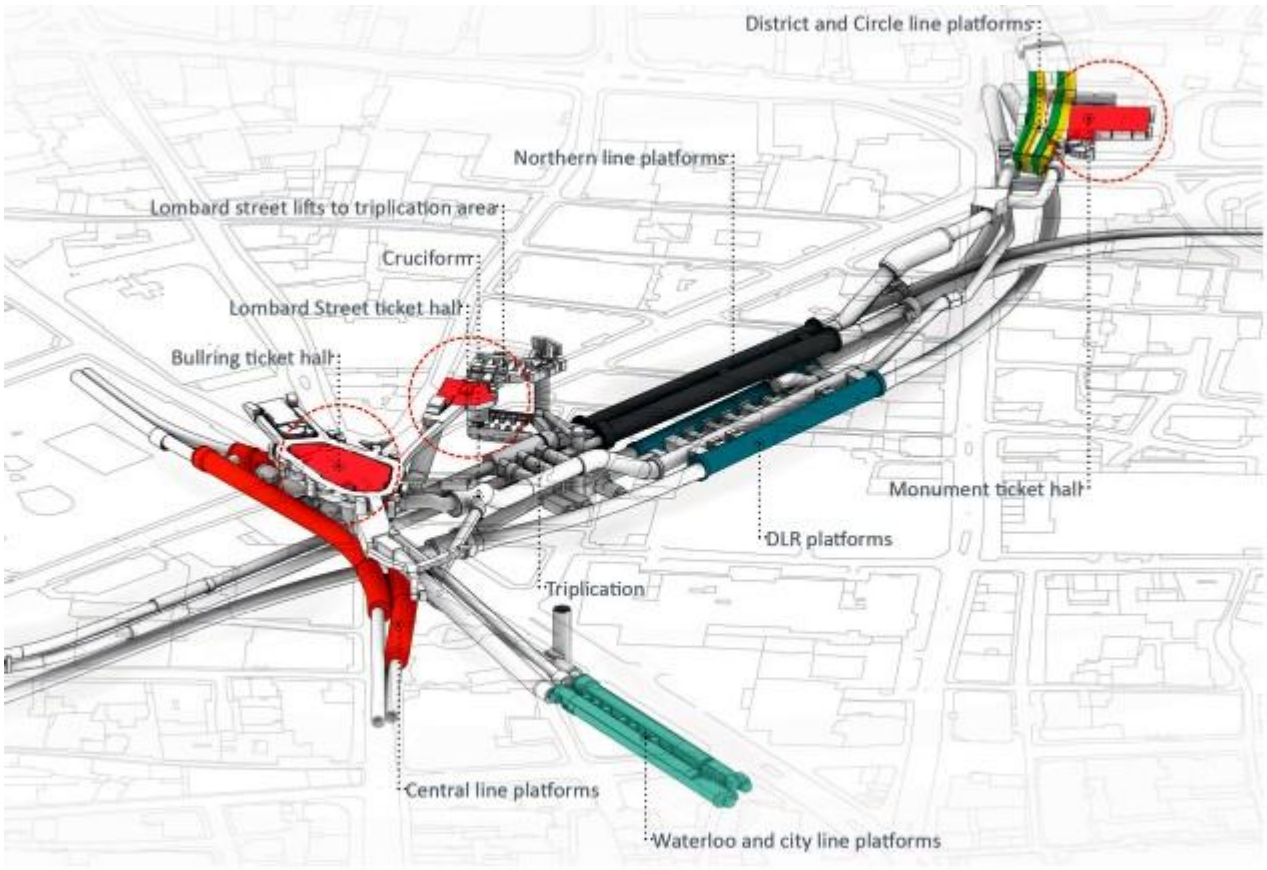
5.4.7 Specific alignment of a new running tunnel, such as horizontal curvature and vertical depth, is fundamentally governed by considerations of ride quality and train speed. It also needs to support and integrate with wider station improvements, while minimising third party impacts such as settlement and utility diversions.

5.4.8 A new running tunnel aligned to the east of the existing tunnel was not considered feasible due to existing infrastructure and building foundations as well as being in close proximity to the below ground vaults of the Bank of England. There were also no available sites for a station entrance over this

tunnel alignment, nor easy access for construction. Constructing a new running tunnel to the west was therefore taken forward for further design and assessment.

5.4.9 In addition to the Northern Line improvements, the need for additional passenger interchange capacity and facilities (including with the Central Line and Waterloo and City Line) was evident. The need for a new station entrance would also provide relief to below ground congestion, particularly in the 'Triplication Area' (where the Northern Line platforms currently join with the passenger connection to the Central Line, see Figure 5.2). It would also improve fire evacuation and protection measures, and provide step-free access.

Figure 5.2: Existing Station Layout



Station Entrance

5.4.10 LUL concluded that a new station entrance was needed to improve fire evacuation and protection measures, and provide step free access, as well as further alleviate existing bottlenecks within the station by removing conflict between exiting and interchanging passenger flows. During construction the site of the new station entrance will also be used as a work site and access shaft for the works below ground, and for construction vehicle access to the

site. Given the absence of open space of an adequate size in the surrounding area, it was established that the acquisition and demolition of existing buildings (at least at ground level) will be required to accommodate the work site and subsequent station entrance.

5.4.11 The location for the new passenger entry point to the station and construction site and access shaft would be optimally located above the existing below ground station infrastructure and proposed tunnels between Bank and Monument Station Entrances. However, given the sensitive townscape, with numerous listed buildings located within a conservation area and consequent design requirements of City of London Corporation, as well as connectivity to existing LUL infrastructure, the selection of a suitable site was severely constrained.

5.4.12 The area between King William Street and Cannon Street was identified as being ideally placed in relation both to the existing and proposed below ground works as well as good for providing access at street level during construction. Two options were identified – one at Phoenix House and one at 10 King William Street. Both options would require demolition of existing buildings.

5.4.13 Further study into the use of the Phoenix House location as a new station entrance identified that existing below ground infrastructure constrained the potential to increase capacity from the DLR to surface, and would not ease congestion or reduce journey times within the station sufficiently. The limited size and triangular shape of the site at Phoenix House would make construction logistics difficult and lead to a longer construction programme. Also, its location at Monument Junction would mean that construction and delivery access would detrimentally affect existing heavily congestion traffic movements.

5.4.14 Due to its location in relation to the below ground infrastructure, 10 King William Street was identified as the preferred work site location.

Interchange

5.4.15 Passenger modelling has shown congestion as a particular problem for passengers interchanging between DLR and Northern Line services; and Central Line to other parts of the station. As mentioned above, provision of a new station entrance at Walbrook provided by the Bloomberg Place project will serve to alleviate congestion at the Waterloo and City Line.

5.4.16 Improving the interchange capacity between the DLR and Northern Line, by providing additional stairs or escalators, would allow faster passenger journeys to the rest of the complex and alleviate the bottlenecks experienced on leaving the DLR. Escalators or lifts are favoured over stairs to maximise capacity increase and journey time improvements, and are normally required where the

vertical travel distance exceeds 5m (the vertical distance between Northern Line and DLR is approximately 10m).

5.4.17 The interchange capacity between the Central Line and other parts of the station is constrained by the Triplication and Cruciform (see Figure 5.2) because both interchanging and exiting passengers are using this same route. Relief to interchange for the Central and District and Circle Lines would come from the Central Line link between the Northern Line and Central Line, as well as the new Station Entrance Hall which will remove conflicting passenger flows.

Step Free Access and Improved Fire Evacuation

5.4.18 Improvements to congestion, interchange and particularly provision of a new station entrance, would provide improved evacuation times for DLR and Northern Line passengers, as well as providing direct step free access from the Northern Line to surface. Construction of a new station entrance introduces an access point between surface level and the below ground infrastructure that can be used to provide fire fighting and lifts for passengers with reduce mobility.

5.5 Concept Development (2009 – 2013)

10 King William Street RIBA D

5.5.1 Following the feasibility exercises described in Section 5.4, further development of the design was undertaken to understand the options, constraints and opportunities in more detail. This culminated in adoption of an Innovative Contractor Engagement (ICE) process (described in Section 5.5.13) to maximise innovation and market value of the scheme.

5.5.2 This work was initially progressed on the basis of a new running tunnel west of the existing tunnel with construction access via, and a new station entrance at, 10 King William Street. Access from street level to the Northern Line platforms was proposed by four lifts located within a new station entrance hall on King William Street. The existing southbound platform would be reconfigured to provide additional circulation and interchange capacity into the Triplication Area in the Bank Monument Station Complex.

5.5.3 Key environmental design considerations at this stage included the following:

- establishing the minimum tunnel dimensions to reduce settlement, excavation and material disposal as well as concrete required for tunnel lining;
- consideration of excavated material disposal by rail or barge to reduce vehicle movements;

- location and sizing of structures to minimise noise, vibration and other impacts during operation;
- construction planning to reduce line disruption and closures; and
- design of above ground infrastructure (and possible Over Site Development (OSD)) in sympathy with the surroundings.

5.5.4 In developing this proposal to RIBA D design level, although meeting the LUL requirements (see Section 5.3), it was found not to be optimal in terms of cost, programme and constructability. The limited size of the site and constraint on construction vehicle access would require multi-storey construction facility arrangements resulting in inefficiencies including risks of traffic disruption and the requirement of additional satellite work sites. On review of these cost and programming constraints, it was therefore concluded that a larger construction footprint would be required. This would also better allow for protective measures during construction, such as compensation grouting, should that be necessary.

Platform to Surface Access

5.5.5 Lifts provide a quick means of access between levels. However, whereas escalators can still be used when not operating, lifts cannot. Also passengers tend to choose alternate routes if required to queue or wait too long for lifts, and as a result lifts are often not used to their full capacity. In addition, escalators were identified as the preferred passenger option during consultation in 2012. Three layout options for street to platform passenger movement were considered during consultation:

- lifts to 10 King William Street;
- lifts within the whole block; and
- escalators, with PRM lifts, within the whole block.

5.5.6 Further modelling work, including passenger behaviour, confirmed that escalators rather than lifts would provide the better congestion relief by dispersing flow of passengers. Provision of lifts would also be required to provide alternative, and step free and fire fighter access from street to the Northern Line platform level.

Base Case

5.5.7 LUL investigated options involving varying degrees of land take within the site bounded by King William Street, Nicholas Lane, Cannon Street and Abchurch Lane. The land take options studied included 10 King William Street only, the whole block (all the buildings within the site), and various options of partial site acquisition (see Figure 5.3 in ES Figures Volume).

5.5.8 10 King William Street and the adjacent buildings are of no signficant architectural merit, with the exception of the façade of 20 Abchurch Lane. City of London Corporation officers advised that the richly detailed elevation of the former Cannon Street Buildings should be retained to maintain the townscape setting for St Mary Abchurch, unless it could be demonstrated that retention would prevent achievement of project objectives.

5.5.9 Comparing partial acquisition of the site to provide a larger construction site identified potential benefits over the 10 King William Street design, including a shorter and more efficient construction programme, additional access and potential space for construction facilities. Use of the whole block was identified as favourable in terms of optimising the layout of the station access for congestion relief and journey time for passengers.

5.5.10 Further option appraisal was undertaken comparing the 10 King William Street site with the whole block; this included environmental considerations. One option included the replacement of the demolished building(s) with a new over site development (OSD) and its relationship with the station entrance. The findings are summarised in Table 5.1.

5.5.11 The whole block would allow for the provision of two banks of triple escalators in order to get from street level to the Northern Line platforms level 30m below. An escalator solution with fire fighter and PRM lifts, built on the whole block, with an entrance on the Cannon Street side of the block was developed and presented as the Reference Case.

5.5.12 It was concluded that use of the whole block would allow use of escalators from the new station entrance hall and give significant benefits to the constructability of the BSCU while also providing for a coherent, high quality and valuable commercial replacement building.

Table 5.1: Comparison of 10 King William Street and the Whole Block

Theme	10 King William Street	Whole Block
Traffic and Transport	Limited options for accommodating lorries on site without the use of a multi-storey construction site. Construction lorry movements on King William Street considered too disruptive. No alternative bus routes.	Lorries could be stopped or held on site, and a one-way system adopted for entering and exiting the work site in a forward gear. Lorry movements would likely be concentrated on Cannon Street. Reduced period of disruption due to shortened construction programme. Increased construction movements due to increased excavation and demolition requirements. Enables space to off-load materials efficiently.
Noise and Vibration	Existing buildings directly adjacent to work site. Extended construction programme therefore longer disruption.	More buildings to be demolished therefore longer periods of activities with noise and vibration impact; however overall shorter construction programme lessens duration of disruption. By demolishing or using all existing buildings within the whole block, there are no directly adjacent buildings to the work site; removing constraints associated with party walls.
Demolition and excavated materials	Single building to be demolished. Congested site with little ability to store or sort waste on site.	Greater levels of waste generated due to demolition of whole block. Larger site therefore potential to store and segregate waste on site.
Heritage	Smaller site limits opportunities to support public realm improvements and retail space.	Comprehensive replacement building solution offers more opportunities to support the Bank Area Enhancement Strategy, including better heritage protection of St Mary Abchurch, locating the deep excavation of the station box on the furthest side of the block.

Innovative Contractor Engagement Tender Process

5.5.13 LUL adopted a new approach to its procurement process to enable bidders to propose and discuss innovative ideas identifying and delivering significant cost, risk and programme benefits. An Innovative Contractor Engagement (ICE) process was adopted to consult with potential contractors at an early design stage. Adoption of such an approach has also reduced the constraints experienced in previous projects where TWAO powers had been sought prior to contractor engagement limiting implementation of construction efficiencies within limits of deviation. Four pre-qualified bidders were asked to evaluate and improve upon the design and to reduce cost, risk and programme, managed in a confidential process, based on specified core requirements (see section 5.3) rather than a predetermined scheme.

5.5.14 All tenderers were given the 10 King William Street RIBA D design (and LUL's evaluation of it), the Base Case and the Reference Case. It was made clear during the bidding phase that the whole block should be considered as available as a construction site, not just 10 King William Street, with the use of escalators encouraged.

5.5.15 Two bidders submitted variations to the Reference Case, providing access from platform to street level by escalators. One used the whole block during construction, and located the station entrance at 10 King William Street, with the remainder of the site provided to the OSD. The other bidder (Dragados SA) located the station entrance on the east corner of the whole block on Cannon Street, with escalators and lifts optimising passenger flows and direction to the platform level.

5.5.16 One bidder explored the possibility of an on-line expansion of platform space, by constructing a new southbound platform tunnel adjacent to the existing alignment, changing the direction of embarkation and converting the existing platform to circulation space. This bidder then submitted a variation of the 10 King William Street design, with lifts providing access from Northern Line to the street level.

5.5.17 The fourth bidder submitted a single 'super platform' proposal, with no new station entrance and tunnelling constructed from Redcross Way, to the south of the River Thames in the London Borough of Southwark.

5.5.18 Dragados SA, with a variation to the Reference Case, submitted the successful proposal. This was taken forward in the design process as the solution that best addresses the project requirements, as well as achieving a considerable improvement on the business case benefit cost ratio.

5.6 Detail Design Development (2013 – Onwards)

5.6.1 The Dragados proposal was considered to provide the best solution for easing congestion and enhancing capacity at the BSCU overall. Key features of the design included:

- a dedicated link tunnel incorporating moving walkways between the Northern Line and Central Line platforms, which reduces the need for passengers to pass through the congested Triplication Area and improves journey time;
- triple escalators from street to Northern Line and DLR platforms, thereby significantly increasing vertical capacity and operational resilience;
- a station entrance on Cannon Street rather than King William Street, which allows for better circulation of pedestrians from platforms to street level and onward destinations; and
- lifts direct from street level to Northern Line and DLR to improve step free

access and emergency evacuation.

5.6.2 Dragados also proposed a second work site as an independent tunnel access point. This is discussed further in Section 5.7.

5.6.3 Following contract award, design of the BSCU has progressed to its current stage for submission of the TWAO application, and going forward to detailed design and construction, various design principles have been developed in consultation with the City of London Corporation and other stakeholders. These include:

- optimising the route alignment of the new tunnel to minimise pile interfaces with existing buildings and reducing risk and magnitude of settlement to structures and utilities;
- seeking to locate plant and equipment to below ground locations while maintaining suitable access for maintenance and replacement, as well as to maximise active frontages at street level; and
- improving sight lines towards and through the new station entrance.

5.7 Constructability

Construction Sites

5.7.1 Dragados proposed a second work site as an independent tunnel access point and work site for construction at Arthur Street. This provided significant construction programme gains as, by decoupling construction of the station entrance hall from the running tunnel, it allowed more efficient construction phasing not limited by sequential working.

5.7.2 The additional work site would have direct access to the new running tunnel with sufficient space to maintain a safe system of working, including construction plant, storage and welfare facilities. It could also allow for the most intensive construction traffic (for removal of excavated material) to be kept away from the Bank Conservation Area, by managing major material movements via Upper Thames Street, a location already heavily used by pedestrians, cyclists and vehicles.

5.7.3 Moreover, with the station entrance located on Cannon Street, the provision of triple escalators and lifts from street to platform level, as well as the requirement to retain the 20 Abchurch Lane façade, the footprint of the Whole Block Site was deemed too small for construction logistics, materials storage and welfare provisions. The loss of construction site space within the whole block would be mitigated by the second work site.

5.7.4 Before the Arthur Street site was agreed as the second site, a number of alternative locations were considered. These are listed in Table 5.2 and shown

on Figure 5.4 (see ES Figures Volume): the sites were grouped into a 'northern cluster' and 'southern cluster'.

Table 5.2: Location and Use of Second Work Sites

Site	Description	Satellite or access work site
Northern cluster		
Worshipful Grocers	A site in the courtyard to the rear of 8-10 Princes Street	Access work site on to the new southbound running tunnel
Lothbury	Adjacent to the existing DLR ventilation shaft to the north of the Bank of England	Access work site close to the planned northern tie-in
Bucklersbury	A disused and partially back filled construction shaft from DLR construction	Access work site into Waterloo and City Line pedestrian access tunnels
Lombard Street	Adjacent to St Mary Woolnoth Church	Access work site into pedestrian access tunnels, close to the Lombard Street lift shafts
Southern cluster		
Monument Street / Fish Street Hill	To the west and south of the Monument respectively	Access work site would be located within the carriageway, close to southern tie-in
33 King William Street	A building due to be redeveloped	Access work site would be located and accessed from the basement of the new building
Swan Lane	An impounded area of the River Thames foreshore	Access worksite would be located and accessed from the foreshore, requiring enlargement of the City and South London Line tunnels
Redcross Way	A disused work site in Southwark, previously used for London Bridge construction during Jubilee Line Extension works	Satellite work site and storage of materials. Possible access work site with tunnel constructed to the existing Bank Station below ground infrastructure
Arthur Street	A carriageway linking Upper Thames street to King William Street	Access work site located within the carriageway, and below ground within the disused King William Street Station

5.7.5 The northern cluster options were found to be too small and were within the Bank Conservation Area close to sensitive structures and listed buildings. They were also not well aligned with the below ground infrastructure and within areas already subject to heavy highway congestion, limiting their efficiency for construction purposes.

5.7.6 The southern cluster options were located outside the Bank Conservation Area. Monument Street has the benefit of being linked to the strategic road network on Upper Thames Street; however, it is not aligned with the proposed tunnels and is directly adjacent to The Monument, a Scheduled Ancient Monument.

5.7.7 33 King William Street, although directly adjacent, is not directly aligned with the proposed tunnels and would require acquisition of the site and demolition of the existing building. TfL was unsuccessful in its attempts to purchase the freehold of this property when it became available.

5.7.8 Swan Lane would require impounding of part of the River Thames foreshore, including an additional substantive area required in order to mitigate flooding risk. The use of barges for the disposal of excavated material would also require a significant stockpiling and loading facility, further increasing the size of the impounded foreshore as well as complex management procedures to mitigate the influence of tides and the Thames Barrier. The works would also have a detrimental impact on already congested river navigation.

5.7.9 Redcross Way is located to the south of the River Thames in the London Borough of Southwark and would have required significant additional tunnelling, resulting in approximately 60 per cent more excavated material. It is considered too far away from the proposed tunnels and main work site to offer credible benefits in terms of construction vehicle access and construction facilities such as pre-mix SCL storage and distribution, ventilation and de-watering facilities. The site is directly surrounded by the Borough High Street, Thrale Street and Union Street Conservation Areas, in an area with greater residential density. Efficient alignment of the tunnel to join the construction area for the BSCU passes under Southwark Cathedral (a Grade I listed building), Borough Market (and associated listed structures), the railways to Cannon Street and Thameslink, as well as the River Thames.

5.7.10 Arthur Street site is located directly over both the new tunnel alignment and is also located above the disused King William Street platform tunnel. The existing below ground infrastructure provides a readymade storage facility for construction operations. The use of Arthur Street requires the carriageway to be shut to through-traffic for the duration of the construction programme. It therefore also requires the diversion of traffic, including the London Bus Route 344 via London Bridge, and creation of fire brigade routes via Suffolk Lane.

5.7.11 Locating certain elements of the work site accommodation on Fish Street Hill whilst using Arthur Street as an access work site was discounted due to the proximity of The Monument, a Scheduled Ancient Monument, and the constrained logistics that would require the workforce to cross the busy King William Street carriageway in its approach to Monument Junction.

5.7.12 The Arthur Street Site has been taken forward as the optimum location for the second access shaft and work site in design development due to its location in relation to the construction activities and away from the Bank Conservation Area, as well as connection with the Strategic Road Network, with suitable mitigation applied.

Excavation Material Removal

5.7.13 Excavated material from tunnel construction will need to be removed from the Arthur Street Work Site. Three main transport options were considered:

- by river – this would require transport of excavation material from the work site to the quayside (double-handling); it could require quayside storage or back-up provision for removal by road if river capacity was not sufficient; this option is also limited by the tide movements, unless motorised barges are used;
- by rail – an additional chamber for loading excavated material onto engineering trains would need to be constructed prior to excavation of the new southbound running tunnel for storage and removal of material from the site, potentially increasing settlement risk; this would also require increased below ground storage areas or back-up provision for removal by road in case removal during engineering hours was constrained;
- by road – the location of the chosen access work site is adjacent to the strategic road network thereby reducing local disruption from construction traffic; this method could also be conducted on a 24 hour basis in line with tunnel excavation; however, there is the potential for secondary noise and air quality impacts, as well as general disruption of the road network.

5.7.14 In view of the above points, removal by road was selected as the most appropriate method.

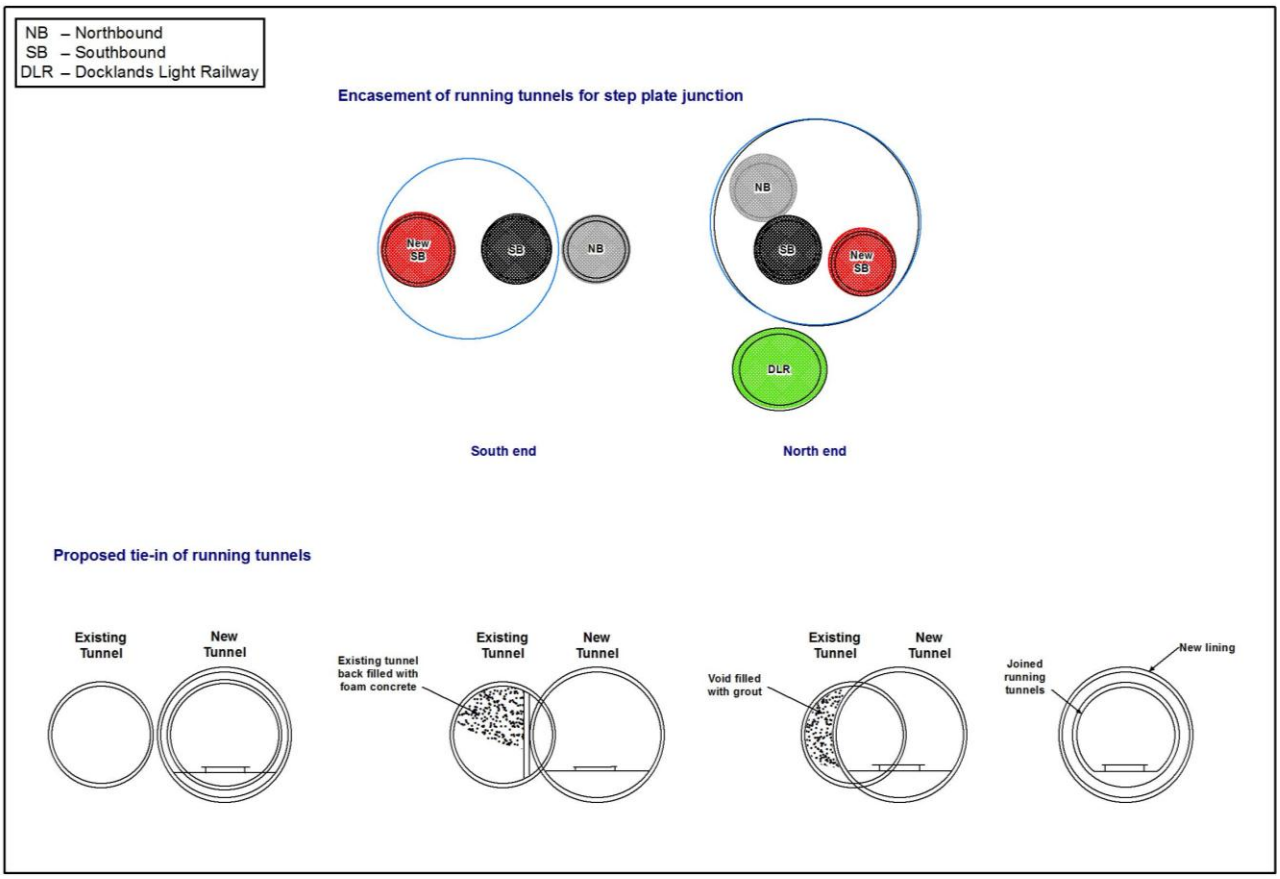
Tie-in Construction of the New to Existing Tunnels

5.7.15 Connection to the existing tunnel via step-plate junction (where two tunnels are joined by enclosing them in a stabilising encased structure, see Figure 5.5) was originally considered as it could potentially be constructed during extended weekend or holiday period possessions of the Northern Line. However, at the northern tie-in, the arrangement of the existing tunnels directly over each other (and the proximity of the Bank of England vaults), make this an infeasible solution. Both the existing northbound and southbound Northern Line tunnels, as well as the new southbound running tunnel would need to be encased in a very large cavern, resulting in unacceptable risk of stability and settlement to existing tunnels and neighbouring structures, and generation of significant excavated material.

5.7.16 At the southern tie-in, use of a step plate junction would be possible, with careful consideration of the proximity to the London Bridge abutments. However, due to this method not being feasible at the northern tie-in, there is no benefit to the programme to adopt this approach for the southern tie-in only.

5.7.17 It was therefore concluded that joining the new running tunnel by breaking into the existing tunnel and connecting the tracks (see Figure 5.5) would be preferable, although this will require extended closure, or blockade, of services on the Northern Line City Branch, with provision of alternative routes via the Charing Cross Branch of the Northern Line, and additional services on local bus routes.

Figure 5.5: Tie-in Construction Options



5.7.18 The blockade is also required to support the connection of the new platform to the existing platform as it is converted into additional passenger circulation area as well as other interchange connections to the existing infrastructure.

Tunnel Construction

5.7.19 Tunnel lining techniques rely either on use of Sprayed Concrete Lining (SCL) or on installation of segments (made of iron or of precast concrete) often used in combination with a tunnel boring machine (TBM). BSCU opted to use SCL

given the relatively small amount of tunnelling required and the consequent lower set-up and other costs of this technique compared with segmental lining.

Compensation Grout Shaft

5.7.20 The TWAO makes provision for two compensation grout shafts should these be required. One would be located within the Whole Block Site to cover the southern sector of tunnelling; and a second would be located at the northern end of Walbrook, close to Mansion House.

5.7.21 A number of alternatives to the Walbrook shaft were considered, including sites on Sherborne Lane, St. Swithin's Lane, Mansion House Place and Bucklersbury. The first three of these roads were all considered to be too narrow to accommodate a 6m diameter shaft; and allow sufficient space for the diversion of utilities. They would also require full road closure for the duration of the tunnelling works. Whilst Bucklersbury would provide adequate space, the existing deep reinforced basements of the Magistrates Court would prevent grouting protection reaching Mansion House. These sites were therefore rejected.

5.7.22 The proposed shaft location on Walbrook has sufficient space to accommodate a work site whilst still maintaining access to Mansion House. However, given its close proximity to Mansion House and other receptors, controls will be required to mitigate construction noise and other potential environmental impacts.

Utilities

5.7.23 During construction of the BSCU, there will also be a need to undertake various utility diversion and protection works. This includes providing structural support and leak lining to Thames Water's main Low Level 2 Sewer which runs west to east, crossing King William Street. These protective works to the Low Level 2 Sewer would require a new access shaft of 3.5m in diameter and 19m in depth to be located on the southern end of Walbrook, between the Walbrook building and the new Bloomberg building currently under construction. The shaft will need to be in place for approximately 13 months. An existing shaft on the corner of King William Street and Abchurch Lane (to the north) will be used for ventilation and emergency egress.

5.7.24 Two alternatives were considered to the Walbrook site: one on King William Street and one at 10 King William Street, within the Whole Block Site.

5.7.25 A site within the carriageway of King William Street would have the advantage of allowing direct access immediately adjacent to the intended working area (an existing manhole sewer access on Walbrook would also be required for emergency egress purposes only). However, this would require the closure of

one lane on what is a busy thoroughfare for 13 months and, therefore, this option was rejected principally for this reason.

5.7.26 An access shaft within the basement of 10 King William Street was considered as this would have the benefit of being constructed within the footprint of the main Whole Block Site and would screen surrounding receptors from the construction activities, including from noise and dust emissions. However, the timing of the vacation of the building and its demolition do not allow the access shaft to be accommodated.

5.7.27 The Walbrook site has the advantage of providing direct access to the sewer without the need for construction adits. Although a shaft in this location will require closure of part of Walbrook to vehicles, pedestrian access and access for service vehicles will be maintained. Impacts during construction will be managed through a Code of Construction Practice.

5.8 Summary

5.8.1 The design of the BSCU has evolved in response to the main objectives and LUL key project requirements so that the operation of Bank Monument Station Complex is enhanced, primarily by reducing congestion and improving capacity within the station, as well as reducing journey time and improving step free access and evacuation.

5.8.2 The design has been developed in response to increases in predicted congestion levels, a better understanding of the passenger use of the station, consultation responses, and detailed design development to optimise engineering and constructability solutions.

5.8.3 Design evolution has rejected alternatives where the project objectives were not met, and chosen solutions where efficient constructability and operation of services is optimised.

5.8.4 The design of the BSCU for the TWAO application submission is described in Chapter 4: The Proposed Development.