Transport for London

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4 May 2017

Dear Gareth

Budget and Performance Committee Request – 31 March 2017

Thank you for your letter of 31 March. Our responses are set out below.

1. **Capital Investment**

   On 18 January you provided us with a project-by-project listing to explain the changes between the March 2016 and December 2016 business plans. It would be helpful to look further back for some of TfL's major projects. Please provide the original business cases, along with any subsequent revisions, for the following investment projects:

   - **The Four Lines Modernisation project**
   - **The Deep Tube Upgrade Programme**
   - **The Northern Line Extension**

   Please ensure you include information on changes to budget estimates, expected delivery dates and key milestones for the projects listed above since 1 April 2012.

Four Lines Modernisation

We provided the business cases for the Four Lines Modernisation to the Committee on 25 February 2016. I have enclosed these at Appendix 1 and Appendix 2 for ease of reference.

Deep Tube Upgrade Programme

For the Deep Tube Upgrade, a business case was prepared in 2013 and an updated business case was completed in October 2016, taking into account decisions made in the intervening years. As these are for a project for which contracts have not yet been let and providing them would require significant work to ensure that we do not compromise TfL's commercial position, I have set out in this letter the relevant information from the business cases about delivery dates and budgets.

Below is an extract from the conclusion of the 2013 business case, which summarises the case for the Deep Tube Programme (DTP) at the time.

> "7.1. Considering the cornerstone DTP objectives of renewing life-expired assets and providing capacity for London's growth, the business case analysis shows a strong case for investing in this programme of line upgrades, with the overall programme options demonstrating Benefit Cost Ratios (BCRs) of up to 4.2 to 1.
>
> 7.1.1. The return from investment on the Piccadilly line is strongest which supports the decision to place the Piccadilly line as the first major line in the deployment sequence, as set out in the 2014/15 TfL business planning submission.
>
> 7.1.2. The returns on investment on the Bakerloo and Central lines are lower than the Piccadilly, with similar returns per pound of investment for these two line upgrades. The choice of which major line should follow the Piccadilly is therefore highly dependent on the emerging asset condition and performance, and the stabilisation costs of maintaining the legacy train systems in service until their eventual replacement. Refinement of the scope and ratification of the costs of supporting continued asset availability on these lines will help to clarify the correct order of renewal. The DTP strategy should therefore leave this choice open for as long as possible.
>
> 7.1.3. The case for upgrade of the Waterloo & City line is most modest which supports positioning of this line upgrade towards the end of the programme. Timing should be determined based on maximising the delivery synergy with one of the later major line upgrades."

Table 1 below is also drawn from the 2013 business case.

Table 1: 2013 Deep Tube Programme Business Case Summary

CAPEX estimate of candidate option			
	Line	2012 prices	Outturn
		(£m)	
Base costs and overheads	Piccadilly	2,701	3,860
	Central	3,138	5,346
	Bakerloo	1,099	2,079
	Waterloo & City	108	202
	Sub Total	**7,046**	**11,487**
With risk and optimism bias at 40% as per business case assessment		9,865	16,424

The updated October 2016 Deep Tube Upgrade business case reflects:

- a decision made in 2014 to reverse the order of the Central and Bakerloo line modernisations to prioritise replacing the oldest trains first
- a decision made in 2015 to bring forward the Waterloo & City line to complete alongside the Piccadilly line

In March 2015, we announced that the Deep Tube Upgrade Programme, and therefore the date envisaged in 2013 for delivering the Piccadilly line modernisation (2025), would be affected by the new schedule for the Four Lines Modernisation. Work has remained on track since, and interim upgrade work is underway. The re-signalling work for the Piccadilly Line modernisation will start in 2020, with new trains arriving from 2023.

The information in the October 2016 business case, including the expected delivery dates for line modernisations, reflects that in a TfL Board Paper of 17 March 2016, which I enclose at Appendix 3.

The October 2016 business case was prepared before the finalisation of the December 2016 Business Plan. As the Committee is aware, the timing of the completion of the Waterloo & City line is now under review to consider whether it is most effective and efficient to carry out the work towards the start of the Central line upgrade or at the end, as they are the same trains. This is in line with the findings from the October 2016 business case. The delivery date for the Bakerloo line has been aligned to the planned Bakerloo Line Extension. This will minimise disruption to London and increase the efficiency of the programme.

On very large programmes such as the Deep Tube Upgrade, which are spread out over many years, it is natural for business cases to be updated as we get more accurate costings and there will inevitably be changes to the estimated final cost. Table 2 below is taken from the October 2016 business case. It shows the same planned expenditure as set out in the March 2016 Business Plan, which has previously been provided to the Committee. In my response to the Committee of 18 January 2016, I explained why we have since revised these estimated costs in the December 2016 Business Plan through value-engineering and reassessed train financing.

Table 2: 2016 Deep Tube Upgrade Programme Business Case Summary

DTUP Impact on Business Plan								
DTUP (LU-PF200)	Spend to date (P05)	2016-17 (Remainder)	2017/18	2018/19	2019/20	2020/21	Future Years	**Total**
	(£m)							
Development Work Feasibility and Early Design	56.6	21.2	68.1	-	-	-	-	**145.9**
Main Works Piccadilly	-	-	64.8	201.1	252.7	496.9	4,794.7	**5,810.2**
Bakerloo	-	-	0.0	0.0	3.7	22.3	2,388.1	**2,414.1**
Central	-	-	0.0	8.9	0.7	0.9	7871.1	**7,881.5**
Waterloo & City	-	-	0.0	0.0	0.2	2.4	255.3	**257.9**
Total Estimated Final Costs	**56.6**	**21.2**	**132.9**	**210.0**	**257.2**	**522.9**	**15,309.3**	**16,509.7**

Work is continuing on the detailed plans for these vital line modernisations and we expect the next step will be to tender contracts for signalling and rolling stock. In the meantime, we are also investing in new infrastructure and improvements to trains for these lines.

On the Piccadilly line, we are installing a new signalling control system, including moving the existing line service control centre to a new, upgraded location in early 2018. This will help us to run a better Piccadilly line service using modern technology. The new system has so far been installed and commissioned between Cockfosters and Earl's Court. This is an interim upgrade to ensure that the Piccadilly line remains reliable until the full line upgrade takes place.

The Central Line Improvement Programme will replace propulsion systems and train computers, modify trains to improve accessibility, install CCTV and make repairs to train structures. These improvements will be delivered between 2019 and 2021.

Northern Line Extension

I enclose a copy of the business case for the Northern Line Extension at Appendix 4, which formed part of our inquiry documents for the scheme. Good progress is being made in delivering the extension and tunnelling has begun. We continue to discuss the significant design changes to the over-station development planned by the developer, which were detailed in a paper to our Finance and Policy Committee published in January 2016 (Appendix 5).

List of adjustments between capital renewals and capital investments
We understand TfL has reclassified some of your planned capital renewal expenditure to capital investment, and that this was done in line with accounting standards. To allow us to make a fair comparison from the March 2016 to the December 2016 business plan, please provide a list of adjustments showing which projects were affected and the value of the adjustments.

As Ian Nunn explained to the Committee in January and as I set out in my letter to you of 18 January, we were directed by the previous Mayor to publish a five-year Business Plan in March 2016. The Mayoral Direction is available on the london.gov.uk website. As a result, the two-page Business Plan section of the March 2016 Budget and Business Plan was created in a short space of time, with a necessarily broad brush approach applied to the classification of renewals and enhancements.

Having been directed to issue a five-year Business Plan, we produced a top-down capital investment programme, applying a 10 per cent value engineering assumption. An additional high-level estimate of savings was then added. This resulted in the below total capital expenditure which was not broken down by project.

Budget Capital investment	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21**
	(£m)				
Total capital expenditure	(1,974)	(2,127)	(2,117)	(1,860)	(1,993)

We separated capital renewals from new capital investment for the first time in the March 2016 Budget and Business Plan. Splitting renewals from enhancements is in line with best practice and is intended to provide lenders a better picture of the underlying capital requirements of the business.

Given the timeframe we were given, we used a top-level percentage split between renewals and enhancements. This was partly informed by an average produced from high-level analysis undertaken in January 2016. As a result, the March 2016 Business Plan assumed that 55 per cent of capital investment in 2016/17 would be renewals, decreasing to 48 per cent in 2017/18 and then increasing to 50 per cent for the final three years of the plan. In addition, some £1.1bn of new Mayoral priorities were added to the March 2016 Business Plan, as set out in the below table.

Values used for ratio split	**2016/17**	**2017/18**	**2018/19**	**2019/20**	**2020/21**
	(£m)				
Capital Renewals	**(1,086)**	**(1,021)**	**(1,059)**	**(930)**	**(996)**
New Investment	(888)	(1,106)	(1,059)	(930)	(996)
Mayoral Priorities	(133)	(193)	(203)	(147)	(400)
Total new enhancements	**(1,021)**	**(1,299)**	**(1,262)**	**(1,077)**	**(1,396)**
Total capital expenditure – Per March 2016 Budget	**(2,107)**	**(2,320)**	**(2,320)**	**(2,007)**	**(2,393)**

Although the split was not calculated for individual projects, we have applied these splits retrospectively at Appendix 6 to aid the Committee's understanding.

Throughout the rigorous and lengthy process to produce the December 2016 Business Plan, we have refined the approach to the split of expenditure between renewals and enhancements and I enclose the split for the December 2016 Business Plan at Appendix 7.

We will continue to work on the accuracy of these splits and I would expect there to be further changes as the work develops. Given the broad brush approach used for the March 2016 Business Plan and that we are continuing to refine this process, I would urge the Committee not to place too great an emphasis on specific movements between the retrospectively-calculated allocations for individual projects in March 2016 and those for December 2016.

Third party funding for Growth Fund projects
What third party funding is a) secured and b) under negotiation for the potential Growth Fund projects. Is third party funding needed for these projects to go ahead?

- **The Bakerloo line extension**
- **The Metropolitan line extension**
- **The Sutton Tram extension**
- **Old Oak Common station (Crossrail)**
- **Woolwich station (Crossrail)**
- **Elephant and Castle ticket hall**
- **DLR extension to Thamesmead**
- **Overground extension to Barking Riverside and Abbey Wood**

In the March 2016 Business Plan, £350m was attributed to the Growth Fund and was allocated to 12 schemes which, in total, unlock more than 55,000 homes and thousands of new jobs. The December 2016 Business Plan allocated a further £200m to the Growth Fund to support transport projects which unlock housing and jobs growth. This additional funding has not yet been allocated. We are working with the GLA Growth Board and the Deputy Mayor for Transport to identify suitable schemes to fund.

The project-by-project listing we provided to the Committee on 18 January 2017 included a note about the Planning Projects budget line that included the unallocated £200m Growth Fund. In the table's notes, we said that the unallocated Growth Fund 'could contribute, alongside third party funding contributions, towards projects such as Sutton Tram and Old Oak Common'. The note went on to list a number of further schemes included in the Planning Projects budget line. Of the eight schemes listed in your letter, only three have a contribution from the original £350m Growth Fund allocation. They are the Metropolitan Line Extension (£16m), Woolwich Crossrail station (£24m) and Elephant & Castle ticket hall (£70m). The remaining five schemes do not currently have an allocation from the Growth Fund. These schemes are also at

varying stages in their feasibility or design and do not yet have full finance packages in place.

The table at Appendix 8 lists those schemes with existing Growth Fund contributions and the third-party funding they have secured, as well as what is currently subject to negotiation.

Investment in the Old Oak Common site

On 23 March 2016 the Budget Monitoring Sub-Committee heard from representatives from the Old Oak and Park Royal Development Corporation about progress at the site. We were concerned to hear that funding had been removed from the TfL business plan for two Overground stations on the Old Oak Common site. There was a clear expectation TfL would be providing funding for road and pedestrian links. Please set out what funding TfL has allocated for the Old Oak Common site, and what it will be used for.

The new High Speed 2 and Crossrail station set to open at Old Oak Common in 2026 will help unlock development opportunities and enable the creation of tens of thousands of new homes and jobs for Londoners.

While our March 2016 Business Plan included a notional allocation for Old Oak Common, rather than funding for a specific station or scheme, this was not fully funded or costed. We continue to work on the development of options for new London Overground stations at Old Oak Common Lane and Hythe Road as part of the €4m match funding from the European Commission Connecting Europe Facility.

We will work with the Old Oak and Park Royal Development Corporation to progress plans for a complementary package of transport investment in and around North Acton, Willesden Junction and Old Oak Common expected to be required after the lifetime of the current Business Plan (2021/22).

2. Cost reduction programme

Clarification on the savings figures in the Business Plan: On 18 January 2017 you provided us with a breakdown of TfL's target efficiency savings from 2017-18 to 2020-21. Savings over the four years total £2,227 million. This compares to the £4,000 million savings set out in the Business Plan, to be made over five years from 2017-18 to 2021-22. Please provide a full reconciliation between these two figures.

Further breakdown on planned savings: Reconciliation between savings figures provided (£2,227m – 2017/18-2020/21 – provided to the Committee on 18 January 2017 AND £4,000m – 2017/18-2021/22 – set out in our Business Plan

The £4bn comprises £3bn in cumulative cost reductions from our operating expenditure and some £1bn in one-off cost reductions and value engineering from our planned capital investment, for the full period covered by our December 2016 Business Plan.

The £2,227m represents reductions in operating expenditure only and does not include 2021/22, the final year covered by our December 2016 Business Plan. The table below shows that the comparable, cumulative figure for cost reductions from operating expenditure for the full plan is £3bn.

TfL cost reduction (Operating expenditure)	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**
	(£m)				
London Underground	64.7	182.1	248.2	350.1	377.1
Surface Transport	87.8	80.9	100.1	102.4	120.3
Planning and Commercial	75.1	292.3	342.0	301.4	312.3
Total (run rate cost reductions)	**227.6**	**555.3**	**690.3**	**753.9**	**809.7**
Cumulative savings	**227.6**	**782.9**	**1,473.2**	**2,227.1**	**3,036.8**

In addition, the table below represents the value engineering and cost reductions in our capital programme. As these reductions relate to individual projects, they are not cumulative but together they represent around £1bn in cost reductions.

TfL cost reduction (Capital expenditure only)	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**
	(£m)				
London Underground	85.9	126.3	175.6	214.3	139.2
Surface Transport	70.5	65.2	85.7	59.1	92.4
Planning and Commercial	18.7	22.7	11.5	3.8	1.4
Total (cost reductions)	**175.1**	**214.2**	**272.8**	**277.2**	**232.9**

The breakdown referred to above split savings out into three broad categories: London Underground, Planning and Commercial, and Surface Transport. Please provide a detailed breakdown showing what directorates and services are included in these categories.

London Underground

London Underground runs and maintains the Tube network and is responsible for the delivery of capital programmes, aimed at improving and expanding the network.

Surface Transport

Surface Transport includes all contracted services. This includes Buses, London Overground and TfL Rail, Docklands Light Railway, Trams, Emirates Air Line, London River Services, Santander Cycle Hire and Dial-a-Ride. Surface Transport is also responsible for the licensing of taxi and private hire vehicles and maintaining London's red routes and 6,000 traffic lights.

Planning and Commercial

Planning and Commercial represents all of our professional services functions, including Customers, Communication and Technology, Finance, Commercial, Human Resources, Planning, General Counsel and Commercial Development.

3. Journey forecasting

Information on TfL's journey forecasting model
For bus fares:

- **What data feeds into the forecasting model?**
- **What are the key assumptions in the model?**
- **How and when are the model and forecasts reviewed?**

Our bus fares income is forecast by applying variables that are known to affect bus demand to the income from the previous year. These variables are:

- Macro-economic such as changes in population, economy, tourism, education and income – provided by the Greater London Authority
- Fare levels
- Service volumes such as the change in total supply measured by the operating kilometres forecast – from our own data
- Service quality – we use change in Excess Waiting Time as a proportion of Scheduled Waiting Time from our own data

We monitor actual data against forecast data every period. If there is any significant unexplained variance, we review our data and assumptions.

Thank you again for your letter and I trust that the enclosed information is useful.

Yours sincerely

Kind regards

Mike Brown MVO

cc: Lucy Pickering, Scrutiny Manager, Budget and Performance Committee

Enc:

1	SSR Upgrade Business Plan
2	4LM Business Case
3	New Tube for London Board Paper, Pt 1 – Item 12
4	NLE Economic and Business Case
5	NLE Finance and Policy Committee Paper
6 and 7	March and December Splits
8	Growth Fund Projects

Appendix 1

Transport for London
London Underground

Sub-Surface Railway Upgrade
Business Case Narrative

Version: 3.0

Date: 30th November 2012

[redacted]

Prepared by	Kate O'Brien, Senior Planner, SSR Upgrade Sponsor Team, LU S&SD	Date: 3rd Dec 12
[redacted]		5/12/12
Checked by	Michael Stubbs, Senior Planner, Train Systems & Upgrades, LU S&SD	Date:
[redacted]		
Reviewed and authorised by:	Hedley Calderbank, SSR Upgrade Sponsor, LU S&SD	Date: 6-12-12

Revision History

Issue	Date	Revisions
3.0 Draft	16th Nov 2012	First Draft
3.0	30th Nov 2012	Final Issue Minor changes made following comments from Hedley Calderbank

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1.0: Description

Since 2003, an upgrade of trains, signalling and supporting systems has been in progress on London Underground's Sub-Surface Railway (SSR) – defined as the Circle, Hammersmith & City, Metropolitan and District lines. Following the re-integration of the Metronet SSL Infraco into Transport for London (TfL) in 2009, the Upgrade has been delivered and sponsored by London Underground (LU). The original business case for the scheme was generated during 2010. A comprehensive review of this business case has now been undertaken, to meet the following aims:

- To assure the Sponsor that the current Upgrade Programme continues to represent good value for money;
- To incorporate all new elements of scope;
- To reflect fully, the latest understanding of expected benefit streams, developed through production of the Benefits Managements Plan and Reports.

In order to continue running reliable and regular services on the SSR, a programmed replacement of fleet, signalling and supporting systems was instigated as part of the LU Public Private Partnership (PPP), because most existing assets were at, or beyond, their design life. The necessity for asset replacement, simultaneously affords the opportunity for asset modernisation. Installation of modern equipment on all SSR lines will facilitate the delivery of improved journey times and capacity, both of which are essential to accommodate London's projected population and employment growth.

As mentioned above, a separate Benefits Management Plan (see Livelink below), with reports, has been developed to track and manage the delivery of the business benefits from the SSR Upgrade.

2.0: Main Items of Scope and Objectives of Scheme

The SSR Upgrade includes the:-

- Introduction of 191 new S-Stock trains (58 x 8 car and 133 x 7 car) to replace the 178 A-, C- and D-Stock trains between 2010 and 2015. New fleets will initially be introduced alongside existing "legacy" signalling assets, with restricted performance, and at baseline service levels;
- Replacement of the existing signalling and control system with a new transmission-based Automatic Train Control (ATC) system, by 2018. This system will be controlled from a single location and will be capable of Automatic Train Operation (ATO), Automatic Train Regulation (ATR) and Continuous Automatic Train Protection (ATP);

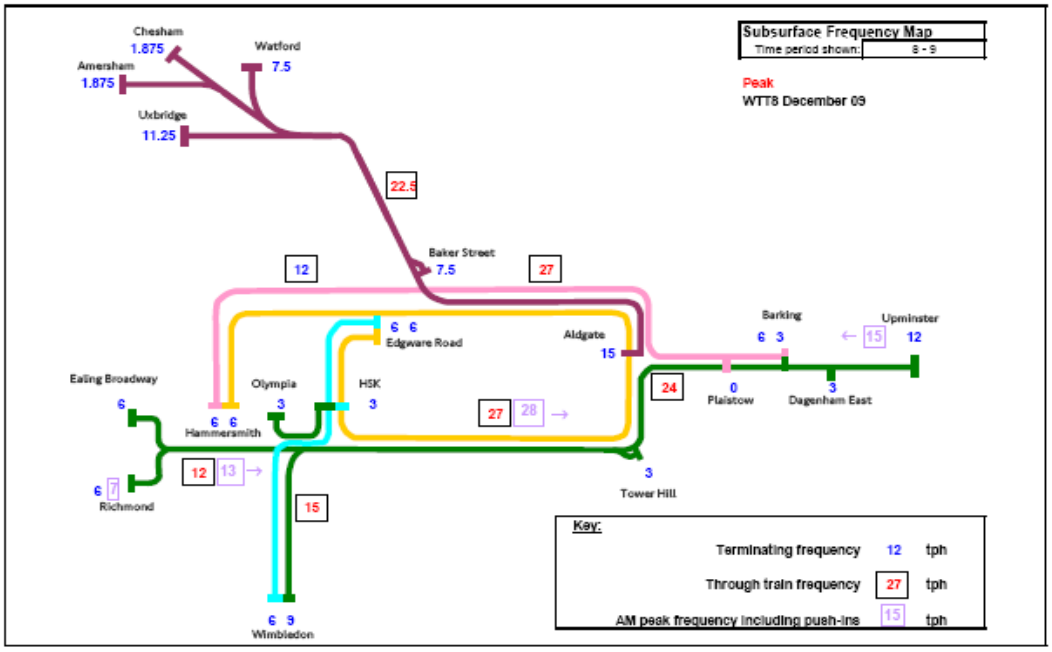
- Partial replacement and upgrade of the associated power infrastructure, to facilitate faster train speeds and higher frequencies, as well as to support the new signalling infrastructure. Delivery of these power assets will be aligned with the rolling stock implementation programme;
- Infrastructure modifications necessary to enable the network to accept the larger fleet of longer trains. This will be achieved by adapting legacy signalling, stations, depots and sidings; and
- Bringing together of the package of new assets to deliver a more frequent, more reliable and better quality passenger service. This will be achieved via timetable changes which will be designed, and timed – as new assets are introduced – to exploit the opportunities to deliver improved passenger journey times. All components of the package need to be in place before the total passenger benefits can be delivered. Therefore, the major improvements to service levels and runtimes will only be achievable once the final asset, the new signalling system, has been successfully delivered.

The high level objectives of the scheme are:-

- To renew life-expired train systems to enable continued provision of services on the SSR; and
- To exploit the opportunity presented by asset-renewal, to upgrade to higher specification assets and systems, in order to realise journey time improvements for SSR passengers. This will be achieved through provision of faster, more frequent and more reliable services.

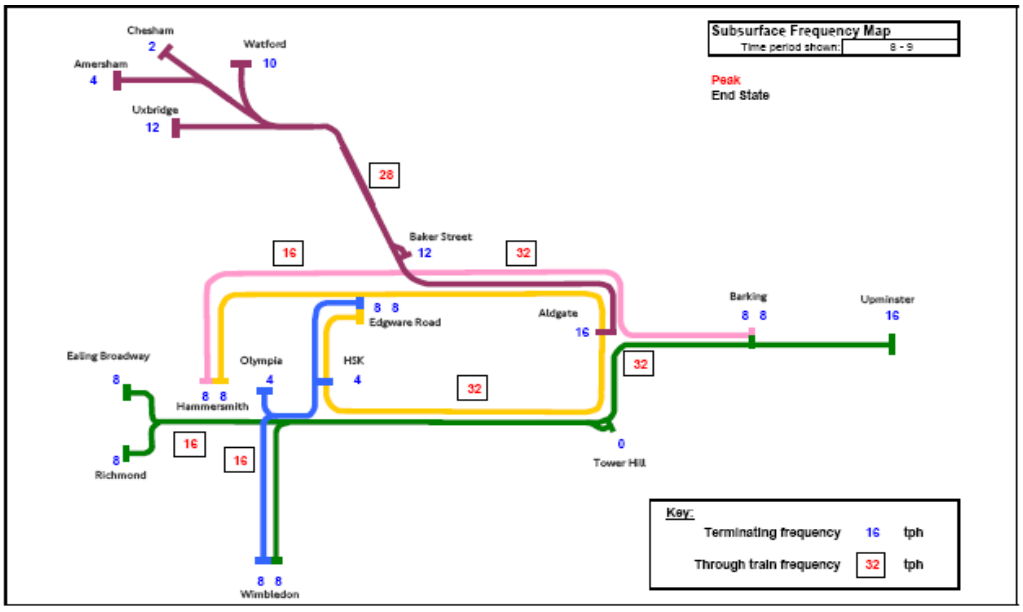
The SSR Upgrade addresses many of the policy objectives of the Mayor's Transport Strategy (MTS), May 2010. The MTS sets out the vision for the future of transport in London. It notes that London Underground has increased its customer satisfaction scores to record levels, whilst simultaneously experiencing significant modal share increases, following the increased use of London's public transport network since 2001. However, it recognises that the standard of service cannot be maintained without renewal of the current key assets. These are defined in the MTS as "track, civils, trains, signals, stations". The MTS describes the programme of LU's Line Upgrades as being the "cornerstone" without which LU will not have the capacity to provide the same service as today, let alone keep up with the growth in demand, which is forecast to continue increasing over the next two decades. The peak service levels provided on the SSR pre- and post- Upgrade are shown in Figures 1 and 2.

Figure 1 – Pre-Upgrade Peak Service Levels (1)



Notes: A push-in is a uni-directional trip operated in addition to core service levels

Figure 2 – Post-Upgrade Peak End-State Service Levels, 2018



In addition to stating the need for extra capacity on London's public transport network, the MTS aims to make passengers' experience of travelling on public transport more pleasant. This not only requires improved levels of comfort and ambience on LU's services, but also a restriction on Londoners' exposure to pollution. The SSR Upgrade is a response to these political imperatives; the new fleet, operating a more frequent service, provides greater capacity and a more

1. Following the December 2009 extension of Circle line services to Hammersmith

pleasant journey, encouraging modal shift to the Underground from more polluting road vehicles. The SSR Upgrade increases accessibility for the mobility-impaired with rolling stock designed, as far as possible, to be compliant with 'Rail Vehicle Accessibility Regulations' (RVAR) legislation.

The MTS states that the safety and security of transport in London should be "incorporated into the planning and design" of new projects. The Upgrade introduces a new signalling system and a new class of rolling stock, cutting the risk from collisions and fire. The new rolling stock is also designed with regard for passenger security; CCTV coverage will increase from fewer than 50% of trains, to 100%, when the new fleet is in service, and every train will be completely walk-through. Through-gangways are expected to reduce graffiti and other anti-social behaviour by providing fewer areas where these activities can be carried out unobserved.

The MTS requirement for public transport to support the successful delivery of the London 2012 Olympic and Paralympic Games was aided by the SSR Upgrade; the new trains on the Metropolitan line directly served the events held at Wembley. In the future, the upgraded services on the District line will support the legacy of the Olympics, providing access to the Queen Elizabeth Olympic Park via West Ham.

Following the Upgrade, those arriving in London from Europe and the British regions by train will also be aided by the increased frequency and capacity provided by the Sub-Surface Railway – every National Rail terminus in London north of the river is either directly served by, or within walking distance of, an SSR station.

3.0: Options Considered

This section summarises the options appraised in this version of the business case. Table 1 provides a summary of the main features of each option.

3.1: Current Upgrade Programme

This option captures the elements of the SSR Upgrade as per the specification in November 2012. See Section 2 for a description of the main items of scope and timings.

The Upgrade is treated as an entire system in the business case, because the combination of upgraded signals, trains and power assets enables delivery of post-Upgrade service levels and performance.

3.2: "Do Minimum" (representing minimum spend option available in 2003)

This option was constructed in 2010 to represent the Do Minimum available at the outset of the SSR Upgrade Programme (SUP) in 2003. In constructing the scenario, the following objectives were used:-

- Minimise capital expenditure whilst ensuring assets can support unchanged levels of service, reliability and safety on the SSR; and
- Defer the capital expenditure that is required on programmed asset-renewal for as long as practicable.

This option was developed to track the whole Upgrade benefits and to provide assessment of the overall benefits and costs of the Upgrade. In developing the scenario, consideration was given to the minimum cost and latest date at which programmed renewal of train and signalling assets could practicably have been undertaken. A "Do Nothing" base case was not considered appropriate given the age of the current assets (in 2010; trains: up to 50 years old, signals: 62% of assets over 45 years old).

In summary this scenario assumes:-

- Renewal of signalling by 2028 with a basic transmission-based signalling system, with life-extension of legacy signalling required in the interim;
- Replacement of A- and C-Stock trains by 2020, and D-Stock by 2026, with the same number of similar length Modern Equivalent Replacement (MER) trains. Life-extension of legacy fleets is required in the interim;
- Fewer upgrade enabling works required, with lower costs assumed for traction power, stabling and route-enabling;
- No delivery of performance or service enhancements. Corresponding incremental OPEX and traction power CAPEX is therefore saved, and associated passenger benefits and revenue foregone; and
- Traction power voltage remains at 630V.

Appendix C provides more details on the rationale for the signalling and fleet asset replacement assumptions used in this "Do Minimum" scenario.

Table 1 – Options Appraised and their Key Features

	Current SSR Upgrade Programme	"Do Minimum" (representing 2003 choice)
Rationale	• Capture all impacts of the current programme. • Programme seeks to renew and upgrade train, signalling and supporting assets to meet TfL objectives through enhancing service delivery, safety and reliability.	• Scenario for minimising discretionary CAPEX and deferring until latest possible date from point of Programme Inception. • Renewal of assets still required to avoid reduction in safety, reliability or current service levels.
Rolling Stock Assets	• Continue fleet replacement with air conditioned, walk-through S-Stock, as per the current programme, with all trains replaced by 2016. • Longer 7 car trains on Wimbledon - Edgware Road, Circle, and Hammersmith and City lines and slightly longer trains on all other lines. • Fleet size increases from 178 to 191. • Trains run at interim performance on existing signalling until re-signalling.	• Before 2020, A- and C-Stock fleets to be replaced by a new class of MER rolling stock which conforms to all current standards and legislation, including RVAR. • This stock would not have air conditioning or through-gangways and would be the same length as current trains. • A-stock replacements would be 8 cars, while the C-stock replacements would be 6 cars • D-stock assumed to be largely RVAR compliant and, due to condition, offering more opportunity for life extension; replaced by MER trains by 2026. • All legacy trains replaced in advanced of signalling for migration purposes. • Greater spending on maintaining the existing fleets than is currently the case incurred to ensure that it continues to function until replacement.
Signalling Assets	• Signal Immunisation programme to enable new train introduction. • Continue the current Automatic Train Control (ATC) signalling contract process, leading to roll-out of the new signalling system by 2018. • ATC system to consist of Automatic operation, regulation and continuous speed supervision. • Signalling constraints removed to allow trains to operate at full performance.	• Signal Immunisation programme to enable new train introduction. • SSR signalling system to be replaced with a transmission based system with in cab signalling and continuous speed supervision, deferred to 2028 – representative of the maximum level of deferral considered to be sustainable. • No train performance uplift sought and no automatic regulation functionality to be purchased. • Greater spending incurred on maintaining the existing system than is currently the case to ensure it continues to function until replacement.
Other Assets	• SSR power assets to be upgraded to coincide with new fleet and signalling system, traction power upgrade includes voltage increase from 630v to 750v. • Extensions and other enabling works required at certain platforms, sidings and depots across the SSR network.	• SSR power assets to be upgraded to coincide with new fleet, but a reduced requirement compared with the current programme. • Essential renewals to be undertaken in the interim. • No platform, siding or depot lengthening necessary, due to shorter trains than in the current programme.
Timetable Changes	• No significant change prior to ATC • Peak service enhancements from Dec 2009 timetable to end-state of 32tph realised during signalling migration.	• No service enhancements possible beyond Dec 2009.

4.0: Explanation of Costs, Cost Savings and Revenues

This section details the cost and revenue changes applied in the appraisal.

4.1: Capital Expenditure (CAPEX)

Capital costs for the SSR Upgrade Programme (SUP) and all supporting projects have been analysed and included in this analysis including projects which have commenced since 2010, and ones which were excluded from the previous business case because they were insufficiently advanced for full assessment to be made. This applies to the following projects: 750 volt Conversion; End-State Track Layout; Wheel-Rail Interface; and S-Stock Heavy Maintenance.

The costs were sourced from the London Underground 2011/12 Period 13 forecasts. The management contingency valuation was supplied by SUP Integration & Controls and has been incorporated following the latest TfL guidance.

The current SUP costs (with appropriate management contingency applied) were used to derive estimates of the capital expenditure associated with the "Do Minimum" option. This included proportional adjustment of risk allowances (past costs inherently incorporate a proportion of costs that were held as risk at the programme outset, and future risk allowances are probability-weighted).

4.1.1: Current Programme (CAPEX)

The Upgrade, including all supporting projects, is forecast to cost LU £4.942 billion in outturn – excluding management contingency (MC) and real growth – of which £4.157 billion is allocated to the SSR Upgrade Programme (SUP). The remaining £0.785 billion is allocated to other supporting projects, and largely comprises power upgrade works, kept in-house by LU throughout the PPP. In 2011/12 prices the corresponding values are £4.820 billion, £4.072 billion and £0.747 billion.

Table 2 shows the capital costs of the SSR Upgrade in constant 2011/12 prices. Project/Programme risk budgets were included in all of these figures. These risk allowances were based on quantified risk assessments, and accounted for 9% of the future costs.

Costs were disaggregated into those which:-

- contribute towards introduction of S-Stock, including enabling & power works;
- enable introduction of ATC and associated timetables including all enabling and power works; and
- reflect old spending streams:-
  - the aborted Westinghouse signal upgrade contract. This cost item was included as a sunk cost in the "Do Something" option. However, it was excluded from the "Do Minimum" because it resulted directly from the

course of action taken in the early stages of the current Upgrade Programme which would not be applicable for the "Do Minimum" scenario.

- A small number of other miscellaneous projects.

Table 2 – Capital Costs for Current SSR Upgrade

£m 11/12 prices, undiscounted excluding forecast real growth & MC	Cost
Rolling Stock	
Rolling Stock and enabling works	3,246
Signalling	
Signalling and enabling works	1,216
Other	
Aborted Westinghouse signalling supply	355
Other old costs in Programme	2
Total	4,820

Note that table totals may not sum, due to rounding.

The TfL Business Case Development Manual (BCDM) requires that management contingency be added to future project capital costs in order to remedy overly-optimistic early cost projections. It ensures that the benefits of a project continue to be sufficient to justify the costs, in the event that the costs increase during implementation. Guidance states that this should be attributed as the difference between the P80 and P50 risk valuation. A total value of £106.5m was supplied in Q1 2012/13 by Finance. This value covers the projects within the SUP portfolio which were unfinished at that point.

The figure has been profiled in line with SUP risk and included in the analysis. A value for management contingency for the supporting (power and stations) projects was also included. This was estimated using the equivalent rate of management contingency per pound of risk as for the SUP, giving a total value for management contingency across the complete portfolio of Upgrade projects of £124.2m.

The total figure for management contingency, expressed as a weighted average of the total spend on the SUP and all associated projects, is 3%.

Table 3 shows the CAPEX costs of the project with and without management contingency added.

Table 3 – CAPEX for Current SSR Upgrade With and Without Management Contingency (at 2011/12 Period 13)

£m 11/12 prices, undiscounted excluding forecast real growth	Cost Excluding Management Contingency	Management Contingency	Cost Including Management Contingency
Rolling Stock			
Rolling Stock and enabling works	3,246	44	3,290
Signalling			
Signalling and enabling works	1,216	81	1,297
Other			
Aborted Westinghouse signalling supply	355	0	355
Other old costs in Programme	2	0	2
Total	**4,820**	**124**	**4,944**

Columns may not sum due to rounding.

4.1.2: "Do Minimum" (minimum spend option available in 2003) CAPEX

As described in Section 4.1, the CAPEX estimate for the "Do Minimum" was derived by adjusting the CAPEX forecast for the "Do Something" scenario, to reflect the different scope included in this option. The following changes to current programme CAPEX, excluding management contingency valuations, were estimated for the "Do Minimum" option:-

- Revision of fleet CAPEX cost to represent MER trains, as shown in Table 4..

Table 4 – "Do Minimum" Undiscounted Fleet CAPEX

£m 2011/12 prices	Cost	Notes
S-Stock price – excluding MC	**1,723.77**	
Reduce powered axles by 25%	-44.13	Based on £32k per motored axle
Remove air conditioning	-17.90	From air conditioning specified right
Remove through-gangways and simplify layout	-21.09	LU S&SD estimate
Reduce fleet size	-145.51	Reduce fleet by 138 cars at £1.05m per car
MER fleet estimate – excluding MC	**1,495.14**	
Saving excluding MC	**228.62**	

Columns may not sum due to rounding

- Reduction of £163.81m CAPEX, for rolling stock enabling works, due to shorter MER trains, reduced low voltage power requirement, and reduced overheads;
- Reduction of £192.86m CAPEX for traction power and high voltage traction power upgrades, as MER trains would draw less power than S-Stock and no service enhancements would be implemented;
- Cancellation of the project to convert and migrate to 750V, saving £16.91m in 2011/12 prices;
- Reduction of £4.96m from the ATC contract, representing the saving from the non-specification of ATR. This is described in Appendix C;
- Savings in programme engineering, management and risk items related to re-signalling, totalling £26.39m;

- Life-extension costs for the current legacy signalling assets of £60.1m to maintain the current level of availability until the deferred signal replacement. This would be incurred in the years 2011/12 – 2015/16; and
- Life-extension costs for the current legacy fleets of £45.8m to maintain the current level of availability until the deferred replacement.

All costs associated with rolling stock replacement were attributed to later years appropriate for replacement of A- and C-Stocks by 2020 and D-Stock by 2026. All costs associated with the signalling system replacement and the End-State Track Layout project were attributed to later years appropriate for the system being implemented for service by 2028.

Table 5 summarises the total CAPEX for this option, inclusive of management contingency and shows the saving with respect to the current Upgrade Programme.

Table 5 – "Do Minimum" (minimum spend option available in 2003) CAPEX

£m 11/12 prices, undiscounted excluding forecast real growth	Current Upgrade Programme Including Management Contingency	"Do Minimum" Including Management Contingency	Saving
Rolling Stock			
Rolling stock and enabling works	3,290	2,858	432
Signalling			
Signalling and enabling works	1,297	1,080	217
Other			
Aborted Westinghouse signalling supply	355	0	355
Other old costs in Programme	2	2	0
Additional life extension costs	0	148	-148
Total	**4,944**	**4,089**	**855**

4.2: Operational Expenditure (OPEX)

The Upgrade will have impacts on the ongoing operations and maintenance costs (OPEX) of the SSR. This section provides details of the OPEX impacts included in the appraisal, summarised in Tables 6 and 6.1, below. For the "Do Something" case, the figures shown have been extracted from those presented in the latest agreed Benefits Management Reports, with amendments made to incorporate the effects of the "Piccadilly Line Gap" – discussed in more detail in section 5.1.2 – and ATC Phased Timetable Migration, which is discussed in more detail in section 4.2.2. In the case of the "Do Minimum" scenario, the BMR figures have been adjusted to reflect the revised portfolio of assets to be delivered, and the later delivery profiles of those assets.

Table 6 –Annual Maintenance OPEX Impacts Resulting From the "Do Something" SSR Upgrade Scenario

	Maintenance OPEX (£k 2011/12 Prices, +ve value represents savings)				
	Fleet	Signals	Power	Track	Total
2010/11	2,874	-	-	0	2,874
2011/12	5,768	-	-1,070	0	4,698
2012/13	7,603	660	-2,945	-110	5,208
2013/14	2,920	4,302	-3,906	-260	3,056
2014/15	4,961	5,402	-3,963	-505	5,895
2015/16	-9,879	6,346	-4,105	74	-7,564
2016/17	-7,917	7,682	-4,146	-195	-4,576
2017/18	-4,094	9,052	-4,187	-211	560
2018/19	1,010	10,416	-4,229	-647	6,550
2019/20	1,044	10,382	-4,272	-542	6,612
2020/21	1,245	10,453	-4,314	-532	6,852
2021/22	1,121	10,627	-4,357	-585	6,806

Table 6.1 –Annual Maintenance OPEX Impacts Resulting From the "Do Minimum" SSR Upgrade Scenario

	Maintenance OPEX (£k 2011/12 Prices, +ve value represents savings)				
	Fleet	Signals	Power	Track	Total
2012/13	-	-	-	-110	-110
2013/14	-	-	-	-111	-111
2014/15	-	-	-	-112	-112
2015/16	-	-	-	-113	-113
2016/17	-	-	-1,001	-114	-1,115
2017/18	-	-	-2,166	-115	-2,281
2018/19	-	-	-2,862	-117	-2,979
2019/20	-	-	-3,716	-118	-3,834
2020/21	-	-	-3,753	-119	-3,872
2021/22	-	-	-3,791	120	-3,671
2022/23	-	729	-3,829	121	-2,979
2023/24	-	4,752	-3,886	238	1,104
2024/25	-	5,967	-3,943	416	2,440
2025/26	-	7,010	-4,087	-352	2,571
2026/27	-	8,486	-4,127	-220	4,139
2027/28	-	10,000	-4,169	-411	5,420
2028/29	-	11,505	-4,210	62	7,357
2029/30	-	11,468	-4,252	-61	7,155

4.2.1: Maintenance

Fleet Maintenance

The costs of fleet maintenance are linked to the complexity and size of the fleet to be maintained. The current Annual Asset Management Plan (AAMP) forecasts the effect of S-Stock implementation on fleet maintenance budgets. Some of the maintenance of S-Stock will be carried out under LU's Technical Support and Spares Supply Agreement (TSSSA) with Bombardier (BTUK).

The forecast included in this version of the business case is derived from the March 2012 Benefits Management Report for Fleet Maintenance (see link below). The impact of the SUP on fleet maintenance determined in the BMR was based on a forecast of end-state headcount, which was determined using relevant benchmarks and national comparisons. The effect of overlays and APD efficiencies (where they impact headcount) was also considered during its production.

The expected headcount is dependent upon the maintenance strategy and concept to be deployed in the end-state, and the current forecast assumes those concepts agreed at the time of the BMR's production (i.e. Hammersmith will become a siding, heavy maintenance for all 191 S-Stock trains will be undertaken at Neasden). The headcount includes every person from Fleet Managers downwards.

The current BMR forecast also includes the costs of the TSSSA. It is believed that, currently, these costs do not represent value for money for LU, and include a high profit and risk margin for BTUK. It has been assumed, therefore, that from 2018/19 onwards, the TSSSA will not be renewed, and that the required overhauls will instead be undertaken by the Trains Division at Acton Works. Fleet OPEX is therefore forecast to reduce to a steady-state as a result of the SUP. It is likely the savings will be greater than has currently been claimed in the BMR.

In addition to the figures contained within the BMR, increases in fleet maintenance costs resulting from the "Piccadilly Line Gap" have also been included. These are based on Tube Lines' estimates of the cost of maintaining ATC-compatible signalling equipment on 73TS. These costs amount to £1.2m p.a. from 2015, and apply until 2023, when the Piccadilly line upgrade is expected to occur.

The long term fleet maintenance budget is therefore forecast to decrease by £1.03m p.a. (in 2011/12 prices) following the change of stock type. This value has been included in the current Upgrade Programme option. The predicted saving results from a combination of more economic and efficient fleet operation, a new S-Stock maintenance regime that is less burdensome than for legacy fleets, and a moderate improvement in S-Stock reliability, when compared with legacy fleets.

For the "Do Minimum", no change to fleet maintenance budget was assumed, based on procurement of a similar fleet size (circa 178 trains) of MER trains with minor additional complexity, which is assumed to be offset by improved train reliability.

Signal Maintenance

The net end-state impact of the SUP on signals OPEX is an annual saving of £9.73m in 2011/12 prices, based on the forecasts made in the December 2011 Benefits Management Report for Signals Maintenance (see link below), adapted to include the effects of the "Piccadilly Line Gap".

This forecast reflects adjustments to the LU headcount arising from the SSR ATC contract award. This has been based on work undertaken in 2011 by LU's Asset Performance Directorate (APD) and the benchmarking team. The total signalling OPEX effect is calculated as the complete costs of SSR South and SSR North, as well as the signalling systems elements within signals projects, less the cost of materials associated with non-SSR lines. This includes cost elements such as payroll (including pensions, NI and overtime), non-payroll, staff expenses, operational reallocations, materials and other overheads.

In addition to the assumptions around the SSR ATC headcount requirements, the signalling OPEX change also includes approximate forecasts of incident reduction, based on figures from the Victoria Line Upgrade (VLU). The impacts of the Maintenance Support Contract, the Maintenance Capability Programme (MCP) and Maintenance Unit Rates (MUR) have also been included.

The impact of the "Piccadilly Line Gap" is expected to be an annual signal maintenance saving of £200k p.a. based on Tube Lines' estimates.

The same profile of savings has been applied in both the "Do Something" and "Do Minimum" cases, but with a 10 year deferral in the latter case. The rationale for including the "Piccadilly Line Gap" in the Do Minimum is that, for the "Do Minimum" to occur, it is assumed that there would have to be a serious budget crisis within LU which would necessitate a deferral of other upgrade works including the Deep Tube Project. In this event the "Piccadilly Line Gap" would remain an issue at the commencement of the deferred SUP.

Civils & Station Maintenance

Civils and station maintenance costs were forecast to be unaffected by the options appraised (see link below).

Linked Documents: Signals Maintenance BMR
Stations Maintenance BMR

Power Maintenance

The change in power maintenance OPEX resulting from the SSR Upgrade is forecast to be an increase of £3.99 p.a. in 2011/12 prices, based on the January 2012 Benefits Management Report for Power Maintenance (see link below). This figure is comprised of the following three components.

The increased suite of low voltage assets, specific to the SSR Upgrade, is expected to increase end-state power maintenance costs by £0.08m p.a. (2011/12 prices). This includes new traction switches and feeder cables. This figure incorporates the impacts on power delivery team headcount of the SUP. These changes are driven by both planned maintenance requirements and asset reliability; corrective and reactive. The adjustments have been forecast based on experience with comparable programmes e.g. VLU. The impact of overlays and APD efficiencies has also been considered. The forecast includes the impact on LU labour costs (including pensions, NI and overtime), all material costs, all plant & equipment costs and all other costs associated with the new power assets.

Maintenance of LU's high voltage (HV) power assets is managed through a Private Finance Investment (PFI) contract with Powerlink. The changes to power assets brought about by the Upgrade Programme are forecast by LU's Power Sponsor to result in an increase in HV maintenance of £3.86m p.a. (2011/12 prices). This includes the overall service charge payable for PFI maintenance, covering; maintenance, operation, profit margin, renewals and debt repayment. It is assumed that this service charge will continue to apply over the life of the power assets, whichever company is contracted to provide the power maintenance.

The maintenance cost impact associated with Low Voltage Alternating Current (LVAC) requirements – AC cables, distribution pillars and power pillars – has also been included at an end-state value of £0.05m p.a. (2011/12 prices).

The "Do Something" profile of OPEX spending has been re-phased in the "Do Minimum" case to reflect deferred delivery. In addition, maintenance cost increases associated with traction power have been reduced by 10% in the "Do Minimum" case, to reflect the fact that the MER trains require less power infrastructure and therefore less ongoing maintenance.

Linked Document: Power Maintenance BMR

Track Maintenance

The forecast for track maintenance OPEX included in the business case is based on data captured in the Track AAMP and Business Plan and reported via the February 2012 Benefits Management Report for Track Maintenance (see link below). It amounts to £0.54m p.a. overall in the end-state. This has been included in version 3.0 of the Business Case. This figure includes the following SUP-specific impacts – shown in 2011/12 prices:-

- Corrective track works as a result of increased tonnage, owing to heavier and more frequent S-Stock trains. This is equivalent to an annual increase of £1.86m at SUP end-state;
- Increase of lubricator maintenance during S-Stock migration, resulting in an OPEX increase of £110k p.a. in 2012/13, 2013/14, 2014/15;
- Removal of line-side equipment once the lubrication maintenance strategy becomes train-based, following the full introduction of S-Stock trains. This leads to an OPEX saving of £0.58m p.a. from 2015/16 onwards.
- Reduced points and crossings (P&C) asset base and part-conversion from bull-head to flat-bottom rail, as a result of the SUP End-State Track Layout works, with small increase to preventative P&C tamping owing to increased flat-bottom P&C. This results in a net OPEX saving of £0.59m p.a. at SUP end-state;
- APD efficiencies identified as of 2011/12.

Taken together, the track OPEX forecast represents a decrease in cost impact from that captured in v2.1 of this Business Case. This is because more robust modelling of the impact of heavier and more frequent trains has now been completed. In addition, the savings due to the End-State Track Layout (ESTL) scope, including the reduction in the forecast number of point failures, have been included. These were not available at the time of the previous Business Case.

In the “Do Minimum” case, the lubricator maintenance costs have been extended and the remainder of the OPEX effects deferred, to reflect the later delivery profile. All “Do Something” cost impacts have been applied, unchanged, at the later deferral date, with the exception of those associated with tonnage. These tonnage impacts have been reduced by 30% to reflect the combined impact of lighter MER trains, operating at lower frequencies and travelling at slower speeds.

It should be noted that the BMR forecast is not reflective of the entire impact of the SUP on track OPEX, as accurate information is not yet available to support inclusion of the following effects, which have been assumed to net off to zero in version 3.0 of the Business Case:-

- The maintenance of more sidings (e.g. Lillie Bridge, Hammersmith, Ealing Common and Upminster Depot North Sidings) which v2.1 of the business case partly captured. This will result in an OPEX increase;

- The positive impact of increased track-friendly trains/wheel-rail interface phase 2. This will result in an OPEX decrease;
- The quantified risk for squat defects.

In addition to OPEX increases, the SSR Upgrade is likely to impact track CAPEX in ways which are not yet fully understood. The introduction of heavier rolling stock may adversely impact on the life of track assets, and may require earlier spending on asset condition renewals. However, flat-bottom rail has a longer asset life than bull-head rail, which may therefore extend the time before asset condition renewals are required. The relative impacts of the positive and negative effects are not fully understood and have therefore been assumed to net off to zero in this assessment.

End-State Track Layout

The End-State Track Layout (ESTL) project will implement a package of changes to track alignments and new track assets, which taken together is intended to enable faster speeds, better operational flexibility and improved asset reliability. The project covers multiple sites and will be implemented alongside ATC re-signalling, with the aim of delivering the maximum benefit from the new signalling assets.

The implementation of these multiple revised layouts will impact ongoing costs in two ways; firstly, via reduced track maintenance OPEX, as captured in the BMR and described above; and secondly, via ongoing avoided asset condition renewals CAPEX. This latter has been included as a form of OPEX in this version of the business case.

The savings accrue, because the ESTL project will result in a net reduction in the track asset base. In consequence, over time, there will need to be fewer asset condition track renewals. In addition, the installation of the portfolio of ESTL track assets will mean that, at some sites, legacy renewal work which would have been necessary over the coming years will be directly avoided. This version of the business case includes the net valuation of this effect which is defined as:-

- the expected cost of renewing the portfolio of post-ESTL assets; relative to
- the avoided cost of renewing the larger portfolio of legacy track assets.

These costs have been profiled over time, based on the best understanding from Track Engineering of the likely half- life and end-of-life renewal dates for legacy track assets. These have been compared with the assumed half-life renewal dates of new assets, 20 years after the installation date in the ESTL programme.

Using a cost per renewed unit of £1.5k, and £0.5k per half-life renewal, the total impact is calculated as a saving of £193m PV. These savings apply in both the “Do Something”, and “Do Minimum” cases, however in the latter scenario, the savings are deferred, in line with the assumed later installation of ATC re-signalling in that case. This deferral reduces the savings to £142m PV.

4.2.2: Operations

Train Operators

The majority of peak-period service enhancements proposed during the Upgrade Migration will result in increased numbers of train operators. Off-peak service enhancements were excluded from this appraisal, as any decision on implementation of such enhancements could be taken independently of the capital works being delivered by the SSR Upgrade. Claiming benefits, and including OPEX impacts, from such changes would improve the business case.

Once ATC re-signalling has been implemented, peak-period service enhancements will result in more trains in service at peak times. However, in off-peak periods, with no change in service levels applicable to this business case, the number of trains in service will reduce, as faster run-times enable delivery of a given service frequency with fewer trains. Overall, this latter impact outweighs the former, due to the greater number of hours when an off-peak service is operated. Therefore, fewer train operators are required in the end-state as a result of the SUP. In practice, it is expected that there would then follow (a) some wastage via retirement, and (b) some redeployment for off-peak enhancements or other service requirements. However, such changes do not result directly from the SUP, and have been excluded from this analysis.

Version 2.1 of this Business Case captured an increase in train operator staff required during migration (2011/12 – 2017/18) because of the peak-period service enhancement planned at the time. However, it is not now intended to deliver an increased service enhancement following full introduction of the new rolling stock. All service level increases are now planned to occur at end-state.

At the time of production of both the previous version of the business case and the BMR, the timetabled ATC-migration stages were not known. However, planning has since progressed and it is now planned to implement the end-state frequency over three timetable implementation dates between December 2016 and May 2018, as sectional commissioning of ATC is delivered. These changes are planned as:-

- December 2016, frequency enhancements on the Metropolitan line north of Baker Street, commensurate with ATC “Sectional Completion 1”;
- December 2017, frequency enhancements on the Circle and Hammersmith & City lines, plus further Metropolitan line enhancements, in line with ATC “Section Completion 2” ;
- May 2018, frequency enhancements on all lines including all District line branches. This is in accordance with ATC “Sectional Completion 3” also known as the end-state.

The April 2012 BMR for COO OPEX (linked below) forecasts the migration year COO impacts, which have been based on the 2011/12 Period 12 Demand Plan. The demand plan is updated by SSR Operational Upgrades (OU), and reviewed with Human Resources & Operational Resourcing. All predicted changes to headcount during the SUP Migration have been included, with an amendment to incorporate the effect of the three phased ATC-Migration timetable implementations. The estimates of the effect of the latter changes on headcount were made using outputs from the S&SD Transport Planning Trains in Service model, which were overlaid on the Demand Plan forecasts.

The headcount within the Demand Plan is summarised, and is therefore shown regardless of grade. A standardised train operator salary of £62k p.a. in 2011/12 prices has been assumed per headcount, as provided by the OPEX Efficiencies Analyst, Finance.

S&SD Transport Planning has forecast the number of train operators required to deliver the end-state SSR timetable using the Trains in Service (TIS) model, which forecasts total train hours for a given service pattern. This shows a headcount reduction of 39 staff, following delivery of the end-state timetables. The train operator salary has been applied for each headcount, giving a saving, in 2011/12 prices, of £2.4m per annum from 2018/19 onwards. Table 7 describes the profile of these OPEX changes, covering train operator and service control staff.

The SSR Upgrade Business Case v2.1 captured an increase in both train operators and duty managers. Subsequent advice from OU and Transport Planning was that, in practice, there is a very low likelihood that the number of duty manager posts would be reduced as the post-Upgrade timetables are introduced. Therefore, the current end-state forecast includes a decrease in train operator posts, and no change to duty manager numbers.

In the “Do Minimum” case, migration-state impacts were profiled over a longer time period, reflecting the longer delivery profile of the MER trains, notably for the D-stock replacement trains. In addition, no end-state service enhancements are planned for delivery in the “Do Minimum” scenario, and therefore, no long term staff OPEX savings have been recorded; with a null impact from 2027/28 onwards.

Linked Document: COO OPEX BMR

Table 7 COO OPEX Impacts in 2011/12 Prices Plus Timetable Changes

	Upgrade Timetable Change	Forecast Change in Service kms (000 p.a.)	Forecast Change in Train Operator Headcount	Forecast Total Train Operator OPEX Impact (£k)	Change in Forecast SCC Headcount	Forecast Total SCC OPEX Impact (£k)	Forecast Total COO OPEX Impact (£k)
2008/09			4	**- 200**	0	**0**	**- 200**
2009/10			43	**- 2,700**	0	**0**	**- 2,700**
2010/11			43	**- 2,700**	0	**0**	**- 2,700**
2011/12			58	**- 3,600**	0	**0**	**- 3,600**
2012/13			96	**- 6,000**	0	**0**	**- 6,000**
2013/14			24	**- 1,500**	0	**0**	**- 1,500**
2014/15			42	**- 2,600**	0	**0**	**- 2,600**
2015/16			70	**- 4,300**	0	**0**	**- 4,300**
2016/17	Dec 2016 (North of Baker Street)	145	7	**- 400**	0	**0**	**- 400**
2017/18	Dec 2017 (C&H)	555	-13	**800**	0	**0**	**800**
2018/19	May 2018 (End-State)	750	-39	**2,400**	-67	**3,600**	**6,000**

Signal Operators

The Upgrade includes consolidation of signal control into a single Service Control Centre (SCC) at Hammersmith, which will result in efficiencies in the number of staff required to control the SSR network. Operational Upgrades confirm that, at this stage, there is no reliable data for service control staff impacts during migration, as not enough is known about how training will occur for the ATC system.

The forecast saving in the SSR signal operations budget from 2018/19 is therefore £3.6m p.a. based on 2011/12 wage rates. This saving was included in both options at the point of switch-over to transmission-based signalling, because in both scenarios asset renewal was assumed to include replacement of legacy control facilities with a single SCC.

Station Staff

No change is recorded for Stations staff as a result of the SUP.

Train Service Energy

The SUP is forecast in the June 2012 Benefits Management Report for Energy Consumption & Carbon Dioxide (linked below), to impact significantly upon LU's energy bill.

The energy consumption rates associated with the BMR outputs are shown in Table 8. These impacts were incorporated into the business case using an assumed energy cost of 7.9p per KwH (in 2011/12 prices), which is in line with the LU Project Carbon Model. In addition, year-on-year growth in energy retail prices was included in the appraisal. The growth series was taken as the industrial use central case, forecast by the Department of Energy and Climate Change, and shown in Table 17.

Table 8: Average Annual Energy Consumption Rates Including Auxiliary Loads

Scenario	Stock	Voltage	Regen. Voltage	Inter-Operable Sections Voltage	Performance	KwH per service km
Base	**Legacy**	630	Nil	630	Baseline	17.07
Stock Migration	**Legacy**	630	Nil	630	Baseline	17.07
	S-Stock	630	650	630 (650 regen)	Interim (1)	24.79
S-Stock	**S-Stock**	750	890	630 (650 regen)	Interim (1)	19.01
End-State	**S-Stock**	750	890	630 (650 regen)	Full	21.45
"Do Minimum" Migration	**MER**	630	650	630 (650 regen)	Interim (1)	24.01
"Do Minimum" End-State	**MER**	630	790	630 (650 regen)	Interim (2)	18.82

Notes: (1) Performance constrained to maintain safety levels with legacy signalling
(2) MER trains assumed to remain at similar performance to today to avoid expensive power upgrades in the "Do Minimum" scenario

The S-Stock will draw more power than the current fleet, and each service uplift planned as part of the Upgrade Programme will result in higher energy usage, due to faster running speeds, improved acceleration, more air-conditioned S-Stock trains in service, and more service kilometres operated. The effects of these factors were taken into account in this appraisal. Energy use is also affected by a range of options, all of which have been assessed and included in this appraisal. This includes, in chronological order; operation in "constrained" mode i.e. with mixed S-Stock and legacy fleets; switching on of regenerative braking, once all legacy fleets are withdrawn; and the move to 750v operation in the end-state.

Linked Document: Energy & CO2 BMR

During the introduction of S-Stock fleets into service, train performance will be constrained to mirror that of legacy fleets, in order to maintain safety levels with legacy signalling. During this migration period, energy-saving regenerative braking will be available, limited to 650v. However, the impact of the heavier and more energy-hungry fleet of new trains will outweigh the effect of the regenerative braking, leading to an overall increase in KwH per service km operated during this period. The value is forecast to be 24.79 KwH per km operated, compared with 17.07 KwH per km for legacy-only fleets.

In the period following S-Stock migration, but prior to ATC re-signalling, fleet performance will continue to be "constrained", but regenerative braking is planned for enhancement to 890v. This will reduce energy usage to 19.01 KwH per service km.

In the end-state, the move to 750v operation will reduce energy use due to the lower transmission losses associated with higher voltage. However, once ATC re-signalling is complete, restrictions on train performance can be withdrawn, leading to a forecast increase to 21.45 KwH per km operated.

In addition to the values calculated in the BMR, additional adjustment has been made to account for the increased kilometrage associated with the phased introduction of higher service frequencies at the time of ATC commissioning.

In the "Do Minimum", the MER trains were assumed to increase energy consumption – compared to legacy stock – by 90% of the equivalent S-Stock increases. This reduction is due to the lower relative weight of the MER trains compared with the S-Stock; the reduced number of motored axles; and the lack of saloon air cooling.

The predicted increases in service kilometrage in each year were applied to the energy cost per kilometre, resulting in an end-state increase in energy costs of £12.8m p.a. in 2011/12 prices.

Table 9: Energy OPEX Series

	Energy OPEX excluding real growth (£k 2011/12 Prices, +ve value represents savings)								
	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Energy	250	1,580	3,690	5,560	6,860	5,540	3,440	12,760	12,760

4.3: Revenue

Improvements to the generalised cost of travel (i.e. reduced journey times on the SSR following the Upgrade) make a service relatively more attractive compared to competing modes of travel. As a result, not only do existing passengers benefit from the improvements, but the service will also attract completely new passengers, and abstract passengers from competing modes because they find travelling on the SSR increasingly attractive. An estimate of the revenue expected to be generated by the scheme was included in the appraisal following BCDM guidance, by crediting the fare box with 28 pence for every £1 of passenger benefit delivered by each option, and setting this revenue increase against the cost of the options.

In practice, a time lag will occur between the implementation of a service enhancement and potential new users firstly becoming aware of the benefits, and then opting to transfer to the improved service. To account for this, a gradual build-up of revenue, over the first four years of each benefit type, was applied, as per BCDM guidance, at a rate of 35% of total possible revenue in year one, 75% in year two, 90% in year three, and the full revenue allowance in all further years. In the case of the phased geographical delivery of timetabled benefits following re-signalling, these standard BCDM factors were weighted to reflect the proportion of total SSR passengers affected by each timetable change.

Furthermore, following BCDM guidance, a cap was applied to the revenue claimed in the business case. This is required to ensure the amount included in an appraisal is not overly optimistic. The cap was applied as follows:-

- During benefits modelling, the impact of each option was assessed on a constant number of passengers, forecast from TfL LTS and Railplan models for 2026 assuming the SSR Upgrade goes ahead as planned; this represents around a 13% increase in demand compared with 2011/12 levels – see Section 6.0 for the full demand series used;
- Some proportion of this passenger growth is expected to be attracted to the SSR by the Upgrade improvements, with the remaining growth in patronage assumed to result from background economic factors, and is therefore forecast to occur irrespective of the Upgrade;
- Estimating these proportions is not straightforward. Recent analysis of historic LU patronage trends, by S&SD Transport Planning, concluded that, during periods of major upgrade, the proportion of increased demand attracted by upgrade improvements can reasonably be assumed to be 50%. Therefore, the proportion of increased demand which contributes to revenue generation has been taken as 50% in this analysis;
- In the appraisal, any revenue generated by the standard elasticity, in excess of the amount implied by this number of new users, was capped based on the demand growth in combination with the LU average fare. This was taken as £1.69 in 2011, with 3% real growth p.a. in 2012 and 2013, 2% real growth p.a.

until 2021/11, and 1% real growth p.a. thereafter, as defined by LU Strategic Planning and the Business Case Development Manager.

The impact of the revenue cap on the revenue claimed in the business case is described in Table 10 below.

Table 10: Incremental Revenue Generation & Revenue CapSeries

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	Incremental Revenue Generation & Revenue Cap, £k undiscounted 2011/12 Prices							
Year	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Incremental Revenue	-1,520	-1,370	11,960	19,510	23,410	19,810	23,870	43,630
Cap	20,080	20,160	24,290	26,600	30,120	34,520	37,930	43,630
Year	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27
Incremental Revenue	48,540	69,900	72,970	74,970	77,010	79,080	81,180	83,760
Cap	48,540	69,900	72,970	74,970	77,010	79,080	81,180	83,760

It should be noted that total forecast revenue generation has reduced since the previous version of the business case, from £1.72bn to £1.46bn PV. This is partly due to reductions in forecast benefits, discussed in section 7.0, but also results from a correction in the application of the revenue cap. In this version of the business case, total annual revenue has now been capped. Previously, each individual annual revenue stream had been capped, leading to a total annual revenue figure which could exceed the cap. It can clearly be seen in Table 10, that the total revenue now claimed in the business case, increases gradually, meets the cap in 2018/19, and does not exceed the cap thereafter.

5.0: Explanation of Non-Financial Benefits

This section details the benefits forecast to result from the Upgrade.

As discussed in the previous section, the proportion of SSR users attracted by the Upgrade has been assumed to be 50% of the forecast total growth, or 26.1m new passenger journeys per year. The remaining 50% growth is assumed to result from extraneous factors, such as population growth and increased employment, and would therefore occur even if the Upgrade did not happen.

In determining the benefits of the SUP, the 50% of demand growth attracted by the upgraded assets has been allocated half of the full benefits, in accordance with the economic principle of the 'rule of a half'. This is based on the understanding that in the base case, i.e. 27 tph with legacy assets, passengers would travel by other more attractive means, at a generalised cost lower than that offered by the current SSR service, but higher than the more attractive upgraded SSR. The base generalised cost of travel for this group of passengers can therefore be assumed to be the mid-point between these two levels, on average, meaning this passenger group would only realise half of the full benefits.

As described above, the remaining 50% of the forecast growth in passengers (a further 26.1m annual passenger journeys) is accounted for by people who would have travelled on the SSR regardless of whether the Upgrade had occurred. For these people, a correction was required in this version of the business case, to resolve an over-estimate in demand in the original modelling of journey time benefits. As discussed below in section 5.1.1, the Train Service Model (TSM) was used to determine several of the key journey time benefits. The input level of demand for this modelling was the 2026 Railplan output. In this way, the journey time impact of the upgraded service pattern was assessed using a level of demand which already assumed the Upgrade had occurred. In order to correct for this, an evaluation was made of the SSR demand curve using demand data, and two supply curves were calculated for both the current case (27 tph and legacy assets) and the upgraded scenario (32tph, S-Stock and ATC), using the outputs from TSM modelling. Assessment of the areas under the curves then permitted the evaluation of the over-estimate, which was calculated to be 15%.

This was applied as follows:-

- The baseline, or 2011/12, demand levels were attributed 100% of all benefits not derived from TSM, and 85% of the benefits determined using TSM;
- The growth in demand due to the SSR Upgrade Programme, i.e. 50% of forecast new trips, were attributed 50% of all benefits;
- Passengers representing growth in demand due to background factors, the remaining 50% of growth, were attributed 100% of benefits not derived from TSM and 85% of the benefits determined using TSM.

5.1: Journey Time Benefits

This section describes the journey time benefits included in the appraisal. A breakdown of the monetisation of journey time benefits for the SUP and "Do Minimum" options is included in Appendix B.

New trains and signalling will deliver journey time improvements for passengers across the SSR. During the Upgrade Migration, improvements will result from operating new, more reliable S-Stock trains. Post-ATC, improvements will result from S-Stock operation at full performance, under ATO, and at higher frequencies.

The majority of journey time benefits are accrued post-ATC introduction. Following introduction of the ATC system a recasting of the timetable to account for new run and dwell-times will be made. The exact specification of these changes will be finalised once the ATC system has been designed in full. Currently, net run and dwell-times are forecast to improve by an average of approximately 11-12%.

Table 11 shows the asset introduction dates assumed for each option. Table 7, in Section 4.2.2, shows the timetable changes proposed to exploit the new capability and functionality.

Table 11 – Asset Introduction Timings Applied in each Option

Option \ Asset change	A-Stock fully replaced by	C-Stock fully replaced by	D-Stock fully replaced by	Signalling fully replaced by
Current Programme	2012	2014	2016	2018
"Do Minimum"	2018	2020	2026	2028

5.1.1: Train Service Model Benefits

The Train Service Model (TSM) has been used to simulate service operation on the SSR network, based on the key timetable and infrastructure features each option represents. This was used to provide quantification of the majority of the journey time benefits of each option. As discussed in section 5.0, the model was run for post-Upgrade year 2026/27, with SSR patronage in that year forecast from GLA economic forecasts and TfL's Railplan model. Benefits were applied to non-modelled years based on the demand series shown in Section 6.0.

The quantification of the benefits in TSM includes account of features such as automatic train operation, improved inter-station run and dwell-times resulting from new trains and signalling, in addition to the reduced and more regular headways achievable in the post-Upgrade peak timetable.

The benefit of each option from the TSM results is shown in Table 12. Appendix A provides a more detailed breakdown of these results.

Table 12 – Train Service Model Total Journey Time Benefits Compared to December 2009 Service Levels

Options	Summary of Effects	Peak Benefits (mins per peak passenger)	Off-Peak Benefits (mins per off-peak passenger)	Average Benefits (mins per passenger) 45% of passengers in peak
Rolling Stock	Introduction of S-Stock. No service performance or service level improvement.	0.60	0.14	0.34
Signalling	ATC introduced. Service performance and service levels uplifted to 32 tph	5.82	1.65	3.51
Current Upgrade Programme End-State	Introduction of S-Stock. ATC introduced. Service performance and service levels uplifted to 32 tph	6.42	1.79	3.85
"Do Minimum"	MER stock introduced (1)	-0.28	0.11	-0.06

Notes: (1) Peak disbenefit results from increased crowding caused by lower total capacity than current stocks. This results from the need to design compliant-width seats within a new train of the same dimensions as the legacy stock.

The major benefit underpinning this business case is the TSM-estimated improvement in journey time, forecast to be realised by the ATC-enabled timetable changes. This amounts to a reduction of 3.51 minutes per SSR passenger; over 90% of the total TSM-estimated journey time improvement.

This improvement has been staged over the three expected migration timetables, described in section 4.2.2, above. The benefits were scaled using Transport Planning's SSL Signalling Upgrade Phasing Benefits Assessment Model, into which Transport Planning's initial plans for the timetable designs were input. The result showed a 0.5 minute journey time improvement to all SSR passengers following the improvements north of Baker Street, a 1.56 minute improvement to all SSR passengers following ATC enabling on the Circle & Hammersmith & City lines, and a final 1.46 minute improvement following completion of ATC across the SSR.

Taken together, these three timetables facilitate the implementation of increased frequency, in addition to train performance enhancements, beyond that constrained by operation with legacy signalling. Table 13 shows the breakdown of this main benefit.

Table 13 – Breakdown of Major Benefit Items in Business Case

TSM Journey time benefits from SSR ATC in 2018/19, 2011/12 prices	
Peak benefits per peak SSR passenger (mins)	
Improvement in weighted platform wait time (weighting 2.5)	1.46
Improvement in unweighted on train time (improvement in run-times)	1.79
Improvement in weighted element of on train time (reduction in crowding)	3.94
Improvement in weighted interchange and left behinds	0.42
Total benefit per peak SSR passenger (mins)	**5.82**
Off-peak benefits per off-peak SSR passenger (mins)	
Improvement in weighted platform wait time (weighting 2.5)	0.00
Improvement in unweighted on train time (improvement in run-times)	1.57
Improvement in weighted element of on train time (reduction in crowding)	0.08
Improvement in weighted interchange and left behinds	0.00
Total benefit per off-peak SSR passenger (mins)	**1.65**
Forecast number of peak SSR passengers (m 2018/19)	193.8
Forecast number of off-peak SSR passengers (m 2018/19)	241.0
Total benefit per SSR passenger (mins)	**3.51**
Forecast total number of SSR passengers (m 2018/19)	434.8
Value of time pence/minute 2011/12 prices	14.70
Scaling factor to apply rule of half to benefits for new passengers	0.99
Scaling factor to account for over-estimated demand input	0.85
Monetised benefits 2018/19 (£m)	**188.4**

The benefits shown in this table represent the step-change increase from S-Stock operation to post-ATC operation, based on the TSM modelling results.

5.1.2: Additional Journey Time Benefits

A number of features of the Upgrade are forecast to result in journey time benefits which are not captured in the TSM modelling. These include provision of new functionality and improved asset availability, as summarised in the following sub-sections.

FLEET

Fleet Reliability

The S-Stock is forecast to be more reliable than the legacy fleet. This will reduce the number of fleet-related incidents and the level of unavailability, and will thereby reduce the customer disbenefit incurred from faulty trains and poor availability. This has been forecast to provide a journey time benefit of 0.06 minutes per SSR passenger, based on lost customer hour (LCH) forecasts in the June 2012 BMR for Asset Reliability (linked below), which is based on the 2012/13 Annual Asset Management Plan (AAMP). This journey time reduction represents a substantial improvement from version 2.1 of the business case, for the following key reason:-

- Improved modelling of S-Stock reliability and its LCH impacts. Recent projections have a higher degree of confidence, as they are aligned with SUP Reliability, Availability and Maintainability (RAMs) analysis. In the case of the Metropolitan line, this sees a betterment of end-state reliability compared to the older projections, but for the Circle & Hammersmith and District lines, older projections were overly ambitious.

In addition to the large positive impact noted above, the following negative effects were also recorded in the BMR:-

- Performance of the legacy fleet has substantially exceeded (for the better) the projections made in 2008/09, owing to reliability improvement schemes and better management of failures. The step-change in reliability due to the introduction of S-Stock is therefore reduced;
- Later stock delivery, following delays to the delivery programme.

The size of these negative impacts is small relative to the impact of the improved modelling, which leads to a positive overall impact on fleet reliability.

This benefit was included in the “Do Something” appraisal case. It was also used for the “Do Minimum” case, as new MER trains would be expected to operate with the same level of reliability as the S-Stock fleet. A linear deterioration of reliability was assumed in both cases.

Metropolitan Line Faster Running

Operation of A-Stock on the Metropolitan line was limited to 50 mph or lower, in order to restrict the rate of fatigue-induced bogie-cracking. Timetables were specified using lower run-times calculated on this basis. Prior to the speed reduction, the Metropolitan line had a top speed of 60mph, in areas where track condition, geometry and length of inter-station link permitted.

The introduction of the S-Stock enables faster running to be scheduled on the Metropolitan line, as the new trains have a design speed of 100kph (approximately 60mph). This extra performance capability had been due for introduction alongside the delivery of the new ATC signalling system. However, it is now proposed to introduce this improvement earlier, in May 2013, on the following inter-station runs:-

Northbound

- Finchley Road to Wembley Park (except Neasden to Wembley Park);
- Harrow on the Hill to Moor Park (fast line).

Southbound

- Moor Park to Harrow on the Hill (fast line);
- Harrow on the Hill to Finchley Road (fast line, not stopping at Wembley Park);
- Harrow on the Hill to Wembley Park (fast line);
- Wembley Park to Finchley Road.

This increase in speed is predicted to reduce the average SSR passenger journey time by 0.04 minutes. This improvement has been recorded as applying between 2013 and the introduction of the Metropolitan line ATC-migration state timetable, in December 2016.

The energy implications of this faster operation have also been assessed and amount to a total increase in OPEX of £0.9m and in carbon emissions disbenefit of £0.5m. Both energy effects and journey time benefits been included in the “Do Something” case, but are excluded from the “Do Minimum” scenario, as no upgrades to power infrastructure are proposed in this option, and faster speeds would not therefore be possible.

Through-Gangways on S-Stock Trains

Through-gangways create additional journey time benefits, as they facilitate smoother loadings between carriages, which speeds boarding and alighting times, and reduces standing. This is not captured in TSM, as the model already assumes an even distribution of passengers in trains without through-gangways. In order to capture these journey time benefits, benefits quantified for the appraisal of the Bakerloo Line EVO1 train were used, as these represent the most advanced of LU's estimates of the positive journey time benefits of through-gangways. These benefits were included in the appraisal for the introduction of S-Stock, but not for the "Do Minimum", which assumes a more conventional train design. The benefits and quantifications are shown in Table 14.

Table 14 – Journey Time Benefits from Through-Gangways

Benefit Item	Weighted Peak Journey Time Benefits (minutes per SSR peak passenger)	Weighted Off-Peak Journey Time Benefits (minutes per SSR offpeak passenger)
Reduced standing penalty from circulation facilitated by through-gangways	0.02	0.01
Reduced dwell time from circulation facilitated by through-gangways	0.06	0.03
Reduced egress time from circulation facilitated by through-gangways	0.03	0.01
Weighted Total	0.05	0.03
Weighted Total Peak and Off-Peak	**0.07**	

Multiple-Door Selective Door Opening (SDO)

At four stations in central London, the difference in length between the platforms and the S7 trains will necessitate multiple doors remaining closed when trains serve these stations. The disbenefits of these impacts were forecast by S&SD Transport Planning, and include additional dwell-times due to longer boarding and alighting times, and longer total journey times for passengers whose egress and interchange times will be extended. During migration, when two different rolling stock types will be serving these platforms, and when S7s will be new and unfamiliar, passenger disbenefits were forecast to be higher. In year one of operation of the longer trains on the Circle line (2012/13) the disbenefit is estimated to be £0.1m. In year two, as more trains are brought into service, this increases to £2.8m, falling to £1.2m in year three and approximately £0.6m p.a. thereafter, as passengers become more familiar with the new train layout. These disbenefits were included in the "Do Something"

case, but were excluded from the “Do Minimum”, as train lengths were assumed to be unchanged from legacy stock in this option.

Single-Door SDO (not quantified)

Single Door SDO will be required temporarily at some platforms in the period prior to re-signalling due to sub-optimal sight-lines from the cabs of the S stock, as they were designed for in-cab signalling from the outset. Quantification of these disbenefits was not available at the time of this report but is not expected to have a significant impact on the overall results.

SIGNALS

ATC Journey Time Improvements

Provision of a modern signalling system is expected to enable the delivery of a service-level closer to schedule than can be delivered with legacy assets, through improved control functionality and co-location of service controllers, improved asset availability, plus ATR functionality. The benefits of these improvements to journey time were forecast by S&SD Transport Planning as follows:-

- Improved control functionality, stemming mainly from the consolidation of 16 service control locations into one Service Control Centre, was estimated to reduce weighted journey time by an average of 0.49 minutes per SSR passenger. This was based on S&SD and Operational Upgrades' (OU) assessment of the contributors to journey time levels with legacy assets. This assessment included a forecast improvement of 10% in recovery from incidents of two minutes or more. This was in addition to an improvement of 25% in background excess journey time. This 25% improvement would result from shorter incidents and from service controllers being able to focus more on general variations in operation once new assets have been implemented;
- SSR service-affecting failures (SAFs) resulting from legacy signalling assets contribute to passenger disbenefit of £12.1 million per annum. RAMs analysis for the new ATC system now estimates this will reduce to £2.1 million of passenger disbenefit p.a. following implementation. This reduction, equivalent to 0.19 minutes per SSR passenger, is the result of enhanced resilience to SAFs, and represents a significant improvement (c 34%) when compared with the previous estimate for version 2.1 of the business case. This is due to a higher level of disbenefit per incident now recorded for legacy signals assets and an improved end-state (ATC) figure now contracted with BTUK; and
- Implementation of ATR functionality, which will result in more consistent headways and inter-station run-times. This was estimated to reduce weighted journey time by an average of 0.09 minutes per SSR passenger.
- Implementation of the End-State Track Layout changes, which will result in improved operational flexibility, enabling services to be diverted or altered more simply during periods of degraded operation, or when lines are partially closed for engineering access. These benefits have been assessed using Railplan and journey time capability (JTC) analysis. The impact is expected to reduce weighted journey time by an average of 0.07 minutes per SSR passenger. The benefit of bi-directional operation SSR-wide, above-and-beyond that made possible by the ESTL works will have a small additional benefit, which has not been included in this analysis.

All of these benefits were included in the appraisal of both the "Do Something" and "Do Minimum" options. However, the benefits of ATR were excluded from the "Do Minimum" option, as it has been assumed that a more basic transmission-based system would be procured in that scenario.

Piccadilly Line Gap

The Piccadilly line shares signalling sections with the District and Metropolitan lines. With the District line, this section lies between Barons Court and Hangar Lane Junction via Acton Town, and with the Metropolitan line the section is between Rayners Lane and Uxbridge. The "Piccadilly Line Gap" therefore refers to the section of the Piccadilly line connecting the shared section south of Hangar Lane Junction to the shared section north of Rayners Lane.

Under the contracted plans for ATC re-signalling, ATC-compatible equipment would be fitted onto 73TS in order to enable joint operation on the shared sections. The Piccadilly line would therefore have operated using standard line-side signalling Cockfosters – Barons Court, Hangar Lane Junction – Rayners Lane, and Acton Town – Heathrow, switching to operate under ATC on the sections shared with the SSR. However, this would have required each driver to switch signalling mode between 4 and 6 times per round trip, with associated risk of staff error and equipment failure, leading to potentially significant service delays.

The decision has been made to extend full ATC signalling across the "Piccadilly Line Gap", to restrict the number of boundary switching events per round trip. The solution to be implemented will create signalling boundaries for Piccadilly line services at Barons Court and Northfields. This leads to a maximum of 4 switching events per round trip on the Heathrow branch, and 2 per round trip on the Uxbridge branch. This is a benefit from the original proposal, but still creates a disbenefit overall for the Piccadilly line, as a result of the SSR Upgrade.

The assessment of the level of disbenefit was based on observations of staff errors and equipment failures recorded at Dollis Hill on the Jubilee line during implementation of TBTC. This resulted in a rate of failure of 0.16% for each boundary switching event, causing an average 12 minute delay per failure. The resulting disbenefits amount to £13.81m p.a. in 2018/19, the first year of full operation of ATC. It has been assumed that as staff awareness develops, the number of these staff errors will reduce, such that in 2019/20 the disbenefits will fall to £6.90m p.a. dropping again to £3.45m p.a. in 2020/21 and thereafter to a constant £1.38m p.a.

As described in section 4.2.1, extension of the ATC signalling solution onto the "Piccadilly Line Gap" is considered still to be applicable in the deferred "Do Minimum" scenario. The disbenefit has therefore been recorded in both the "Do Something" and "Do Minimum" options, but at a deferred date in the latter case.

It should be noted that the Piccadilly line will also benefit from the introduction of the ATC signalling system, via improved asset availability and reliability. This is particularly notable given the age and fragility of the line's existing signalling assets,

and the expected time until the Piccadilly line is upgraded. However, no estimate has been made of these benefits within this business case.

5.2: Ambience Benefits

New rolling stock will bring noticeable improvements to ambience and therefore journey quality for SSR customers. In addition, ambience benefits are derived from improved customer information systems, brightness of lighting, size of windows, train noise, ride quality and access between carriages. The introduction of trains with CCTV cameras on the Metropolitan, Circle and Hammersmith & City lines also adds significant benefit through increased security.

The quantification of these benefits was included in the July 2012 BMR for Ambience (linked below). This report derived its estimates from the 2012/13 Business Plan, which includes improvements to Mystery Shopper Survey (MSS) results, now recordable for the S8 fleet, plus non-MSS categories, as shown in Table 15. It is of note that the ambience scores are now predicted to be up to +13/+14 points greater than were used in version 2.1 of the business case. This is because previously, no S-Stock trains were in operational service, so the limited available data from Victoria line 09TS, and D-Stock refurbishment, was used to develop the forecast. Actual S-Stock scores, now available, show S-Stock trains achieving much higher scores than 09TS and D-Stock refurbishment suggested. This may be partly due to the 'open' SSR environment not being as prone to dust as on the 'enclosed' Victoria line.

Table 15 – Ambience Scores in Mystery Shopper Survey and Non-MSS Categories

	A-Stock: at 2011/12	C-Stock: at 2011/12	D-Stock: at 2011/12	S-Stock: on introduction
Actual / forecast MSS scores (out of 100)				
Overall cleanliness inside train	55	57	59	78
Graffiti on windows and fixtures	22	41	36	97
Surface graffiti on inside of the train	49	60	94	99
Cleanliness of seats	60	67	68	88
Condition of seats	57	68	74	96
Outside cleanliness of the train	50	49	57	74
Graffiti on outside of train	86	90	93	100
Clarity of driver's delivery over PA	85	93	95	98
Ride Quality	67	70	71	80
Noise from trains (wheels/track etc)	67	70	73	78
Brightness of lighting	92	95	97	99
Non MSS categories				
Surveillance Cameras	No	No	Yes	Yes
Access between carriages	No	No	No	Yes
Newness of train	Un-modernised	Un-modernised	Refurbished	New

The ambience benefits were quantified based on BCDM guidance, and are shown in Table 16. These were included in the appraisal for options which assume S-Stock trains replace the existing fleets.

In addition to these core ambience improvements, the inclusion of air conditioning on the S-Stock will give additional ambience benefits for passengers. Valuation of these benefits was taken from the original business case for air conditioning, which undertook an assessment of forecast changes in seasonal ambient air temperatures. The total benefit was estimated to be £7.1m p.a. in 2011/12 prices, which equates to 1.69 pence per passenger journey.

Table 16 – Ambience Benefits

Pence per passenger journey	S8	S7C	S7D	Total S Stock fleet
Passengers in group p.a. (2016/17)	72.62	127.61	226.77	427.00
MSS	7.29	3.35	3.37	4.03
Non-MSS	11.29	6.86	2.05	5.06
Air conditioning	1.69	1.69	1.69	1.69
Total	**20.27**	**11.9**	**7.11**	**10.78**

Overall, S8 ambience benefits are notably higher due to the poor later-years MSS scores of A-Stock trains, the step-change introduction of in-car CCTV (also a key factor on C-Stock replacement trains) and the relatively long average journey time on this line. S7D benefits are relatively low as the trains being replaced have recently undergone interior refurbishment, which has led to relatively strong current MSS scores.

The same benefits were used for the “Do Minimum” option, as the MER trains were forecast to result in similar levels of ambience improvement to S-Stock, although no ambience benefits have been credited for air conditioning or through-gangways in this scenario.

See Appendix B for a more detailed breakdown of components of the ambience benefit calculations included in the business case.

5.3: Other Benefits and Disbenefits

Engineering Access

Any renewal or upgrade programme will require access to the railway, to enable installation, commissioning and testing, beyond that which is available in standard overnight engineering hours. Such access will typically take the form of weekend closures and occasional multi-day blockades.

The current Upgrade Programme's access requirements are forecast in the March 2012 Benefits Management Report for Railway Access (linked below). This shows that a total of 14.5 million customer hours of disbenefit will be required due to closures of the SSR to enable installation, commissioning and testing of new systems. This represents a journey time disbenefit of 2.4 minutes per SSR passenger. Approximately 51% of this is forecast for ATC and associated projects, with the remaining 49% for S-Stock enabling projects.

These figures were used as a basis for deriving estimates of the access requirements for the "Do Minimum" scenario, with phasing and scaling applied where appropriate. In addition, disbenefits of 0.29 million customer hours p.a. were applied to the "Do Minimum" scenario, to enable the 10 year life-extension works for signalling to be completed (see Table 17).

Table 17 – Access Disbenefits (Million Customer Hours' Disbenefit)

Scenarios Applied to:	S-Stock enabling	ESTL installation	Signalling life extension	Total
Current Programme	7.05	7.40	-	**14.45**
"Do Minimum"	6.34	7.40	1.47	**15.21**

Carbon Emission Benefits

The effect of both options on greenhouse gas emissions, in the form of carbon dioxide (CO_2), was assessed in the June 2012 BMR for Energy Consumption and Carbon Dioxide (linked on page 24), and has been fully incorporated in this appraisal.

For every kilowatt hour of power LU draws from the National Grid, the amount of CO_2 released is estimated, in the LU Project Carbon tool, to be 0.48kg. This has been revised down from the value of 0.54kg, used in Version 2.1 of the SUP business case, because DEFRA's Guidelines have since been updated. The BMR combines this information with the forecast future kilometrage resulting from Transport Planning's Trains in Service Model, and this reveals an expected increase in end-state carbon emissions of 78,200 tonnes per year. For this version of the

business case, the ATC Migration stages have also been included, as summarised in Table 7.

This increase in emissions has been monetised based on BCDM advice, using DECC central case estimates of the social cost of non-traded sector emissions. The values are shown in section 6. This demonstrates that, at end-state, the emissions resulting from the SUP will increase LU's social cost of carbon by £4.92m p.a. in 2011/12 prices.

Carbon emissions effects have also been evaluated for the "Do Minimum" case. Due to lighter trains, no speed increases, and no improvements in service frequency in that scenario, the increase in carbon emissions is only 19,000 tonnes per year, which is valued at £1.35m p.a. in the end-state, in 2011/12 prices.

However, it should be noted that the improvements in journey time and quality which will be delivered by the SSR Upgrade will also have the effect of making travel by Underground more attractive to users of other transport modes. This is expected to result in modal shift to the Underground and a subsequent reduction in journeys made using other higher-polluting modes of transport. LU has also made a commitment to source more of its electricity from low-carbon sources of power generation in the future. Quantification of these impacts on net energy use and carbon emissions was not available at the time of this report. However, given the background improvement in road vehicle technology leading to reduced emissions for given usage levels, this would be expected to be a short term effect.

Safety Benefits (not quantified)

The SSR Upgrade Programme will bring safety benefits to LU passengers and staff. The new rolling stock meets modern crashworthiness standards, providing higher levels of protection against front-end and lateral collisions compared to the existing fleet. Improved Correct Side Door Enabling (CSDE) equipment is also a feature of the S-Stock, reducing the risk to SSR passengers of being presented with wrong-side door opening. The new signalling system also delivers safety improvements. Continuous speed supervision and ATP will reduce the safety risks associated with human error, particularly the issues of speeding and signals passed at danger. Quantified assessment of the risk profile improvements associated with these safety benefits was not available for including in the appraisal calculations at the time of this report.

Improved Accessibility (not quantified)

Many features of the new S-Stock trains will improve accessibility for all passengers, including people with reduced mobility. These changes will improve journey quality for many passengers and attract new users to SSR services. It is considered that these benefits would also be applicable to the modern trains assumed in the "Do Minimum". Quantified assessment of the benefits from improved accessibility was not available for including in the appraisal calculations at the time of this report.

Reputational Benefits (not quantified)

The SSR is the largest sub-network within the London Underground system, and the radical improvements to assets and their availability which is being delivered by the SSR Upgrade Programme will play a key part in ensuring that LU achieves its mission of "a work class tube for a world class city". The benefits in terms of the gain in reputation among commuters, tourists, media and politicians, from the delivery of air-conditioned, fully accessible trains, operating at faster speeds and higher frequencies with better asset availability, will be significant. These benefits are, however, very difficult to quantify, and have not therefore been included in this analysis.

6.0: Key Assumptions

Core appraisal assumptions and techniques were applied in line with the TfL Business Case Development Manual (BCDM). The following provides a summary of the core assumptions and inputs used:-

- All costs and benefits were treated in base year 2011/12 prices;
- All future values were converted to Present Value (PV) by discounting to the base year using BCDM standard discount rates;
- The appraisal was undertaken for the full life of the substantive programme asset, which on cost grounds is the rolling stock. Therefore benefit and cost streams were captured to 2052/53, the year at which, on average, the S-Stock will reach their 40-year design life;
- Where assets were expected to have economic lives extending beyond 2052/53 the value beyond the appraisal period was captured through inclusion of residual values in 2053/54;
- The cost and benefit of all projects within the SUP have been captured, including projects previously not known or well-enough advanced at the time of production of the previous version of the business case. This includes 750v Conversion, End-State Track Layout, Wheel Rail Interface, S-Stock Heavy Maintenance and “Piccadilly Line Gap”;
- The run-time benefits modelled in TSM assume full compliance with RVAR door chime times. A concession is being sought to reduce this from 3 seconds to the current 1.75 second chime. This would increase the level of journey time benefits delivered by the SUP from the figures quoted in this business case.
- No impacts of the Hertfordshire County Council-supported scheme – known as the “Croxley Rail Link” – which diverts and extends the Metropolitan line to terminate at Watford Junction station, have been included in this appraisal;
- 2011/12 average passenger Value Of Time (VOT) of £8.82 per hour, based on BCDM guidelines;
- For the calculation of ongoing journey time benefits, the S-Stock delivery programme has been assumed to accord with the position at November 2012. From this, profiles of delivery into service were averaged across quarters to provide the weighted annual average delivery for each stock type; S8, S7C and S7D. However, where the delivery profile was utilised in the development of benefits management reports, this was consistent with the date of production of the specific report;
- In the “Do Minimum” scenario, the business case version 2.1 spending profile was re-used, with the exception of the S7D delivery profile which was brought forward 2 years to 2026, in order to avoid new stock being delivered simultaneously with new signalling assets;
- Future years’ real growth in VOT was captured, based on BCDM estimates;

- The social cost of carbon was taken as the DECC central case £ per tonne of CO_2 for non-traded emissions, in line with BCDM Appendix L8, and converted to 2011/12 prices. The series is shown below in Table 18.

Table 18: Social Cost of Carbon (£ per tonne of CO_2)

Year	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Index	56.64	57.49	58.35	59.22	60.11	61.02	61.93	62.86
Year	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27
Index	63.80	64.86	65.93	66.99	68.05	69.12	70.18	71.25
Year	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35
Index	72.31	73.37	74.44	81.35	88.26	95.17	102.09	108.99

- Forecasts of future years' real growth (differential inflation) in CAPEX, wage-based OPEX and energy costs was captured and included in the appraisal as follows:-
  - Energy costs were forecast to grow in line with the DECC estimates for industrial central case energy inflation, showing rapid increases until 2030/31, with zero real growth thereafter. This is in accordance with latest BCDM advice. Applied rates are shown in Table 19 below:-

Table 19: Energy Cost Real Inflation Index

Year	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Index	1.00	1.05	1.13	1.14	1.14	1.16	1.17	1.16
Year	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27
Index	1.19	1.23	1.28	1.30	1.31	1.36	1.39	1.40
Year	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35
Index	1.43	1.44	1.44	1.46	1.46	1.46	1.46	1.46

  - Wage rates were forecast to grow in real terms by 1% per annum, in line with latest BCDM advice;
  - Real tender price inflation for CAPEX was applied based on latest advice from the BCDM, as shown in Table 20.

Table 20: Differential Tender Price Inflation Index

Year	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Index	1.000	0.997	1.006	1.009	1.016	1.021	1.021	1.021
Year	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27
Index	1.021	1.021	1.021	1.021	1.020	1.018	1.016	1.014
Year	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35
Index	1.012	1.010	1.010	1.010	1.010	1.010	1.010	1.010

- Half-life renewals/refurbishment of CAPEX items were assumed for all options at rates of 16% for rolling stock and rolling stock enabling works, and 12% for signals and signal enabling works. Asset condition renewals for assets resulting from the ESTL project were treated as a form of OPEX in this appraisal and are discussed in section 4.2.1;
- The average fare per journey was assumed to be the LU Strategic Planning figure of £1.69 for 2011/12, with 3% real growth in 2013 and 2014, 2% real growth in the remainder of the Business Plan period to 2022 and 1% real growth thereafter. This is consistent with those in use by LU Strategic Planning and the Programme Management Office (PMO);
- The base level of demand is taken as 2009 daily SSR RODS data, uprated for 2011/12 actual SSR gate-line data, and averaged across the whole year to provide a seasonally-adjusted figure for daily SSR journeys. This was calculated for each day-type and subsequently annualised, after which the 0.9668 SSR trips to boarders ratio was applied, resulting in a figure of 414.5 million passenger journeys per annum in 2011/12. This is considered, by Transport Planning, to be a more reliable figure for current SSR passenger journeys than to factor down from the network-wide figures provided by LU Strategic Planning;
- Table 21 shows the demand series used for the application of benefits in non-modelled years. This is based on actual recorded demand in 2011/12, LU Strategic Planning forecasts to 2012/13, after which the expected growth profile for SUP benefits was applied until 2020/21. Thereafter, straight line growth has been assumed until the latest Railplan modelled year, 2026, followed by zero growth until the end of the appraisal period, in accordance with PMO guidance:-

Table 21: Passenger Demand Series

Year	2011/2	2012/3	2013/4	2014/5	2015/6	2016/7	2017/8	2018/9	2019/20
Index	1.000	0.9985	1.008	1.013	1.021	1.030	1.037	1.049	1.059
Year	2020/1	2021/2	2022/3	2023/4	2024/5	2025/6	2026/7	2027/8	2028/9
Index	1.106	1.110	1.113	1.116	1.119	1.122	1.126	1.126	1.126

7.0: Outcome of Quantified Analysis

7.1: Full SSR Upgrade Business Case

Table 22 provides the results of the full SSR Upgrade business case compared to both the "Do Minimum" scenario, and the previous version of the business case.

Table 22 – Results of Appraisal

	"Do Minimum"		Current SSR Upgrade		Current SSR Upgrade vs. "Do Minimum"	Change from v2.1
Description	Undiscounted £m	PV £m	Undiscounted £m	PV £m	PV over 40 yrs £m	£m Positive = improvement
Costs						
CAPEX: Rolling stock + enabling works, including power	-3,935	-2,705	-4,004	-3,665	-960	265
CAPEX: Signalling + enabling works, including power	-1,542	- 984	-1,550	-1,289	-305	97
CAPEX: TOTAL (1)	-5,622	-3,700	-5,911	-5,387	-1,687	312
OPEX	15.79 p.a. (3)	-150	9.33 p.a. (3)	-98	-52	-14
Residual Value		280		42	-238	45
Total Costs		**-3,271**		**-5,248**	**-1,976**	**343**
Revenue (4)	32.10 p.a. (3)	371	89.48 p.a. (3)	1,451	1,460	-255
Net Financial Effect					**-516**	**88**
Benefits						
Journey Time: trains	0.51 p.a.	-47	27.85 p.a.	626	673	-595
Journey Time: Signalling (2)	48.51 p.a.	610	253.80 p.a.	5,550	4,940	153
Journey Time: TOTAL	**49.02 p.a.**	**563**	**281.65 p.a.**	**6,176**	**5,613**	**-441**
Ambience	38.23 p.a.	795	48.87 p.a.	1,286	492	68
LU Carbon Emissions	-1.94 p.a. (3)	-39	-7.98 p.a. (3)	-151	-112	-86
Total Benefits	**85.31 p.a.**	**1,319**	**322.53 p.a.**	**7,312**	**5,993**	**-460**
Benefit Cost Ratio					**11.6 to 1**	**Previously 10.7 to 1**

Notes (1) Includes costs resulting from aborted Westinghouse contract, plus other old spending streams, not shown in rolling stock and signals totals.
(2) Signalling journey time benefits are broken down in Table B2 and Table 11.
(3) Value shown is for mid-point year of 2033/34, as this series does not stay constant.
(4) Revenue streams do not sum due to the effect of the revenue cap.
(5) Columns/rows may not sum due to rounding.

`

The following key findings can be observed:-

The current SSR Upgrade is forecast to cost a total of £5.25 billion (bn) to 2052/53, including CAPEX, OPEX, real growth, management contingency and residual value; this is £1.98bn more than the "Do Minimum", but £0.34bn less than was forecast in version 2.1 of the business case. This difference is mainly due to reductions in management contingency, as project lifecycles have progressed since 2010, reducing the risk of cost increases, and it is, to a lesser extent, driven by delays in the spending profile on some projects.

The Upgrade is forecast to generate £1.46bn of incremental revenue, resulting in a net cost to TfL (negative Net Financial Effect [NFE]) of £0.52bn, an improvement of £0.09bn from the previous business case.

The monetised social benefits (which mainly consist of journey time benefits with some ambience improvements, partially offset by increased LU carbon emissions) show that the current SSR Upgrade is forecast to generate £7.31bn of benefits to 2052/53. The "Do Minimum" was forecast to generate £1.32bn, yielding an overall differential resulting from the SUP of £5.99bn. This represents a £0.46bn worsening from the previous business case, due primarily to:-

- Reduced estimates for fleet reliability improvements;
- Delays in the stock delivery schedule;
- The measures, now included, to rectify the overestimate of demand in the TSM modelling;
- The increase in the social valuation of carbon emissions;
- The disbenefits to Piccadilly line passengers from boundary switching failures not previously included; and
- The increase in engineering access requirements.

The Upgrade has a strong benefit cost ratio of 11.6 to 1; generating incremental social benefits more than ten times greater than the incremental net cost of the programme.

7.2: Sensitivity Tests

A series of sensitivity tests has been carried out to assess the impact of changes in costs and benefits on the core appraisal. The results of the sensitivity tests are shown in Table 23. Two basic tests have been appraised in which adjustments were made to incremental totals, where the term "incremental" refers to the discounted differential between the "Do Something" and "Do Minimum" effects. The tests were:-

- 20% increase in total discounted incremental CAPEX; and
- 20% reduction in total discounted incremental benefits and revenue.

In addition tests assessing specific changes have been appraised as follows:-

- ATC programme (costs and access) extended, and benefits and OPEX impacts delayed, by two years;
- Demand series and TSM journey time benefits scaled down by 10%, to represent a low future patronage estimate;
- Demand series from 2019/20, and TSM journey time benefits, factored up by 10%, to represent a high future patronage estimate; and
- The proportion of demand growth resulting directly from enhanced services, reduced from 50% to 25%.

Table 23 – Results of Sensitivity Tests

£m PV to 2052/53, 2011/12 prices		NFE	Benefit	BCR
Core results for reference, Current Programme	vs. "Do Minimum"	-516	5.993	11.6 to 1
Basic Tests				
Test 1: Incremental CAPEX increased by 20%	vs. "Do Minimum"	-854	6,019	7.1 to 1
Test 2: Incremental journey time and ambience benefits, and revenue reduced by 20%	vs. "Do Minimum"	-808	4,793	5.9 to 1
Specific Tests				
Test 3: ATC programme extended and benefits/OPEX changes delayed by 2 years	vs. "Do Minimum"	-908	5,570	6.1 to 1
Test 4: Demand series and TSM benefits scaled down by 10%	vs. "Do Minimum"	-1,638	5,104	3.1 to 1
Test 5: Demand series from 2019/20 and TSM benefits factored up by 10%	vs. "Do Minimum"	-230	6,865	29.9 to 1
Test 6: Proportion of demand growth resulting from service changes reduced by 50%	vs. "Do Minimum"	-1,228	6,098	5.0 to 1

Tests 1 – 4 & 6 include more pessimistic inputs, and under each of these tests the benefit-cost ratios of the full Upgrade reduce, but the conclusions remain similar; the overall business case for the current programme compared to the "Do Minimum" is strong, with BCRs ranging between 3.1 and 7.1 to 1. These sensitivity tests demonstrate that the case for investment is secure, even in situations where significant negative variation in costs and benefits occur. They also demonstrate that a 2 year delay in delivery of the ATC programme could result in £0.39bn additional incremental cost, excluding contractual charges, and a loss of £0.42bn of incremental passenger benefits. This equates to an increase in cost and a loss of benefit of over half a million pounds for every day of delay to the ATC delivery programme.

Test 5 includes a more optimistic forecast of demand. Under this test the overall Upgrade business case improves to 29.9 to 1.

8.0: Feasibility & Risk

Renewal and upgrade of the assets on the SSR requires a major multi-disciplinary engineering programme which will inevitably contain a range of risks, the main ones for the SSR Upgrade as currently scoped being:-

- Commitment of significant expenditure over a long time frame, including very large supply chain contracts;
- Resource availability, especially for legacy signalling disciplines required for S-Stock introduction pre-ATC;
- Development of ATR functionality, within Bombardier's existing ATC product, which can operate sufficiently effectively around the complex flat junctions of the SSR, to enable delivery of the full journey time benefits as forecast here; and
- Complex handover requirements to integrate with existing systems and deliver new assets into service.

9.0: Overall assessment

Overall, the SSR Upgrade has a very strong business case with a benefit to net cost ratio of 11.6 to 1, and incremental quantified benefits of £5.99bn, demonstrating excellent value for money. The Upgrade will deliver additional highly valuable associated qualitative benefits streams, such as enhancing the reputation of LU, which have not been incorporated in these figures. Furthermore, quantitative benefits, beyond those assessed at this time, are attributable to the programme, including the delivery of improved reliability to the Piccadilly line; reliability improvements being a key Mayoral policy objective. In consequence, the Upgrade of the Sub-Surface Railway is an extremely good investment, which is of great significance to London and, by extension, the UK.

The majority of the benefits, almost 90%, result from journey time and service level enhancements made possible by implementing ATC in the programmed timeframe, and making the incremental investment in traction power required to realise performance and service level enhancements. The remaining 10%, results from introducing higher capacity and higher quality trains in the current programmed timeframe.

The forecast gross cost of the Upgrade is significant, at £5.2bn PV including risk and management contingency. However, this is only £2.0bn PV more than the minimum that could have been spent to retain baseline levels of service, reliability and safety on the SSR.

The Upgrade works have been in delivery for a number of years, and consequently, a significant proportion of the costs are now sunk or committed. The business case has been subject to a range of sensitivity tests, which show it to be robust to fluctuations in the key appraisal inputs.

In summary, the case for continuing with the SSR Upgrade is financially positive from today, due to the substantial benefits not yet delivered, resulting from CAPEX which has already been spent or committed.

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Appendix A: Summary of TSM results with commentary

The table in this appendix provides a breakdown of the TSM benefits used in the appraisal, with a commentary on the key observations that can be made.

TSM results summary					Peak									Off-peak	
Option	**Service Pattern**	**Rolling Stock**	**Train performance**	**Part of SSR Re-signalled**	**Unweighted PWT (mins per pax)**	**Weighted PWT (mins per pax) Weight: 2.5**	**Unweighted OTT (mins per pax)**	**OTT Crowding Factor**	**Weighted OTT (mins per pax)**	**Weighted Left Behinds (mins per pax)**	**Weighted Interchange (mins per pax)**	**Weighted Journey Time (mins per pax)**	**Weighted Journey Time Benefits (mins per pax)**	**Off-peak Weighted On Train time (mins per pax)**	**Off-peak Weighted Journey Time Benefits (mins per pax)**
Baseline	27 tph	A, C, D	Current	None	2.56	6.39	14.72	1.40	20.57	0.29	1.32	28.57		13.21	
Current Upgrade Programme	32 tph	S	Full S stock performance	All	1.94	4.85	12.78	1.27	16.25	0.02	1.03	22.15	6.42	11.42	1.79
Do Minimum	27 tph	MER	Interim	None	2.53	6.33	14.60	1.43	20.95	0.25	1.32	28.85	-0.28	13.10	0.11
Commentary on features of baseline and explanation of changes for each option															
Baseline	6 tph on branches, trains reversing short of branch termini, uneven intervals on branches, e.g.: Wimbledon				Equivalent to av. pax experiencing 11.7 tph service. Some pax experience 2 waits due to complexity of network						Includes estimate of actual interchange time (weighted at 2.5) and interchange penalty for small proportion of pax			Derived from peak. Account for shorter trip length: circa 12%, and typical off-peak crowding factor circa 5%.	
Current Upgrade Programme	8 tph on branches, more trips to end of branches, more even headways				Equivalent to av. pax experiencing a 15.5 tph service. Fewer interchanges		12% reduction as signalling enables trains to run at full performance	8% reduction from more tph spreading load across more trains		Reduction in left behinds due to significant increase in capacity	More trains reach end of branches. More even intervals on branches, e.g. Wimbledon		Net effect of significant improvements in all element of journey		12% reduction as signalling enables trains to run at full performance
Do Minimum	As per baseline				Small improvements to train layout means dwell times reduce, which increases recovery in schedule		Small reduction from dwell time improvements from MER stock train layout etc	Crowding increases as fitting compliant seats in trains of same length as A & C stocks reduces capacity		Small change in left behinds.	No significant change		Net disbenefit largely caused by lower overall capacity of MER trains		Dwell time improvements are the key effect due to minimal crowding in baseline

Notes: pwt = platform wait time, ott = on train time, tph = trains per hour, pax = passengers

Appendix B: Breakdown of Monetisation of Benefits

The tables in this appendix provide a breakdown of the monetisation of benefits in Section 5.1 for the first year following the key step changes in the main business case. These relate to the figures in the Benefits tab of the corresponding Business Case Assistant.

Table B1 – Monetised Journey Time Benefits of S-Stock in Current Upgrade Programme Option in 2015/16, 2011/12 prices

Journey time benefits in 2015/16, 2011/12 prices	Benefit per peak SSR passenger (mins)	Benefit per off peak SSR passenger (mins)	Number of peak SSR passengers (m pa)	Number of off-peak SSR passengers (m pa)	Benefit per SSR passenger (mins)	Total number of SSR passengers (m pa)	Value of time pence/min 2011/12 prices	Benefit scaling factor for rule of half	Benefit scaling factor for high TSM demand input	Monetised benefits 2015/16 (£m)
TSM benefits										
S8 TSM	-0.47	0.02	188.5	234.5	-0.20	423.00	14.70	0.99	0.85	-£10.4
S7C TSM	0.72	0.00	188.5	234.5	0.32	423.00	14.70	0.99	0.85	£16.9
S7D TSM	0.35	0.12	188.5	234.5	0.22	423.00	14.70	0.99	0.85	£11.7
Total TSM benefits	0.60	0.14	188.5	234.5	0.34	423.00	14.70	0.99	0.85	£18.1
Non-TSM benefits										
Through-Gangways	0.07	0.07	188.5	234.5	0.07	423.00	14.70	0.99	-	£4.5
Reliability	0.06	0.06	188.5	234.5	0.06	423.00	14.70	0.99	-	£3.8
SDO at four major stations	-0.01	-0.01	188.5	234.5	-0.01	423.00	14.70	0.99	-	-£0.6
Increased Metropolitan line speed	0.03	0.03	188.5	234.5	0.03	423.00	14.70	0.99	-	£2.0
Total Non-TSM benefits	0.16	0.16	188.5	234.5	0.16	423.00	14.70	0.99	-	£9.8
Total S Stock benefits in 2015/16										£27.9

Notes: (1) Disbenefit caused by reduced seating on trains, resulting from fitting compliant sized seats into trains only marginally longer than legacy stock type

Table B2 – Monetised Journey Time Benefits of ATC in Current Upgrade Programme Option in 2018/19, 2011/12 prices

Journey time benefits in 2018/19, 2011/12 prices	Benefit per peak SSR passenger (mins)	Benefit per off peak SSR passenger (mins)	Number of peak SSR passengers (m pa)	Number of off-peak SSR passengers (m pa)	Benefit per SSR passenger (mins)	Total number of SSR passengers (m pa)	Value of time pence/minute 2011/12 prices	Benefit scaling factor for rule of half	Benefit scaling factor for high TSM demand input	Monetised benefits 2018/19 (£m)
TSM benefits										
Enhanced train performance and increase to 32tph	5.82	1.65	193.8	241.0	3.51	434.79	14.70	0.99	0.85	£188.7
Total TSM benefits	5.82	1.65	193.8	241.0	3.51	434.79	14.70	0.99	0.85	£188.7
Non-TSM benefits										
Reliability from control functionality	0.49	0.49	193.8	241.0	0.49	434.79	14.70	0.99	-	£30.9
Reliability Automatic Train Regulation	0.09	0.09	193.8	241.0	0.09	434.79	14.70	0.99	-	£5.7
Reliability from asset availability	0.19	0.19	193.8	241.0	0.19	434.79	14.70	0.99	-	£12.0
Improved diversionary routeings	0.07	0.07	193.8	241.0	0.07	434.79	14.70	0.99	-	£4.4
Piccadilly line boundary switching failures										-£13.8
Total Non-TSM benefits	0.77	0.77	193.8	241.0	0.77	434.79	14.70	0.99	-	£39.2
Total ATC benefits in 2018/19										£227.9

Table B3 – Monetised Journey Time Benefits of MER Trains in "Do Minimum" Option in 2028/29, 2011/12 prices

Journey time benefits in 2028/29, 2011/12 prices	Benefit per peak SSR passenger (mins)	Benefit per off peak SSR passenger (mins)	Number of peak SSR passengers (m pa)	Number of off-peak SSR passengers (m pa)	Benefit per SSR passenger (mins)	Total number of SSR passengers (m pa)	Value of time pence/minute 2011/12 prices	Benefit scaling factor for rule of half	Benefit scaling factor for high TSM demand input	Monetised benefits 2028/29 (£m)
TSM benefits										
Nominal replacement trains TSM	-0.28	0.11	207.9	258.7	-0.06	466.58	14.70	0.97	0.85	-£3.6
Total TSM benefits	-0.28	0.11	207.9	258.7	-0.06	466.58	14.70	0.97	0.85	-£3.6
Non-TSM benefits										
Reliability	0.06	0.06	207.9	258.7	0.06	466.58	14.70	0.97	-	£4.1
Total Non-TSM benefits	0.06	0.06	207.9	258.7	0.06	466.58	14.70	0.97	-	£4.1
Total MER benefits in 2028/29										£0.5

Notes: (1) Disbenefit caused by reduced total train capacity, which results from fitting compliant-sized seats into trains of the same length as legacy stock types.

Table B4 – Monetised Journey Time Benefits of Re-signalling in "Do Minimum" Option in 2028/29, 2011/12 prices

Journey time benefits in 2028/29, 2011/12 prices	Benefit per peak SSR passenger (mins)	Benefit per off peak SSR passenger (mins)	Number of peak SSR passengers (m pa)	Number of off-peak SSR passengers (m pa)	Benefit per SSR passenger (mins)	Total number of SSR passengers (m pa)	Value of time pence/minute 2011/12 prices	Benefit scaling factor for rule of half	Benefit scaling factor for high TSM demand input	Monetised benefits 2028/29 (£m)
Non-TSM benefits										
Reliability from control functionality	0.49	0.49	207.9	258.7	0.49	466.58	14.70	0.97	-	£32.6
Reliability from asset availability	0.19	0.19	207.9	258.7	0.19	466.58	14.70	0.97	-	£12.7
Improved diversionary routeings	0.07	0.07	207.9	258.7	0.07	466.58	14.70	0.97	-	£4.7
Piccadilly line boundary switching failures										-£13.8
Total Non-TSM benefits	0.75	0.75	207.9	258.7	0.75	466.58	14.70	0.97	-	£36.1
Total re-signalling benefits in 2028/29										£36.1

Table B5 – Monetised Ambience Benefits of S-Stock in Current Upgrade Programme in 2015/16, 2011/12 prices

Journey time benefits in 2015/16, 2011/12 prices	Benefit for a given 15 minute journey (pence per passenger)	Average journey length on line (minutes)	Benefit per passenger (pence per journey)	Number of passengers experiencing improvement (m pa)	Benefit scaling factor for rule of half	Monetised benefits 2015/16 (£m)
Train MSS						
Metropolitan line	4.66	22.05	6.86	71.94	0.99	£4.9
Circle and Hammersmith & City lines	3.33	13.40	2.97	126.42	0.99	£3.7
District line	2.64	17.70	3.12	224.64	0.99	£7.0
Train MSS (External)						
Metropolitan line			0.43	71.94	0.99	£0.3
Circle and Hammersmith & City lines			0.38	126.42	0.99	£0.5
District line			0.25	224.64	0.99	£0.6
Train Non-MSS						
Metropolitan line	7.7	22.05	11.3	71.94	0.99	£8.1
Circle and Hammersmith & City lines	7.7	13.40	6.9	126.42	0.99	£8.6
District line	1.7	17.70	2.0	224.64	0.99	£4.6
Air Conditioning						
All of SSR			1.69	423.00	0.99	£7.1
Total S stock ambience benefits in 2015/16						£45.3

Table B6 – Monetised ambience benefits of replacement trains in "Do Minimum" option in year 2028/29, 2011/12 prices

Journey time benefits in 2028/29, 2011/12 prices	Benefit for a given 15 minute journey (pence per passenger)	Average journey length on line (minutes)	Benefit per passenger (pence per journey)	Number of passengers experiencing improvement (m pa)	Benefit scaling factor for rule of half	Monetised benefits 2028/29 (£m)
Train MSS						
Metropolitan line	4.66	22.05	6.86	79.35	0.97	£5.3
Circle and Hammersmith & City lines	3.33	13.40	2.97	139.44	0.97	£4.0
District line	2.64	17.70	3.12	247.79	0.97	£7.5
Train MSS (External)						
Metropolitan line			0.43	79.35	0.97	£0.3
Circle and Hammersmith & City lines			0.38	139.44	0.97	£0.5
District line			0.25	247.79	0.97	£0.6
Train Non-MSS						
Metropolitan line	7.11	22.05	10.45	79.35	0.97	£8.1
Circle and Hammersmith & City lines	7.11	13.40	6.35	139.44	0.97	£8.6
District line	1.16	17.70	1.37	247.79	0.97	£3.3
Total fleet ambience benefits in 2028/29						£38.2

Appendix C: Rationale for "Do Minimum" Assumptions

This appendix describes the rationale behind the assumptions for signalling and fleet replacement used in the "Do Minimum" scenario.

Signals

A study [2] was undertaken to investigate the minimum cost practical alternative for sustainable signalling of the SSR for the next 40 years. Whilst many parts of the existing signalling system can be kept in service indefinitely by progressive piecemeal renewal, no significant part can be expected to last for a further 40 years. The condition of cabling and wiring within signal interlockings in particular would necessitate wholesale replacement. Furthermore, the absence of over-speed protection on the SSR network was considered a potential future safety issue. Therefore, renewal of all components of the existing system was assumed to be needed at some stage during the time horizon of the Business Case (i.e. to 2053).

Such renewal is most efficiently done as a co-ordinated re-signalling project; the Office of Rail Regulation (ORR) accepts this approach as best practice, underwriting the expenditure for Network Rail renewal plans based on area-wide signalling schemes. To undertake signalling renewal on a more piecemeal approach costs more, inputs more safety risk from multiple changeovers of vital safety systems, and requires more closures of the railway or prohibitively expensive work in engineering hours. This more than offsets the theoretical advantage of delaying some expenditure by only renewing and replacing system components as they reach the end of their economic life.

To estimate the lowest cost of a practical '"Do Minimum" baseline, it is assumed that, based on an understanding of current asset condition, the signalling system can be kept in acceptable working order for 10 years beyond the present plan, albeit with additional expenditure on targeted life extension to 2028. It is unclear that the approach would prove sustainable beyond 10 years, particularly because wholesale replacement of cabling and equipment room wiring would become necessary.
As a consequence the complete, efficient, replacement of the existing system 10 years later than the current programme was assumed for the "Do Minimum" option.

The study considered two options for a minimum cost renewal and assessed the expected costs of:

- A like-for-like modern functional equivalent (MFE) replacement of lineside signalling; and
- Installation of the most basic available modern transmission based signalling system with in-cab signalling.

A cost estimate of the MFE option was derived from the Network Rail 'Signalling Equivalent Unit' (SEU) methodology, which is a 'bottom-up' methodology used by that

2. "Do Minimum" Signalling Scenario Preliminary Assessment, LU S&SD

organisation to price-up outline schemes, and by ORR to determine Network Rail's five-yearly funding settlements. For the transmission based signalling option, both 'top-down' and 'bottom-up' methodologies were adopted

using costs from the Westinghouse SSL PPP Contract, and Tube Lines' Northern line and Jubilee re-signalling schemes, respectively.

The study concluded that the cost of a MFE system was forecast to be approximately 10-20% more expensive than a transmission based system. In addition the analysis estimated that implementation of an MFE solution would require approximately four times the amount of engineering access than a transmission-based system. Therefore an MFE solution has been rejected as the basis for the "Do Minimum" signalling baseline.

The lower boundary of the range of costs for a transmission-based solution (based on Northern and Jubilee costs) was slightly higher than the costs forecast for the SSR ATC system, so the latter has been used as the basis for the re-signalling baseline.

In the "Do Minimum" option the discretionary costs for inclusion of Automatic Train Regulation functionality in this type of system, and the proportion of the traction power upgrade associated with enhancing train performance and service frequencies, have been assumed to be discretionary, and therefore avoided, with train performance and frequencies remaining at baseline levels.

End-State Track Layout

A "Do Minimum" optimisation of track layouts is assumed to be possible at a later time than the current programme, in line with the later delivery of updated signalling assets in this scenario. It is assumed that the "once in a lifetime" opportunity afforded by re-signalling works to rationalise track layouts at key locations would be taken, regardless of the specific signalling package implemented.

It is not possible to predict exactly which sites would be chosen for layout revisions in this scenario. They would be selected in order to resolve operational issues, seek synergy with track renewals programmed for a similar timeframe, and to improve performance with the "Do Minimum" package of assets. As it is not possible to know the exact sites which would apply in this deferred timeframe due to it being beyond the current planning horizon, it was assumed that the extent of the works, the cost impacts and benefits could reasonably be expected to be the same as those in the "Do Something" case, but would apply alongside the deferred signalling works.

Rolling Stock

A "Do Minimum" replacement of rolling stock was also assumed to be practicable in a later timeframe than the current programme, albeit incurring additional maintenance costs for retaining the current fleets in service for longer.

It was assumed that a “Do Minimum” Modern Equivalent Replacement (MER) train design would be a lower specification than the S-Stock design, with:

- 25% fewer motored axles;
- No saloon air-cooling;
- No through-gangways;
- Train lengths no longer than the legacy stocks being replaced, which results in reduced CAPEX for train enabling works, but negatively impacts passenger benefits; and
- A similar fleet size to the combined SSR legacy fleets (178 trains) to enable baseline service levels to be operated.

It was assumed that A- and C-Stock could be life-extended in service before being replaced, in time to avoid the RVAR legislation deadline for existing fleet compliance, of 2020. It was assumed that D-Stock could be life-extended and remain in service to 2026, because the recent refurbishment meets many of the RVAR features required. However, they would then be replaced to avoid abortive costs of installing transmission-based signalling equipment on trains that would then be 50 years old.

Appendix 2

Transport for London

Programme: Four Lines Modernisation

Business Case Narrative

		Signature	Date
Prepared by	Kostas Giannoulis Principal Sponsor	[redacted]	4/2/16
Reviewed by	Endorsement statement Ryan Taylor Business Case Functional Lead, PMO	[redacted]	5/2/16
Approved by	I confirm that this deliverable meets the requirements of the relevant Pathway Product Description and that all consultation comments have been addressed to the satisfaction of consultees. Christian Fowler Head of Line Upgrades Sponsorship	[redacted]	4/2/16

Programme: Four Lines Modernisation

Document Number: 4LM-R280-SSL-BUC-00001

Livelink Nickname: 4LM-R280-SSL-BUC-00001 - 4LM Business Case Narrative - Rev 1.0.docx

Business Case v4.0 Narrative

		Signature	Date
Prepared by	Kostas Giannoulis Principal Sponsor		
Reviewed by	Endorsement statement Ryan Taylor Business Case Functional Lead, PMO		
Approved by	I confirm that this deliverable meets the requirements of the relevant Pathway Product Description and that all consultation comments have been addressed to the satisfaction of consultees. Christian Fowler Head of Line Upgrades Sponsorship		

Document History

Revision	Date	Summary of changes
0.1	13/08/2015	First draft
0.2	30/10/2015	Reviewed draft
1.0	04/02/2016	Final version

Glossary of Terms

Abbreviation	Term
ATC	Automatic Train Control
ESTL	End State Track Layout
EFC	Estimated Final Cost
PCCT	Power Cooling and Communications Team
BCR	Benefit Cost Ratio
QRA	Quantified Risk Assessment
4LM	Four Lines Modernisation

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1 Executive Summary

1.1 The 4LM Business Case v4.0 narrative outlines the scope costs and schedule for the re-baselined programme. The business case now has a BCR of 4.9:1, based on the following assumptions

1.1.1 A programme EFC of £5,412m (as per the re-authority request to the July 2015 TfL Board),

1.1.2 Reliable delivery of planned timetables (see Section 4),

1.1.3 Reduced track changes (ESTL) scope, as agreed at Programme Board April 2015,

1.1.4 Additional weekend closures for ATC, and

1.1.5 The Q1 2015/16 OPEX position

1.2 Despite these changes there remains a strong positive business case for the upgrade. The continuation with ATC completion is stronger still, given the sunk costs associated with the purchase of new trains and supporting infrastructure, and the majority of scheme benefits are yet to be realised.

2 Description

2.1 This document summarises the key changes in the updated Four Lines' Modernisation (4LM) business case v4.0, which concluded in June 2015 with the Thales Sub-surface ATC signalling contract. Comparison with the prior business case (v3.0), which was completed in 2012, is presented where appropriate.

2.2 The business case has been updated to support re-authority of the 4LM, due to the following changes that affected its scope:

- Cancellation of the Bombardier ATC contract and new procurement of signalling with Thales;
- Changes to completion dates;
- Changes to planned closure programme;
- Changes to CAPEX and OPEX; and
- Changes to the End State Track Layout (ESTL).

2.3 The revised estimates presented in this document reflect the changes to benefits and OPEX associated with the re-procurement of ATC signalling, and all CAPEX. Benefits and OPEX associated with S Stock introduction have not been updated, as the changes since v3.0 of the business case were minimal and are being managed by the existing Benefits Management process. All estimates presented are in Present Value, unless otherwise stated.

2.4 This business case provides overarching justification for all expenditure to support Programme delivery, including 4LM, PCCT Major Power Works for SSR, and other enabling projects delivered and budgeted by 4LM or elsewhere in Rail and Underground.

3 Background

3.1 In August 2015, Thales was awarded the contract for the delivery of 4LM ATC Signalling, requiring an update of the business case to reflect the information from the Thales product and the new delivery programme. In addition, Programme re-baselining provided revised costs for the whole Programme. 4LM is the overall title for the upgrade of the Sub-surface Railway (SSR) comprising the Circle, Hammersmith & City, District and Metropolitan lines.

3.2 The original 4LM business case was produced in 2010, and an update (v3.0) was released in 2012. All 4LM business cases have been presented as comparisons against a single "Do Minimum" option, in which a minimum scope of works is defined to maintain current service levels. Version 3.0 of the business case had a BCR of 11.6:1.

3.3 The 'Do Minimum' option has the following objectives:

- Minimise capital expenditure whilst ensuring assets can support unchanged levels of service, reliability and safety on the SSR network; and
- Defer the capital expenditure that is required on programmed asset-renewal for as long as practicable.

3.4 In contrast, the 'Do Something' option, has the following objectives:

- To renew life-expired train systems to enable continued provision of services on the SSR; and
- To exploit the opportunity presented by asset-renewal to upgrade to higher specification assets and systems, in order to realise journey time improvements for SSR passengers. This will be achieved with new ATC signalling, power voltage increase from 630v to 750v, a new End State Track Layout with changes to track assets for faster speeds and better operational flexibility, and service frequency enhancements to 32 trains per hour during peak times.

3.5 More details on the scope of both options can be found in the Business Case v3.0 narrative.

3.6 The updated business case v4.0 maintains the same option comparison as v3.0 and provides an updated BCR, alongside the new financial estimates.

3.7 The 'Do Minimum' option scope has been amended in v4.0 to include variations to the signalling cost, reliability and delivery profiles, and addition of the benefits of the end state track layout scheme. The 'Do Something' option has been updated in v4.0, with new timetable and signalling commission migration dates, updated forecasts on post-upgrade performance and ATC, an adjusted demand growth series to reflect changes of benefit delivery, and updated ATC and ESTL closure requirements.

3.8 Scope items which were relevant to the previous contract with Bombardier have been removed, such as the mode change disbenefits from the fitment of signalling equipment to 73TS.

3.9 Business case parameters such as CAPEX and OPEX have been updated to the latest position in all options. No further update is planned at this stage.

4 Changes Between Business Case v3.0 and v4.0

4.1 A number of changes have been made in version 4.0 of the business case. These mainly reflect updates to the CAPEX, OPEX, timetable and signalling commissioning migration dates, as well as post-upgrade performance forecasts. All figures are based on the P50 schedule at the time of seeking re-authority (it has since been re-labelled as P90).

4.2 The updated 4LM BCR is now 4.9:1, compared to 11.6:1 in business case v3.0. A number of assumptions have been made in calculating the new BCR, namely:

- A programme EFC of £5.412bn;
- 32tph End-State timetable in operation for 3 hour peak periods by December 2022;
- Additional off-peak service enhancements and longer peak periods by December 2023;
- Reduced ESTL scope, as agreed at the Programme Board in April 2015;
- Additional weekend closures for the ATC upgrade works and ESTL;
- An OPEX position as of Q1 2015/16; and
- No change in benefits for the introduction of S stock.

4.3 Other changes involved adjustments due to rescoping of some projects, updated ESTL scope, adjustments to demand growth and the 'Do Minimum' case, as well as updates to the ATC reliability and availability forecast and closures estimates.

4.4 In all other areas the business case remains as per v3.0, including the key appraisal parameters, and the fleet benefits and OPEX.

5 CAPEX

5.1 All 4LM Programme CAPEX figures have been updated to the Q1 19/06/15 forecast, as supplied by the Finance department. The Programme EFC total was £5.412bn in outturn (£5.05bn in current prices), approved by the TfL Board in July 2015. Compared to v3.0, outturn programme authority CAPEX has increased by £1.19bn. Business case v3.0 was based on a programme EFC of £4.15bn, against the £4.22bn authority approved by the Financial Policy Committee in April 2011.

5.2 The 4LM major power work costs have been updated to Q2 2014/15 figures, at a total of £560m. In addition, a range of other projects required to enable full upgrade benefits, but which are not contained in the 4LM or power works EFCs, relating to station RVAR compliance works, have now been included in the business case at a total cost of £73m.

5.3 Optimism bias uplift was applied to the CAPEX based on the contingency line of £78m, comprised of £15m for rolling stock and £63m for signalling, held in the business plan for 4LM, and a P80-P50 difference for the power works.

5.4 The outturn costs have been converted to 2011/12 prices using the same methods as in Business Case v3.0.

5.5 For the purposes of assessing the impact on the business case, an updated Do Minimum CAPEX scenario was generated, using the same method as in v3.0 to reflect the relevant changes to the Do Something CAPEX option. The Do Minimum CAPEX scenario excludes sunk signalling costs contained in the Programme EFC.

6 OPEX

6.1 Business case v4.0 is based on the Q1 2015/16 OPEX figures. The main OPEX changes between v3.0 and v4.0 reflect the following:

- Removal of previously assumed signals efficiencies associated with the prior contract,
- Revised assessment of incident staff efficiencies,
- Revised assessment of signals maintenance staff efficiencies,
- Later train maintainer efficiencies,
- Later delivery of Hammersmith Control Centre,
- Costs of the new Thales ATC implementation, and
- Impacts on train operator costs (which at the time excluded the effect of the off-peak service enhancements).

6.2 In addition, the impact of the revised April 2015 ESTL scope on track maintenance OPEX, based on information provided by the LU Track Sponsor, has been incorporated in the business case v4.0.

6.3 The addition of off-peak timetable enhancements at the End-State necessitate increased energy consumption. This has been estimated using data consistent with v3.0, uplifted to reflect the revised End-State kilometrage.

6.4 The result of the above changes can be summarised in the following OPEX impacts:

- Signals Maintenance – Increased whole life cost of £235m PV;
- Track Maintenance – Reduced whole life cost of £15m PV;
- ESTL Avoided Asset Condition Renewals – Increased whole life cost of £121m PV; and
- Energy – Increased whole life cost of £183m PV, predominantly due to additional off-peak service assumptions.

7 ATC Commissioning & Timetable Migration

7.1 The dates used for signalling commissioning and timetable migration, in v4.0, were agreed with the programme in May 2015. This position includes some changes to the ATC commissioning order compared with v3.0, which is now scheduled to start at Hammersmith.

7.2 The revised timetable migration plan in v4.0 includes off-peak frequency enhancements which were not previously assessed in v3.0. The timetable changes aligned with the delivery of new ATC capability, as prepared by the Sponsor and agreed with Transport Planning and Operations are:

- May 2021: Circle line runtime review,
- Dec 2021: 30 trains per hour on the Circle central area (with additional Tower Hill Reversers), plus 24tph Met line north of Baker Street (90 min peaks),
- May 2022: 32 trains per hour on the Circle central area, plus 26tph Metropolitan line north of Baker Street (90 min peaks),
- Dec 2022: 32 trains per hour on the Circle central area (3 hour peaks), including 26tph Metropolitan line north of Baker Street

  (At this point the vast majority of upgade benefits have been achieved)
- May 2023: 32 trains per hour on the Circle central area (3 hour peaks), including 28tph Met line north of Baker Street, and
- Dec 2023: Off-peak Circle central area uplift to 27 trains per hour, combined with longer peak periods on all lines

7.3 These timetables are later than assumed in business case v3.0, resulting in a Journey Time benefit reduction of £612m PV. The December 2023 off-peak enhancement regains £364m PV from that benefit loss, leaving a net benefit reduction of £248m PV in business case v4.0.

7.4 It should be noted that the appraisal period in business case v3.0 was based on the expected economic life of the rolling stock, which remains unchanged. However, the ATC commissioning and timetable migration has been deferred to a later date, with no change in the end date of benefits. This results in a residual value uplift of the signalling, at the end of the appraisal period, to account for the later implementation.

8 Post-Upgrade Performance Forecast and De-scoping

8.1 The post-upgrade Journey Time benefits forecast in business case v3.0 were based on the Train Service Model (TSM) which used railway performance data correct at May 2010. Given the timescales necessary to achieve re-authority to support the new signalling contract with Thales, it was accepted by Transport Planning and the Sponsor team, that there was insufficient time to undertake new TSM modelling for the Sub-surface Railway to support the business case update.

8.2 An approach was therefore developed to scale the benefits based on Thales' performance forecasts. In order to do this, the Journey Time Capability model was used. The model was calibrated to business case v3.0, and the journey time assessed, it was then populated with the latest performance forecasts and the change in performance was assessed.

8.3 This approach was used to scale the Journey Time benefits for business case v4.0, based on Sponsor Input Data version v6, as provided by Systems Performance, which assumes Thales' system will be in line with that specified in the tendered Works Information, including:

- A 3.2kph speed offset from maximum safe speed; and
- The April 2015 ESTL scope.

8.4 The ESTL operational flexibility benefits were reviewed to reflect the final scope, resulting in a benefit reduction of £39m PV compared with Business Case v3.0, due to the reduced scope.

8.5 The development of World Class schemes on other lines has led to a reconsideration of the potential for off-peak frequency enhancements on the Subsurface beyond the peak-only benefits included in the original business case v3.0. The benefits of 27tph on the central Circle area during inter-peak periods, combined with longer peak periods, have been estimated to yield benefits of £364m PV. Where available, OPEX impacts for this have also been included, with the exception of Train Operator costs, which were not available at the time of this update.

8.6 Overall, the forecast performance levels for v4.0 remain similar to those expected in v3.0.

9 Demand Growth & Other Benefit Changes

9.1 Demand growth over time was adjusted to reflect the later delivery of benefits, as the timetables enhancements have been deferred.

9.2 Closure requirements for ATC installation testing and commissioning were changed based on additional weekend partial closures for ATC installation, testing and commissioning, and for ESTL works. The closure disbenefit reduced by £9m PV, chiefly due to the smaller scope of the ESTL programme.

9.3 The Bombardier-specific requirement to fit ATP equipment to Piccadilly 73TS is no longer necessary, and has been removed from the business case assessment. This adds £47m PV of benefit relative to v3.0.

9.4 The re-signalling of the fast lines of the four-track section between Hammersmith and Acton Town is now out of scope. This reduces the benefits in v4.0 by £28m PV due to flexibility restrictions.

9.5 The increase in off-peak kilometrage, and consequent increase in energy required to run the service, leads to an increase in carbon emissions disbenefit amounting to £100m PV.

10 Reliability

10.1 The post-upgrade reliability benefits associated with an improved control system and ATR, have been revised to reflect the new Thales system. This resulted in a benefit reduction of £257m PV for the control system and a £45m PV benefit reduction for the ATR, at the End-State, when compared with v3.0. In addition, delivery of the full ATR functionality is now deferred until 2023.

10.2 The post-signalling reliability and availability forecasts, and associated Lost Customer Hours, have been revised based on the forecast of the Thales system, using a growth curve build-up forecast provided by RAMS Engineers in May 2015. These updated forecasts resulted in a benefit reduction of £85m PV compared with v3.0. However, the new functionality will provide a significantly enhanced service availability and reliability than existing legacy signalling.

10.3 It should be noted that similar levels of benefit reduction was also necessary for the Do Minimum case, where new signals are assumed to be implemented, without the additional benefit of ATR, thus the overall impact on the BCR is minimal.

11 Business Case v4.0 Results

11.1 Overall, the business case v4.0 BCR has reduced to 4.9:1, compared to the business case v3.0 BCR of 11.6:1, but the business case remains strong (Table 1 and Figure 1).

11.2 The business case for continuing to implement ATC, given the full introduction of new S stock trains remains financially positive.

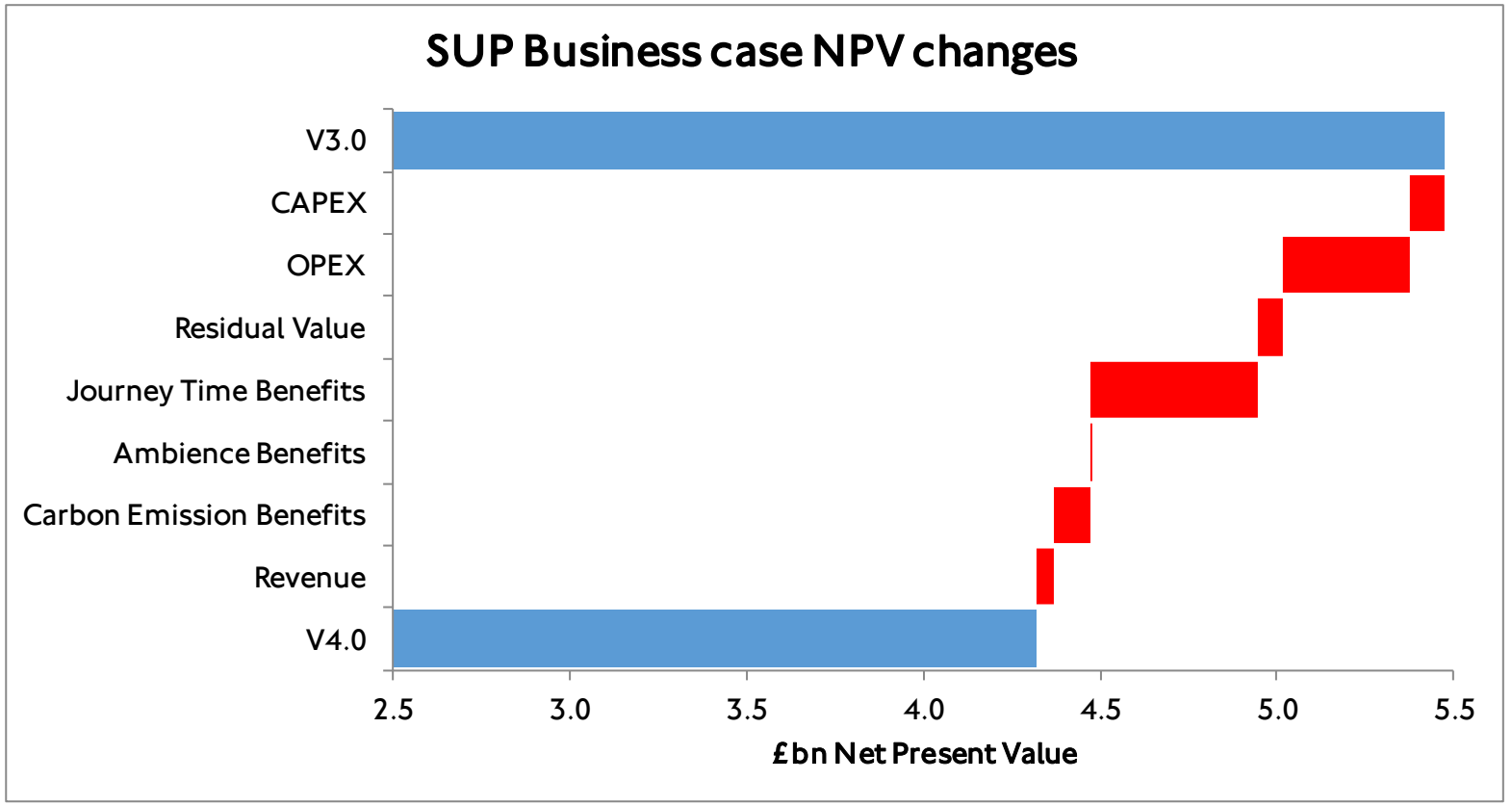
11.3 The business case benefits are illustrated in Table 1 with movements highlighted. Overall, there has been a 10% reduction in benefits between the two business case versions. The slight change in the figures for fleet and ambience results from the change in demand growth to reflect later delivery of the upgrade. Movements marked red show a worse position in v4.0 than v3.0, where movements in green are improvements. Amber movements reflect no change.

	v4A			v3.0			
£m Present Value	Do Something	Do Minimum	Incremental	Do Something	Do Minimum	Incremental	Delta Incremental
CAPEX	-5,998	-4,209	-1,789	-5,387	-3,700	-1,687	-102
OPEX	-492	-84	-408	98	150	-52	-356
Residual Value	89	401	-313	42	280	-238	-75
TOTAL COST	**-6,402**	**-3,892**	**-2,509**	**-5,247**	**-3,271**	**-1,976**	**-533**
Journey Time Benefits	5,528	385	5,143	6,176	563	5,613	-470
Ambience Benefits	1,283	793	490	1,286	795	492	-1
Carbon Emission Benefits	-251	-37	-215	-151	-39	-112	-103
TOTAL BENEFITS	**6,560**	**1,142**	**5,418**	**7,312**	**1,319**	**5,993**	**-575**
REVENUE			1,411			1,460	-48
NET FINANCIAL EFFECT			-1,098			-517	-581
BENEFIT COST RATIO			**4.9**			**11.6**	
NET PRESENT VALUE			**4,320**			**5,476**	**-1,156**
NET FINANCIAL EFFECT OF ATC vs S STOCK ONLY			**108**			**269**	**Fin Pos**
NET PRESENT VALUE OF ATC vs S STOCK ONLY			**1,960**			**5,136**	

Table 1 Comparison of Business Case v4.0 and v3.0

		Current Programme					
		Annual Value at 2025/6 (£k)	Whole Life Value (£k PV)		Annual Value at 2025/6 (£k)	Whole Life Value (£k PV)	Change from v3.0 to v4.0
		V4.0	v4.0 PV		V3.0	V3.0 PV	£k
Fleet	Journey Time	18,807	456,784		18,807	458,033	- 1,249
	Through-Gangways	4,854	125,595		4,854	125,917	- 322
	Reliability	4,112	107,528		4,112	107,801	- 273
	Closures	0	-73,094		0	-73,094	-
	Met line speed increases	0	7,445		0	7,445	-
Ambience	Ambience MSS	18,223	477,632		18,223	478,842	- 1,210
	Ambience Non-MSS	22,889	608,009		22,889	609,529	- 1,520
	Air con	7,627	197,436		7,627	197,942	- 506
Signalling	Closures	0	-59,240		0	-68,113	8,873
	Timetables	201,270	3,819,075		198,675	4,431,507	- 612,433
	Control Functionality	23,367	462,712		32,556	720,044	- 257,332
	ATR Functionality	4,676	87,403		5,985	132,361	- 44,958
	Asset Reliability	9,809	194,048		12,634	279,429	- 85,380
	Improved Diversionary Routings Journey Time	2,827	63,418		4,655	102,534	- 39,116
	Loss of 4 Track Section	-1,365	-27,531			0	- 27,531
	Offpeak service uplifts	20,776	363,967			0	363,967
	Disbenefit from "Picc Gap" signalling boundaries		0		-1,381	-47,423	47,423
Carbon	Carbon emissions	-10,479	-251,060		-5,488	-150,749	- 100,311
TOTAL		327,393	6,560,128		324,148	7,312,006	- 751,879

Table 2 Comparison of Business Case Benefits v3.0 and v4.0



Therefore, the NPV changes from £5.48 bn in v3.0 to £4.32 in v4.0

Figure 1 Movement in Net Present Value Between Business Case v3.0 and v4.0

12 Sensitivity Tests

12.1 Four sensitivity tests were generated for v4.0 to support the re-authority process:

1. Higher CAPEX: £5,543m (Q3 14/15 +24month) provided by Finance on 29th January 2015, this is 2.5% per cent higher than the core assumption and reflected the highest estimate provided by Thales;
2. Later Delivery: Aligned to the later P90 schedule and associated timetable migration plan;
3. Lower Peak Frequency Achieved: Restricted to 30tph central area (with 28tph on Met main); and
4. Worse Performance: Slower runtimes resulting from a 9kph offset from the maximum safe speed.

12.2 All other elements of the appraisal were unchanged in each sensitivity test.

13 Sensitivity Test Results

13.1 Note that CAPEX increases have modest impact on the incremental business case as the cost increases also impact on the Do Minimum scenario

13.2 The importance of successful delivery of the forecast levels of performance, is clear

£m Present Value Incremental to Do Minimum	v4A	1. CAPEX £5543m	2. Later Delivery P90	3. 30tph Service Achieved*	4. Worse Performance 9kph Offset
TOTAL COST	-2,509	-2,610	-2,509	-2,509	-2,509
TOTAL BENEFITS	5,418	5,418	5,324	5,140	4,918
REVENUE	1,411	1,411	1,404	1,363	1,320
NET FINANCIAL EFFECT	-1,098	-1,199	-1,105	-1,147	-1,189
BENEFIT COST RATIO	4.9	4.5	4.8	4.5	4.1
NET PRESENT VALUE	4,320	4,220	4,219	3,993	3,729

* Only benefits effects have been modelled, but OPEX savings would also apply

Table 2 Business case v4.0 Sensitivity Test Results

14 Authority Summary

As described in Section 5, the business case was based on the 4LM capital costs approved at TfL Board in July 2015, see Table 3 for the phasing of the CAPEX in £m outturn.

Investment Funding	Prior Yrs, £m	2015/16	2016/17	2017/18	2018/19	Future	Total
Cost (Out-turn)							
This Authority Request	3,374	361	514	456	270	437	5,412

Table 3 CAPEX outturn phasing

15 APPENDIX A: Consultation

Contact	Department	Aspect Reviewing	Response
Generic			
Ryan Taylor	PMO	Whole Document	Comments incorporated
Christian Fowler	S&SD	Whole Document	Approved
Paul Naylor	COO	Whole Document	Comments incorporated
Melanie Lawrence	PMO	Whole Document	Comments incorporated
Ben Ganney	CFO	Demand growth & other benefit changes Business case v4.0 results	Comments Incorporated
Maureen Jackson	Finance	CAPEX estimate	Approved
Stephen Richards	Finance	CAPEX estimate	Approved
Charles Onuegbu	Finance	CAPEX estimate	Approved
Kishan Teli	Finance	OPEX estimate	Approved
Andrew Fakanmbi	S&SD	OPEX estimate	Approved
Gabriel Smith	CPD	Post-upgrade performance	Approved
Silvia Re	CPD	Post-upgrade performance	Approved
Stuart Coomer	S&SD	Post-upgrade performance	Approved
David Tamagni	S&SD	ATC commissioning	Approved
Dave Hughes	S&SD	Timetable migration & offpeak enhancements	Approved
Andy Bourne	CPD	ATC commissioning	Approved
Ivan Gwynn	S&SD	Whole Document - ESTL scope	Approved

Appendix 3

Board

Date: **17 March 2016**

Item: **New Tube for London programme: Piccadilly Line Modernisation**

This paper will be considered in public

1 Summary

UIP2344	**New Tube for London Programme**			
Existing Financial Authority	Estimated Final Cost (EFC)	Existing Project Authority to 31 Mar 2016	Additional Authority Requested	Total Authority
£ 3,969.3m	£ 16,511.4m	£ 59.1m	£95m	£154.1m

Authority Approval:

To approve budgeted project authority to a total of £154.1m for the New Tube for London programme inclusive of £95m to commence the procurement of new rolling stock and signalling systems for the Piccadilly line modernisation, deliver enabling works and to continue design development for the Bakerloo, Central and Waterloo & City line upgrades by 31 March 2018.

Outputs and Schedule:

This request covers the initial preparatory works for the modernisation of the Piccadilly line and further development of the Bakerloo, Central and Waterloo & City line upgrades, as follows:

- Commencement of procurement for a new Signalling and Train Control system including preparation and issue of an Invitation to Tender (ITT);
- Completion of competitive tendering and supplier negotiations for new Piccadilly line trains;
- Commencement of designs and specifications for the procurement of infrastructure and railway systems upgrades on the Piccadilly line; and
- Commencement of HV power supply upgrades and signalling immunisation works.

These preparatory works will contribute towards the following strategic outputs:

- Delivery of line modernisation, asset renewals and capacity upgrades on the Piccadilly and Waterloo & City lines by 2026; and
- Subsequent modernisation of the Bakerloo line by 2028 and the Central line by 2033;

1.1. On 2 March 2016, the Finance and Policy Committee endorsed the recommendations in this paper.

1.2. A paper is included on Part 2 of the agenda which contains exempt supplementary information. The information is exempt by virtue of paragraph 3 of Schedule 12 A of the Local Government Act 1972 in that it contains information relating to the business affairs of TfL. Any discussion of that exempt information must take place after the press and public have been excluded from this meeting.

2 Recommendation

2.1 **The Board is asked to:**

(a) note the paper and the supplementary paper included on part 2 of the agenda; and

(b) approve additional Project Authority of £95m, taking the Project Authority to a total of £154.1m.

3 Background

The New Tube for London (NTfL) programme

3.1 The New Tube for London (NTfL) programme delivers part of the Mayor's Transport Strategy (MTS), by transforming key parts of London's transport infrastructure through the continuation of the LU line modernisation programme. Responding to current and forecast increases in passenger demand the NTfL programme will modernise four London Underground lines – the Piccadilly, Waterloo & City, Bakerloo and Central lines.

3.2 The NTfL programme will specifically contribute to the following goals in the MTS:-

(a) support economic development and population growth;

(b) enhance the quality of life for all Londoners;

(c) improve the safety and security of all Londoners;

(d) improve transport opportunities for all Londoners; and

(e) reduce transport's contribution to climate change and improve its resilience.

3.3 The NTfL programme aims to modernise the Piccadilly, Waterloo & City, Bakerloo and Central lines with the introduction of a new generation of high capacity, walk-through, air-cooled trains with modern signalling control systems and supporting infrastructure to allow high frequency automatic train operation on these lines.

3.4 The replacement of ageing assets on these lines will also enable a step change in customer service quality and the transformation of operating and maintenance models through the introduction of modern technology.

3.5 Following on from the modernisation of the Victoria, Jubilee, Northern and Sub-Surface lines, the NTfL programme will form the final phase of the LU line modernisation programme. The NTfL lines constitute a third of the Underground network, carrying around two million passengers per day to key locations across

London, including: The City, West End, Stratford, Kings Cross and Heathrow Airport. Underground demand is forecast to grow by over 25 per cent during the next 10 years which will increase the need for additional capacity on these lines.

3.6 Delivery will commence with modernisation of the strategically critical Piccadilly line, which will deliver a 60 per cent increase in peak period capacity.

3.7 The Programme is budgeted within the current TfL business plan. In response to the Comprehensive Spending Review, sufficient funding is anticipated to be prioritised through the business planning process to allow the core elements of this programme to proceed to enable delivery of critical asset renewal and capacity improvements.

3.8 In February 2014, the Board approved an increase of £36.2m in Project Authority, to a total of £59.1m including earlier feasibility phases, to undertake design and specification activities for the NTfL programme by 31 March 2016.

3.9 During this period, the NTfL programme has continued to develop the infrastructure scope and business requirements for the Piccadilly line modernisation. This has resulted in the generation of a detailed technical specification and contract documentation necessary for the NTfL Rolling Stock procurement competitive tendering process which commenced in January 2016 with the release of the Invitation to Negotiate (ITN).

3.10 Work has continued on the definition of the overall NTfL programme scope and requirements with infrastructure analysis and research conducted to further the development of the later Bakerloo, Central and Waterloo & City lines upgrade schemes.

3.11 Programme development is based around an integrated railway system design to ensure that all requirements and interfaces can be effectively specified and managed through delivery. The following key outcomes have been achieved during the current “Design and Specification” stage:

Piccadilly line Trains Procurement

3.12 The issue of a Pre-Qualification Questionnaire in March 2014 resulted in the shortlisting of five bidders in October 2014 for the procurement process for the design, build and maintenance technical support of the new Piccadilly line trains.

3.13 A comprehensive Technical Specification and associated procurement documentation for the new rolling stock has been completed to allow release of the Invitation to Negotiate (ITN) in January 2016. This has included the development of a comprehensive tender evaluation model for assessment of suppliers’ bids.

3.14 This procurement includes whole life technical support by the manufacturer to ensure that high levels of reliability are sustained and options for the supply of rolling stock for the other NTfL lines, which are exercisable at TfL’s sole discretion.

Railway Control/Signalling system

3.15 Railway control system development has focussed on establishing requirements and creating market appetite to allow a competitive procurement for a common

Signalling and Train Control system for all NTfL lines, commencing with the Piccadilly line, which comprise over 30 per cent of the LU network.

3.16 Concept solutions have been developed for the interoperable sections of the Piccadilly line where new signalling will need to allow for operation of District and Metropolitan line trains over common track sections in West London.

Infrastructure

3.17 *Depots* – feasibility investigations have focussed on maintenance facilities for the new trains at the existing depot locations. Outline plans for the location of key maintenance and stabling facilities within the depots have been produced to inform rolling stock bidders' train maintenance proposals.

3.18 *Track and civils* – track capability has been reviewed in order to understand the requirement for track alterations to meet post-upgrade capacity needs and to define an optimised set of changes to deliver beneficial improvements in run times.

3.19 *Power and cooling* – enhancements to the power supply system to support new train introduction, higher service levels, faster runtimes and higher rolling stock auxiliary loads (e.g. air-cooling) have been assessed and system optimisation opportunities (e.g. regenerative braking and 750 Volt supply) considered to understand requirements for power infrastructure reinforcements.

3.20 *Platform Train Interface (PTI)* – the programme has led LU's research and development to investigate technologies for managing safety and performance at the PTI, building on lessons learnt from the Four Lines Modernisation (4LM) programme and metro practice worldwide.

Operations & Maintenance (O&M)

3.21 The embedded O&M team has focussed on developing the vision of how an optimised, post upgrade railway would be operated and maintained. Development of detailed set of User Requirements for each Grade of Automation has commenced to inform the rolling stock Technical Specification. Supporting Operations Concepts documents are also under development to define the future operating environment and management approach to Piccadilly line Operations, Service Control and Depots & Fleet Maintenance.

Line sequence and strategy

3.22 The programme strategy has undergone extensive review to optimise delivery scope and line sequencing to maximise benefits within funding constraints. The main strategic developments since the paper to the Board in February 2014 have been:

(a) that upgraded Piccadilly line services will initially be under manual operation with new trains (Grade of Automation or GoA1) with migration to Automatic Train Operation (GoA2) [(1)] to follow line re-signalling. The upgrade will

(1) Grade of Automation 2 is operation with a Train Operator as currently utilised on the Central, Jubilee, Northern and Victoria lines. GoA4 is driverless operation.

continue to provide the system capability for future conversion to fully automatic (GoA4) operation at a future date. This staged delivery is planned to prioritise funding and resources on the initial, most beneficial, asset renewal and capacity upgrade;

(b) the Waterloo & City line modernisation has been brought forward to be delivered alongside the Piccadilly line, resolving an open item as reported to the Board in February 2014; and

(c) the order of the Central and Bakerloo modernisations has been reversed. With commitment of additional investment on existing Central line assets to secure their continued safety and reliability, the Bakerloo line modernisation has been prioritised ahead of the Central line to accelerate the replacement of the oldest trains on the network which are operating on the Bakerloo line(2). It is intended that the relative order of these two lines in the NTfL delivery sequence be kept under review, informed by emerging asset condition and available funding.

3.23 To enable the programme to continue beyond completion of the current stage in March 2016, further Project Authority is now requested to progress scope development, key system procurements and enabling works for the Piccadilly line modernisation to March 2018.

4 Proposal

4.1 Delivery will commence with the Piccadilly line modernisation, which provides the greatest opportunity to increase capacity and has a high priority for asset renewal. To enable achievement of delivery timescales, the next stage of the NTfL programme will secure the programme team resources to progress critical scope development, train system procurement and key infrastructure enabling works on the Piccadilly line.

4.2 Preparatory design work will also commence for the modernisation of the Waterloo & City line.

4.3 A base programme of work has been developed to progress the delivery of the NTfL programme to the point of award of the rolling stock contract in late 2017. These activities include the following key work packages:

Rolling Stock procurement

4.4 Following issue of the ITN, the programme will progress through the tendering and evaluation process in 2016/17 leading to supplier negotiations for the new Piccadilly line trains contract.

4.5 Tenders will be assessed for compliance with requirements and deliverability, with acceptable bids then being evaluated on the basis of whole life costs and benefits. This evaluation includes capital costs, operating/maintenance costs, passenger

(2) The additional investment recently committed to the existing Bakerloo line 1972 tube stock trains is required under any NTfL line-sequence. The refinement of any additional works required on these legacy trains is being planned in conjunction with NTfL delivery sequence plans.

benefits and the monetised cost of carbon emissions. Carbon costs result from the estimated energy usage of each bidder's train in operational service and include an estimate of energy usage by additional infrastructure cooling schemes required to mitigate heat generated in the tunnels by the new trains.

4.6 Five global train manufacturers have pre-qualified to compete in the tendering process for the NTfL rolling stock and the internal team will lead the tendering and evaluation process. Following the release of the ITN for the NTfL Rolling Stock procurement in January 2016, a tendering period will continue until July 2016 and will conclude with an award recommendation in October 2017. At the point of a contract award recommendation further Project and Procurement Authority will be sought.

Railway Control System procurement

4.7 Following publication of an OJEU notice in March 2016, the procurement process for a new signalling and train control system will commence with the pre-qualification of suppliers and the preparation of a contract specification to support the release of an ITT in October 2016.

4.8 Bidders' capabilities to provide a system that can meet the specified requirements will then be evaluated to identify two tenderers to be taken through into a design development process. This will allow two potential suppliers to demonstrate that their systems are capable of meeting the project requirements which will inform the selection of a winning supplier and product for NTfL application, initially on the Piccadilly line.

4.9 Survey and design works will be undertaken at all Piccadilly line locations (in four tranches) for the re-positioning of train stopping marks and chevrons for new rolling stock introduction. Modifications will also be progressed to the legacy signalling system on the Piccadilly line to ensure electro-magnetic compatibility with modern rolling stock traction systems.

4.10 Work will commence on the procurement of a single railway control system for all four NTfL lines to provide integrated control and monitoring of security systems, fire alarms, ventilation, customer information/CCTV, lifts and escalators and pumps. Design work will also be undertaken for upgrading of the OPO CCTV systems needed for safe PTI management in support of new train operation.

Infrastructure upgrade

4.11 *DC Traction Power* – initial scoping and requirements development will be undertaken for upgrades to the DC traction power systems required to support higher service levels on the Piccadilly line.

4.12 *Performance Modelling* – system performance modelling will be completed for the Piccadilly line including analysis of: HV power distribution, DC traction systems, air temperature, air velocity and the optimisation of energy efficiency mitigations. System modelling for Central, Bakerloo and W&C lines will also be commenced.

4.13 *HV Power* - following concept, detailed design and procurement stages contracts will be awarded for works at Manor House to relocate the telephone exchange to enable power sub-station upgrading. Implementation will commence on an initial

tranche of upgrade works to the HV power distribution system at three priority 22kVa sub-stations (at Mansell St, Cobourg St and Manor House) and frequency conversion works at another three substations to support signalling track circuit immunisation.

4.14 *Depots & Stabling* - concept designs will be completed for major upgrades at Cockfosters and Northfields depots to increase stabling capacity and provide modern maintenance facilities to support the new rolling stock. These concepts will then be developed into detailed designs in readiness for procurement.

4.15 *Cooling* - concept designs will be completed for priority station cooling schemes at Holborn and Knightsbridge as the initial stage of a wider programme of cooling system interventions at multiple locations on the Piccadilly line. These are aimed at mitigating the projected temperature rises resulting from the introduction of new trains, on-train air-cooling and higher service levels.

4.16 *Track* - modelling and business case assessment will be completed to finalise the track layout changes needed to support higher frequency services on the Piccadilly line. Further survey, design and enabling works will then be progressed.

4.17 *Platform-Train Interface* - further system development and detailed design will also be completed on 'safe PTI management' systems required for migration, Automatic (GoA2) and Fully Automatic (GoA4) operation. This will include systems benchmarking, supplier engagement and PTI system development (Platform Edge Doors, gap fillers and secondary detection).

4.18 *Signalling enabling* - following confirmation of preferred strategy and location, feasibility and design will commence on a new Operational Control Centre facility for the NTfL lines.

Waterloo & City line

4.19 Engineering design development will be undertaken to refine the initial feasibility design of the infrastructure and system changes needed on the Waterloo & City line to support new train operation and maintenance and higher levels of automation. This will include designs for track and depot remodelling required at Waterloo and assessment of the closure blockade duration needed to deliver higher service frequencies and new train maintenance capability.

Bakerloo and Central lines

4.20 Engineering design development will be undertaken to update and refine earlier feasibility studies to reflect current assumptions and requirements and develop the maturity of the programme scope and schedule.

Programme Management

4.21 The above programme deliverables will be enabled through the resourcing of a programme management team which will provide essential project controls, estimating, assurance, safety management and reporting functions.

4.22 The existing programme management team capability will be augmented by the engagement of an external Programme Partner to provide expertise to establish the structures, processes and organisation necessary for downstream delivery of a complex infrastructure programme.

Programme Engineering and Systems Integration

4.23 A dedicated Engineering and Systems Integration team will be deployed to support the design development and delivery stages and to develop and manage the processes necessary to ensure an integrated railway system solution.

4.24 On completion of this next stage in early 2018, a further submission will be made requesting Project authority to implement the Piccadilly line modernisation. This submission will occur at the point of the award of the Piccadilly line trains supply contract in late 2017, and will also request Procurement Authority for this contract.

4.25 Operational impacts during the next programme stage will be minimised and any survey and investigation works requiring access to the operational railway will be conducted during Engineering Hours.

4.26 No major closures or operational changes are required during this stage. An Access planning workstream will be undertaken during the next stage to assess the level of intrusive access or closures needed during Piccadilly line implementation.

4.27 Any Equality impacts will be considered as part of programme implementation.

5 Benefits and Value

5.1 NTfL will deliver substantial benefits to London through:

(a) a step-change increase in peak capacity on each of the four lines (36 per cent on average), which are at capacity on the busiest sections, to cater for the forecast expansion of London's population and supporting its continued economic growth:

(i)	Piccadilly line	60 per cent;
(ii)	Bakerloo line	25 per cent;
(iii)	Central line	25 per cent; and
(iv)	Waterloo & City line	35 per cent.

(b) faster and more reliable journeys; and

(c) improved journey quality, with improved accessibility, air cooling (for the first time on the LU deep tube network) and enhanced customer information.

5.2 In addition, the programme will deliver the essential asset renewals required to continue to operate safe and reliable services on these lines.

5.3 The capability to operate in fully automatic modes will be designed into the system, although when the first new trains enter service on the Piccadilly line they will have an operator on board.

5.4 Significant contributions will be made to three of the four Rail & Underground Priorities:

(a) increase capacity from the current network;

(b) improve customer service; and

(c) improve reliability and safety.

5.5 There is no “Do nothing” option for this project as significant investment in the existing life-expired assets would be required to sustain services on these lines in all cases. Consequently the business case is assessed against a “Do Minimum” option for sustaining safe and reliable services on these lines, which includes deferred renewal of trains, signalling and supporting systems.

5.6 The main focus of the next stage of programme development is on the Piccadilly line modernisation. The overall benefit cost ratio for this line upgrade was updated in autumn 2015, and is 4.0 to 1, which falls into the Department for Transport category of very high value for money.

5.7 Further development is underway to refine the business cases for the other lines, which will be delivered sequentially after the Piccadilly line.

5.8 The results of the Piccadilly line business case analysis are shown below:

Net Present Values, £k	***Incremental to Do Minimum***
Discounted NPV CAPEX	-934,637
Other CAPEX	n/a
Other costs	n/a
OPEX (+ or -)	-17,754
Third Party	n/a
Revenue	411,376
Other Income	n/a
Net Financial Effect	-541,015
Payback Period	n/a
Passenger Benefits	2,185,615
Impacts during Implementation	Included in overall benefits
Total Benefit, £k	**2,185,615**
Benefit : Cost Ratio	4.0 to 1

6 Programme Delivery arrangements

6.1 The NTfL programme delivery model is based around an internal LU integrated client team comprising delivery management, engineering and programme controls functions operating in conjunction with embedded Operations & Maintenance and Sponsor teams.

6.2 A suite of requirement documents is being finalised to define the business requirements for the Piccadilly line modernisation. This includes the Sponsor’s Programme Requirements (SPR) and supporting reference data which will form a controlled baseline for programme delivery during the next stage.

6.3 A programme partner (CH2M/PWC) has been appointed to support the development of the programme as it progresses into the delivery phase. The Programme Partner's role is to strengthen the capability of the NTfL delivery organisation to operate effectively in a complex programme management environment through the provision of external skills, knowledge and expertise gained on other large UK infrastructure programmes (e.g. HS2, 2012 Olympic Games).

6.4 A programme delivery partner will be appointed in early 2017 to provide ongoing support and expertise for the delivery stage.

6.5 As the Prime Systems Integrator (PSI), the NTfL programme team will be responsible for the application of a Systems Engineering approach to the definition and management of technical, operational and programme integration issues for the NTfL programme. This will ensure the business requirements and benefits are fully realised and a Systems Integration Team has been formed to manage the processes necessary to achieve an integrated solution.

6.6 Within the PSI framework, in-house LU expertise (e.g. Power and Cooling) will be engaged where appropriate to support the programme's engineering and delivery functions. Major NTfL supply contracts will be sourced through competitive procurement.

6.7 Maintenance of the new NTfL rolling stock will be sourced 'in-house' by LU staff with whole-life technical support by the train manufacturer under a Fleet Support Agreement. This model will ensure that the rolling stock supplier is incentivised and fully committed to the sustained achievement of the high levels of reliability required.

6.8 The NTfL programme has key interfaces and interdependencies with other R&U investments, in particular the modernisation of the District, Metropolitan, Circle and Hammersmith & City lines (4LM programme) which is upgrading signalling on key sections of infrastructure shared with the Piccadilly line.

6.9 The Piccadilly line Interim Control Upgrade project (PICU) also provides a key enabling project for the migration to the new NTfL Piccadilly line signalling system through the creation of an interim control system and modern control facility to replace the existing Earl's Court Control Room. At Holborn, the planned station modernisation project will provide congestion and crowding relief necessary for the introduction of higher train service levels.

6.10 Other downstream dependencies exist with asset renewals investments, significantly the Track replacement programme, where line upgrade service improvements and new train performance are dependent on the achievement of modern track quality standards throughout the Piccadilly line.

6.11 Key milestones identified for the next stage of the NTfL programme are as listed below:

Milestone	Target Date
Piccadilly line HV Power Infrastructure Specification	20 May 2016
Signalling RCS procurement: Issue of the Invitation to Tender	31 October 2016
Programme level maturity level 3: Targeted actions achieved and verified.	31 March 2017
Piccadilly line trains procurement: Award Recommendation	31 October 2017

7 Financial Implications

7.1 The programme currently has Project Authority of £59.1m for completion of the design and specification phase by 31 March 2016. Of this sum, a total of £9.3m is forecast to remain unspent at 31 March 2016.

7.2 The estimated cost of the work covered in this paper is £104.3m. Taking into account the £9.3m unspent, this will require an increase in authority of £95m to an overall total of £154.1m.

7.3 The current budget (at Q3 2014/15) to 2023/24 is £3,969.3m, including prior years. The plan years include a substantial proportion of the Piccadilly line modernisation, and continued development and initial delivery stages of the other three lines. The delivery of the NTfL programme will span many years beyond the current Plan, with approximately 25 per cent of spend in the plan period. This proposal, as part of the overall NTfL Programme, has existing Financial Authority in the Business Plan.

7.4 The full estimated final cost (EFC) of the modernisation of all four lines is £16,511.4m outturn.

7.5 The funding strategy for the programme builds on the earlier approach of progressive maturity linked to staged programme authority requests. The proposed authority to 31 March 2018 will enable major cost elements of the programme (principally Rolling Stock and Signalling & Train Control supply) to be more accurately assessed through competitive tendering and supplier engagement. On completion of this stage, in late 2017, further authority will be sought for implementation of the Piccadilly line modernisation programme with higher confidence and reduced estimating risk.

7.6 A key area of focus in this next phase of the project is to identify efficiencies, challenge scope assumptions and refine cost estimates such that the overall programme EFC is mature, robust and comparable with relevant benchmarks prior to seeking full authority for the Piccadilly line modernisation in late 2017.

7.7 Whole life Operating and Maintenance costs have been modelled for inclusion in the NTfL Business Case. These will be refined during the next stage and informed by suppliers' responses to the Rolling Stock and Signalling procurements.

7.8 The estimated changes in OPEX have been developed with discipline experts, based on assessment of key cost drivers, recent experience on other upgrades and benchmarked maintenance rates from other lines and metro systems. These reflect the expected operating model and level of service together with high level maintenance requirements.

8 External Assurance reviews

8.1 The programme has been subject to ongoing external assurance reviews during the current phase with an annual Integrated Assurance Review at NTfL Programme level now well established. This has been supplemented by Rolling Stock specific reviews during the procurement development process to ensure the robustness of the programme and readiness to enter the procurement stage.

8.2 The Annual Programme Integrated Assurance Review (IAR) was conducted in November 2015 culminating in a review with external experts Jacobs, the Independent Investment Programme Advisory Group (IIPAG) and TfL Assurance on 8 December 2015. This review identified 11 general recommendations to be addressed by the programme.

8.3 The IAR recommendations were directed at the overall need for an integrated programme baseline at the commencement of the delivery stage, including clarity of objectives and requirements, a business change plan to support the transformation enabled by NTfL and finalised operating and maintenance concepts.

9 Views of the Finance and Policy Committee

9.1 On 2 March 2016, the Finance and Policy Committee considered a similar paper. The Committee requested that future papers include reference to carbon costs as part of the tender evaluation. Additional information has been provided in paragraph 4.5 of this paper.

9.2 The Committee raised no other issues for the attention of the Board and endorsed the recommendations in this paper.

List of appendices to this paper:

Exempt supplementary information is included in a paper on Part 2 of the agenda.

Background papers:

None.

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Appendix 4

Transport and Works Act 1992

London Underground (Northern Line Extension) Order

TfL's Inquiry Documents

Category D: Economic and Business Case
(NLE/D1)

MAYOR OF LONDON

Transport for London

Northern Line Extension

Economic & Business Case

Report

2013

steer davies gleave

Volterra

Quod

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Executive Summary

The Scheme

1. The Northern Line Extension (NLE) is a proposal to extend the Charing Cross branch of the Northern line from Kennington to Battersea, via an intermediate station at Nine Elms.
2. The NLE is planned to open in 2020, at an initial peak service frequency of 16 trains per hour. The frequency of the NLE is then planned to increase to 28 peak trains per hour in 2022 following the Northern Line Upgrade 2 (NLU2).
3. The scheme is shown in Figure 1.

Figure 1 Northern Line Extension Scheme Map

4. The out-turn cost of the scheme is estimated to be £998.9m, as set out in the NLE Funding Statement[1]. The scheme will be financed by public sector borrowing, but this borrowing will ultimately be paid back and funded by the private developments enabled by the NLE through developer contributions (Section 106 and Community Infrastructure Levy) and additional business rates, levied through the area's Enterprise Zone designation.

5. The costs used for this economic and business case appraisal within the economic appraisal include an additional cost allowance for risk and optimism bias based on a Quantified Risk Assessment (QRA), in the form of the QRA P50 value plus an Optimism Bias adjustment . Table 1 summarises these capital costs used in the economic appraisal. The overall cost is £809m in 2010 prices discounted to present values after taking into account future expected inflation, and including an allowance for risk.

Policy and Economic Context

6. The primary aim of the NLE[2] is to facilitate the sustainable growth and development of the Vauxhall Nine Elms Battersea (VNEB) Opportunity Area (OA) and thereby encourage economic growth in London and the wider UK economy, through the creation of a major new sustainable business, residential, and leisure district within London's Central Activities Zone (CAZ).

7. This aim reflects the strategic policy objectives that the NLE has been developed to support. The NLE is critical to delivering the density of activity in the VNEB OA to bring it up to CAZ levels, through providing the transport capacity and accessibility that will support high density development and the delivery of 16,000 new homes and 20,000 to 25,000 new jobs as set out in the VNEB Opportunity Area Planning Framework (OAPF). This level of development would not be achievable without the NLE.

8. The NLE will play a similar role to the Jubilee line extension which opened in 1999 and stimulated growth across a large area including London's Docklands. Its impact upon regeneration, land value uplift and employment has been highly significant.

9. Developing the VNEB OA to its full potential is part of London's wider spatial planning objective of supporting the expansion of CAZ

[1] Northern Line Extension (NLE), Transport and Works Act Order Application – Funding Statement, April 2013

[2] Northern Line Extension (NLE), Transport and Works Act Order Application – Concise Statement of Aims, April 2013

activities. The CAZ is a London Plan designation covering London's Government, business, commercial and cultural / entertainment hub, which is at the heart of London's role as a world city and global business location. While VNEB is part of the CAZ designation, it is currently under-occupied and its potential cannot be realised without the NLE. The NLE will provide the capacity and accessibility required to deliver the higher density development in the VNEB OA to meet the growth objectives of the VNEB OAPF.

10. The development of VNEB is part of a broader policy of expanding the CAZ to increase London and the UK's productivity. Higher productivity in central London is a result of both the nature of the business sectors which locate there and the density of economic activity which takes place there, through a process known as agglomeration. The policy involves raising the density of land use in traditional areas of the CAZ and integrating areas on its fringes such as Broadgate (Liverpool Street), King's Cross and the South Bank and London Bridge as well as VNEB.

11. The NLE also supports the sustainable delivery of London's wider growth and economic development objectives. This is achieved through accommodating population and employment growth and supporting the expansion of the CAZ. In summary the NLE is fundamental to delivering the desired scale of economic growth and regeneration in the VNEB OA, and as such has become a policy requirement.

NLE Economic Appraisal

12. This document presents an assessment of the economic benefits and cost benefit analysis of the NLE. The cost-benefit appraisal has been undertaken using a variety of methodologies including Treasury appraisal guidance and DfT guidance.

13. The economic scenarios developed focus on the jobs and productivity that are made possible by the scheme, the Without NLE Scenario has a lower level of development, while the With NLE Scenario reflects the additional development and hence employment enabled by the NLE.

14. Second, delivering higher development density in the VNEB OA will deliver additional economic growth at the London-wide and UK level. Some of the newly facilitated employment will displace or redirect growth from elsewhere and this is estimated both with reference to standard leakage parameters and to the likely attraction to foreign direct investment. The value of this, based on planning guidance,

shows a net additional benefit of the scheme of £6.7bn in present value terms over 60-years.

15. Further analysis looks at the productivity differential between employees in the CAZ and those working elsewhere, and the consequences this has for the benefits of the NLE. A proportion of the roles in the area are likely to be generated by inward investment. This is a more conservative view of the net additional benefit than that based on planning guidance.

16. Productivity estimates generated by the DfT are used to estimate the value of diverting growth to a more productive area, i.e. the CAZ. This estimate of this move to more productive jobs is £4.1bn[3].This takes account of an assumption that 13% of the additional jobs would not otherwise have existed.

17. In addition, DfT guidance gives a basis for estimating the impact of increasing the density of VNEB on the remainder of the CAZ. This measures 'Pure Agglomeration': an effect of enabling better communications between firms, workers, and their homes. This estimate is £600m.

18. Finally transport benefits to users, in the form of time savings, and modelled according to TfL's standard procedures, are estimated at £290m.

19. The economic appraisal is presented in Table 1. It includes all the monetisable costs and benefits of the scheme, and profiles these over a 60-year appraisal period.

20. The appraisal shows that the NLE scheme will deliver a Benefit to Cost Ratio of over 8:1. This means it will deliver over £8 of benefit for every £1 of cost, representing excellent value for money. The single biggest source of benefit is the generation of more productive jobs, accounting for £4,100m of benefits. This benefit reflects the critical role of the NLE in supporting the expansion of the CAZ.

21. The NLE scheme is being financed and delivered by the public sector, but the up-front scheme costs will be recouped through development levy arrangements (CIL) and additional business rates that underpin the scheme financing. Operating costs are more than covered by additional revenues.

[3] In line with TfL and DfT appraisal guidance, future real costs and benefits are in 2010 present values, meaning the cash flows from 2010 onwards have been discounted by 3.5% per annum

Table 1 Economic Appraisal of NLE (£m Present Values, 2010 Prices)

	Economic costs and benefits over 60-years (£m, Present Values, 2010 prices)
Financial Impacts	
Capital Costs	810
Renewal Costs	90
Operating and Maintenance Costs	210
TfL Revenues	-400
National Rail Revenues	-90
Financial Impacts	***620***
Economic Impacts	
Move to More Productive Jobs	4,100
Agglomeration Benefits	600
Public Transport Benefits	290
Highway benefits	50
Accidents, GHG and Air Quality	40
Total Benefits	***5,080***
Net Present Value	***4,470***
Benefit Cost Ratio	***8.2 : 1***

22. The economic appraisal does not distinguish private and public costs and benefits. If the economic appraisal only considered public sector costs, then the full benefits of the scheme worth over £5.0bn would be delivered at small net cost to the public sector (£26m[4] over 60-years). For every £1 to the public sector, the scheme would generate £196 in benefits to London's economy, which represents exceptional value for money to the public sector and the tax payer.

[4] This is the net costs to the public sector, including P50 risk and optimism bias on construction costs and a trainset funded through NLU2 (£125m PV), life-cycle operating, maintenance and renewal costs (£305m PV) which are then offset by TfL farebox revenues (-£405m PV).

NLE Regeneration Benefits

23. The NLE will support the regeneration of London Borough of Lambeth (LBL) and London Borough of Wandsworth (LBW), with a particular impact on residents of the wards within and immediately surrounding the VNEB OA. An assessment of planning consents has shown that the development of the VNEB OA could accommodate over 23,800 additional jobs compared to the current number of jobs in the area. The range and mix of employment opportunities coming forward here are not only significant in terms of London's overall economic growth, but create a substantial opportunity for the local labour market.

24. In addition to the creation of new jobs within the OA, the delivery of the NLE will also improve the accessibility of existing communities in the area to the rest of the CAZ and further afield by significantly reducing travel times, thereby increasing access to employment and leisure opportunities.

25. The local authorities are committed to working together with local stakeholders (including TfL) and land owners to maximise the local benefits arising from employment within VNEB for the wider labour market within both boroughs.

26. As part of the Nine Elms Vauxhall Partnership, London Borough of Lambeth and London Borough of Wandsworth will deliver an Employment and Skills Framework for the OA. An Employment and Skills Plan is required for developments within the OA, the terms of which are set out in the S106 agreements for the consented applications.

27. The demand for infrastructure has been assessed on the basis of the number of residents projected to live within the OA and requirements were identified in consultation with key stakeholders and service providers. This assessment has been carried out to ensure there is sufficient social infrastructure to meet the need of new communities, but also to ensure that the development of the OA does not adversely impact the existing communities or impede their access to existing infrastructure.

28. Social infrastructure will be delivered through a combination of on-site delivery and funded through CIL to provide the necessary schools, healthcare, nurseries, libraries, community centres and other facilities. As much of this will be funded by development enabled by the NLE, the scheme has a significant impact on the delivery of these services.

Conclusions

29. The economic and business case sets out how the NLE will deliver the regeneration and wider economic development objectives that fully align with the London Plan objectives of accommodating employment and population growth and promoting the development of the Central Activities Zone (CAZ). This scale of regeneration in VNEB and wider economic development would not take place without the NLE.

30. The economic appraisal has valued the overall benefit of the NLE in terms of transport benefits and its role in delivering additional economic productivity and jobs to London, and the UK as a whole. The economic appraisal demonstrates that the NLE scheme will deliver a Benefit to Cost Ratio of over 8:1, meaning that every £1 spent on the project will deliver at least £8 in benefits.

31. The capital costs will be recouped over time from the development, every £1 in public money spent on the project will deliver £196 in benefits, making the NLE exceptional value for money to the public sector and tax payers.

1 Introduction

1.1 The Northern Line Extension (NLE) is a proposal to extend the Charing Cross branch of the Northern line from Kennington to Battersea, via an intermediate station at Nine Elms. The NLE is being developed to encourage economic growth in London and the wider UK economy by facilitating the sustainable regeneration and development of the Vauxhall Nine Elms Battersea (VNEB) Opportunity Area (OA).

1.2 Transport for London (TfL) is seeking powers to build and operate the NLE to Battersea under the Transport and Works Act 1992 (the TWA). Orders under the TWA can authorise railway schemes like the NLE in England and Wales. In England, applications for TWA Orders (TWAO) are made to the relevant Secretary for State by the promoters of the scheme. The purpose of this procedure is to allow the Secretary of State to come to an informed view on whether it is in the public interest to grant the TWAO.

Purpose of Economic and Business Case

1.3 This document sets out the economic and regeneration context for the scheme – the need for the NLE, and details the economic benefits of the scheme which underpin the cost-benefit appraisal.

2 NLE Scheme Description and Costs

The Scheme

2.1 The TWAO application proposes an extension to the Charing Cross branch of the Northern line. The NLE works comprise the construction of an underground railway to form an extension of the Northern line (Charing Cross branch) from Kennington to Battersea. It will diverge from the existing railway south of Kennington station from a section of track used by terminating trains (known as the Kennington Loop).

2.2 The extension will include a new station at Battersea, which would be integrated within the Battersea Power Station development, and an intermediate station at Nine Elms. At Nine Elms, the station design allows for over site development (OSD) and the TWAO application documents[5] illustrate the principle of that OSD development, which would be the subject of a subsequent planning application. Both new stations will provide step-free access from train to street.

2.3 The selection of a single option followed a comprehensive option development process including detailed technical work[6] informed by public and stakeholder consultation[7], each of which are reported in detail in the April 2013 TWAO Application.

2.4 A map of the scheme is presented in Figure 2.1.

Operational Assumptions

Opening Year

2.5 The assumed date for the opening of the NLE is assumed to be January 2020.

[5] Northern Line Extension (NLE), Transport and Works Act Order Application - Environmental Statement Volume IIa - Design and Access Statement (DAS) (April 2013)

[6] This is reported in more detail in the Volume 1, Section 3 of the NLE Transport and Works Act Order Application - Environmental Statement 'Options and Alternatives' (April 2013)

[7] Northern Line Extension (NLE), Transport and Works Act Order Application - Consultation (April 2013)

Figure 2.1 Northern Line Extension Scheme Map

Service Pattern and Frequency

2.6 NLE services will be provided by extending Charing Cross branch services currently terminate at Kennington, through to Battersea via a new station at Nine Elms.

2.7 The Northern line will undergo a programme of upgrades unrelated to the NLE. The Northern Line Upgrade Phase 1 (NLU1) is currently underway and is set to be completed in 2014. These works will upgrade the signalling infrastructure which will increase the capacity of the line by 20 per cent and reduce journey times by 18 per cent. The Northern Line Upgrade Phase 2 (NLU2), which is funded as part of the TfL business plan, would deliver an additional 38 per cent capacity on the Bank branch and an additional 25 per cent on the Charing Cross branch in the peak direction. NLU2 is scheduled to be complete in 2022. Both upgrades are included in the TfL Business Plan.

Table 2.1 Service Frequency (Peak Direction), Northern line, at Kennington station, 2014 and 2022

	Time Period	Total Charing Cross branch frequency	Total Bank branch frequency	Total trains terminating at Kennington (Charing Cross branch only)	Total trains terminating at Morden (Charing Cross branch only)
NLU 1 - assumed 2014 to 2022	AM Peak hour	24	24	16	8
	Inter Peak hour	20	20	20	0
NLU2 - assumed post 2022	AM Peak hour	30	33	30	0
	Inter Peak hour	24	24	24	0

Source: TfL

2.8 The NLE will be served through the extension of Charing Cross branch trains from Kennington to Battersea. The assumed frequency provided on the NLE will be 16 tph in the AM and PM peaks and 20 tph in the inter-peak with NLU1. This is because in the AM peak some trains on the Charing Cross branch will continue to Morden, whereas in the inter-peak all Charing Cross branch trains will terminate at Battersea.

2.9 With NLU2 in place, it is assumed that the frequency on the NLE will increase to 28 tph in the AM and PM peaks and 24 tph in the inter-peak[8]. The remaining 2tph in the peak periods will continue to use the Kennington loop rather than extend to Battersea.

2.10 Table 2.2 summarises the NLE frequencies assumed.

Table 2.2 Assumed NLE Service Frequencies

Year	Peak Period (Trains Per Hour)	Off-Peak Period (Trains Per Hour)
2020 (Opening Year)	16	20
2022 (Post NLU2)	28	24
2031 (End-state)	28	24

[8] The NLE has been designed to enable a frequency of at least 28 tph to be run. This is to enable the most efficient operation of the extension as part of the existing northern line and to ensure that it is compatible with the forthcoming line upgrades. The actual train service run will depend on demand and TfL's standard network planning process

2.11 The proposed NLE service pattern for the 2031 peak and inter-peak hours is presented Figure 2.2 and Figure 2.3 respectively.

Figure 2.2 NLE AM Peak Hour Service Pattern, 2031

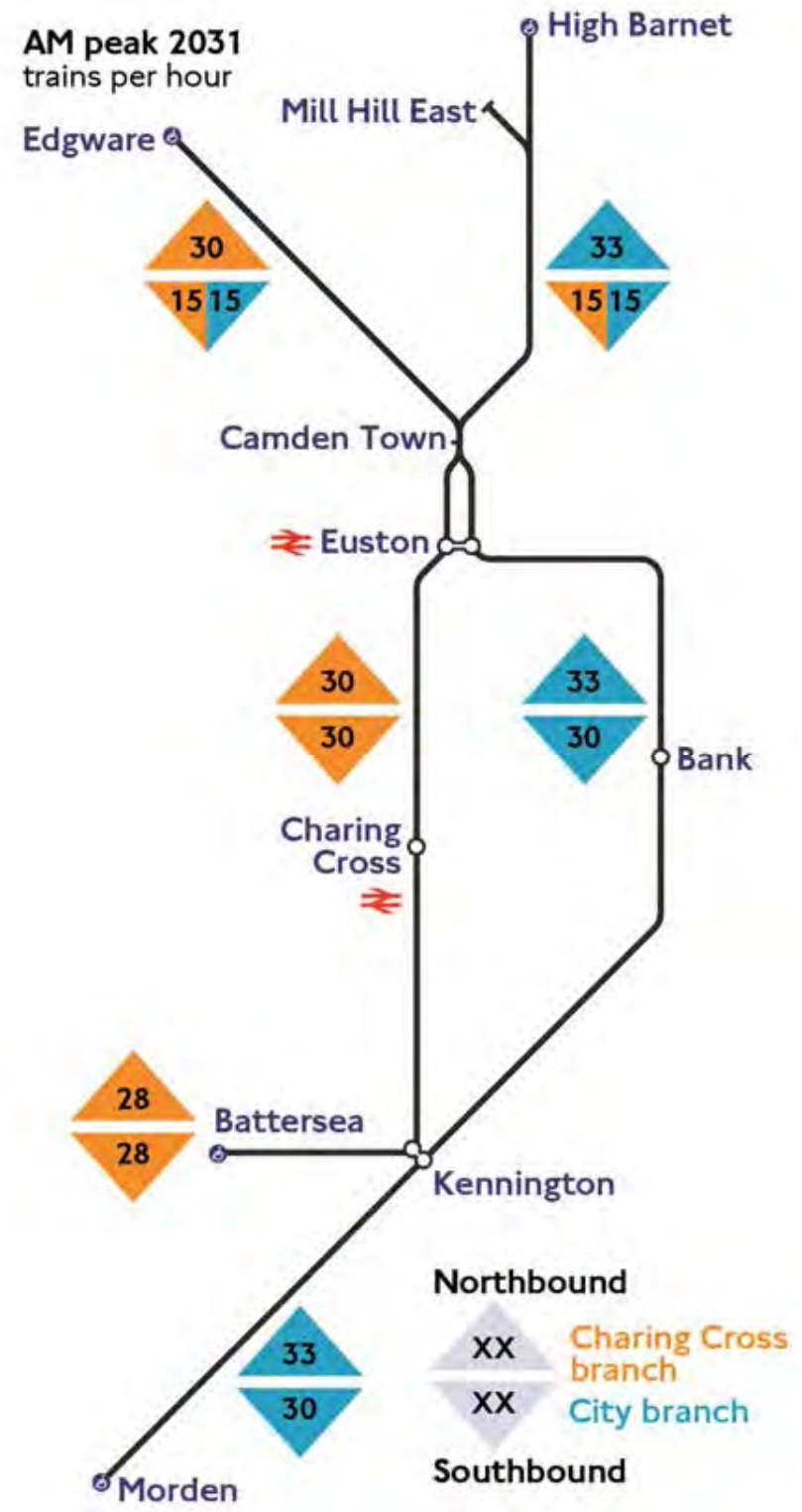
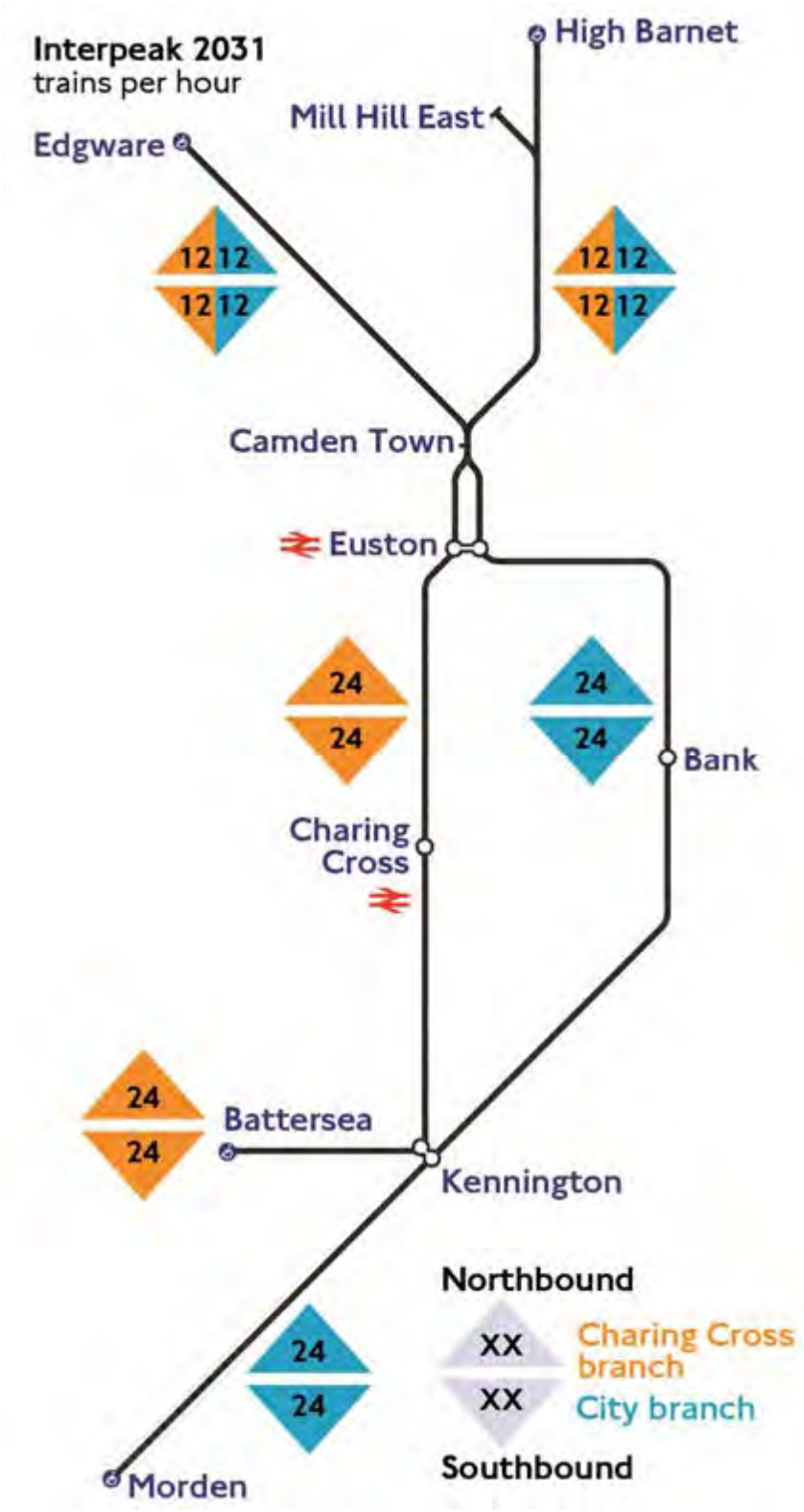


Figure 2.3 NLE Inter-peak Hour Service Pattern, 2031



NLE Journey Times

2.12 The expected journey times on the NLE are set out in the Table 2.3 below. These are based on the latest analysis undertaken by London Underground (LU) in March 2013.

Table 2.3 NLE Journey Times

Direction	From	To	AM Peak (mins)	Inter-Peak (mins)	PM Peak (mins)
Inbound	Battersea	Nine Elms	2.3	2.2	2.3
	Nine Elms	Kennington	3.3	3.3	3.3
Inbound Total			***5.5***	***5.4***	***5.5***
Outbound	Kennington	Nine Elms	3.5	3.3	3.5
	Nine Elms	Battersea	2.1	2.1	2.1
Outbound Total			***5.5***	***5.4***	***5.5***

Source: London Underground

NLE Scheme Costs & Funding

Capital Costs

2.13 The cost of the scheme is estimated at £868.3m in 2012/13 prices as set out in the Estimate of Costs[9]. When future inflation is factored in, this becomes £998.9m in out-turn prices, as presented in the Funding Statement[10]. The breakdown is presented in Table 2.4.

2.14 Table 2.4 also shows the present value of the capital costs employed in the economic appraisal. This is the real cost in 2010 prices (i.e. with background inflation stripped out) discounted at 3.5% per annum into present values.

2.15 The funding and appraisal costs include a Risk Contingency[11], estimated at 22% of the infrastructure costs. The overall level of estimating contingency included in the capital cost is £150.7m in out-turn prices.

[9] Northern Line Extension (NLE), Transport and Works Act Order Application – Estimate of Costs (April 2013)

[10] Northern Line Extension (NLE), Transport and Works Act Order Application – Funding Statement (April 2013)

[11] The Risk Contingency takes into account of the potential variation when estimating construction costs

2.16 In line with TfL guidance, a Quantified Risk Assessment (QRA)[12] process has been undertaken and additional risk provision has been included within the estimate used for this economic appraisal.

2.17 The inclusion of the QRA P50[13] value and optimism bias[14] results in the total costs employed in the economic appraisal £809m in 2010 discounted present value.

Table 2.4 NLE Capital Costs (£m)

Cost element	Base Cost Estimate	Funding Requirement	Cost used for Appraisal
	£m 2012/13 prices	**£m out-turn prices**	**£m 2010 discounted Present Values**
Infrastructure	582.2	663.1	457.5
Vehicles and Stabling	67.8	87.1	61.3
Land costs	22.5	23.8	18.8
Other (Design and project management, TfL resources, insurance)	67.7	74.0	56.0
Risk Contingency	128.1	150.7	101.2
QRA P50 and Optimism Bias (Appraisal only)	0	0	114.1
Total Capital Costs	***868.3***	***998.9***	***809.0***

2.18 The capital costs of the scheme will initially be financed by the public sector but funded and paid back, over time, by the private developments in the VNEB OA. The development will fund the NLE through incremental business rates levied on the Enterprise Zone and through developer contributions, Section 106 and the Community Infrastructure Levy (CIL). The economic appraisal has been presented based on the full cost of the scheme, but in addition looks at the cost to the public sector only (both are presented in Chapter 4).

[12] A QRA assesses the probability of a range of risks and the estimated financial impact of the risk materialising.

[13] A P50 QRA cost means that there is a 50% likelihood that the final cost will be at or lower than the QRA cost.

[14] As per TfL's Business Case Development Manual (BCDM) guidance, the optimism bias is the difference between the QRA P80 risk and P50 risk. This adds an additional 11% to the scheme cost for appraisal purposes only.

Operating and Maintenance Costs

2.19 The forecast annual incremental operating and maintenance costs of the scheme, based on the 2031 service frequency assumptions (28 peak and 24 off-peak trains per hour) are presented in Table 2.5.

Table 2.5 NLE Operating and Maintenance Costs (Annual £m)

Cost Element	Cost £m p.a. (2012/13 prices)	Cost £m p.a. (Q1, 2010 prices)
Maintenance Costs	4.71	4.38
Train Operators	2.74	2.55
Station Staffing	1.40	1.30
Total	***8.84***	***8.22***

2.20 Renewal costs have been estimated by London Underground (LU) based on benchmarked costs for relevant renewal activities. This includes all life-cycle and renewal costs over the 60 year appraisal period. The total renewal costs assumed in the appraisal is £217m in 2010 prices, or £87m in 2010 discounted present values.

2.21 The detailed breakdown of scheme costs is provided in Appendix A.

3 The Strategic Economic Context

3.1 This chapter sets out the aims and objectives of the NLE, and it then considers the strategic economic context that forms the basis for this assessment.

NLE Scheme Objectives

3.2 As laid out in the Concise Statement of Aims15, the primary aim of the NLE[16] is to facilitate the sustainable growth and development of the Vauxhall Nine Elms Battersea (VNEB) Opportunity Area (OA) and thereby encourage economic growth in London and the wider UK economy, through the creation of a major new sustainable business, residential, and leisure district within London's Central Activities Zone (CAZ).

3.3 The CAZ is a London Plan designation covering London's Government, business, commercial and cultural / entertainment hub, which is at the heart of London's role as a world city and global business location.

3.4 The Concise Statement of Aims shows both this central aim and secondary aims for the project, reflecting the goals of the Mayor's Transport Strategy, as follows:

- **Support economic development and population growth** - By enabling the sustainable regeneration and development of the VNEB Opportunity Area, the NLE will catalyse the creation of 16,000 new homes and up to 25,000 new jobs. In addition, it will enhance access to employment for local people in the surrounding area and integrate the VNEB Opportunity Area with the remainder of central London.
- **Enhance the quality of life for all Londoners** - As part of a wider package of transport and urban realm improvements, the NLE will bring economic and accessibility benefits to a wide area, including the existing and new communities around the proposed stations.
- **Improve the safety and security of all Londoners** - The Underground is a safe and secure transport mode whilst stations provide safe and attractive meeting-points: the new stations at

[15] Northern Line Extension (NLE), Transport and Works Act Order Application – Concise Statement of Aims, April 2013

[16] Northern Line Extension (NLE), Transport and Works Act Order Application – Concise Statement of Aims, April 2013

Battersea and Nine Elms will be modern, well-designed landmarks which will be integrated with high quality urban realm, benefiting new and existing communities in the area.

- **Improve transport opportunities for all Londoners** - The NLE will transform accessibility across the VNEB Opportunity Area and deliver standards available elsewhere in central London, assisting and complementing London's transport network. Both new stations will be step-free from street to train and will significantly enhance transport accessibility to all by creating new high quality access points to the Underground network.
- **Reduce transport's contribution to climate change and improve its resilience -** The Underground is a sustainable transport mode and the NLE will be constructed to the most up-to-date design and environmental standards. The NLE will contribute to making the area more typical of central London in terms of providing alternatives to car travel.

The Relevance of London and its Central Activity Zone

London

3.5 London is the UK's only global centre, accounting for over a fifth of the country's total output as measured by its Gross Value Added (GVA). At the same time, the number of employees in London is only 16% of total employment in the UK, highlighting the high productivity of the city's employees compared to other parts of the country.

3.6 Over the past few decades, London has seen increasing levels of employment and economic activity. Between the early 1990s and 2013, the capital has seen an increase in over 1 million jobs, and current employment levels are now above the previous peak of 2008. The projections published in 2013 by the GLA suggest that London's population aged between 16 and 64 (working age population) will increase from 5.7 million in 2011 to over 6.6 million by 2036. Meanwhile, the number of jobs in London is expected to increase from 4,896,000 in 2011 to 5,757,000 in 2036[17].

3.7 This equates to annual average growth of just over 35,000 jobs per year and results in over 850,000 more jobs in London by 2036. These projections rest on the pattern of growth exhibited by particular business sectors and underlying productivity trends. The employment growth expected is largely in services and office based activity.

[17] Based on the projections of the Greater London Authority.

3.8 These latest projections show the strength of the London economy, where employment has stood up well to the stress of the recent recession. Indeed, the loss of economic output was less than during the 1990s recession and is now estimated to be only 1% below the previous peak, while employment has already passed the previous peak level.

3.9 The latest employment projections published by the GLA show that the forecast pace of growth over the next twenty years will continue, on average, at the same rate as it has been over the past twenty years.

3.10 Previous employment projections based on a similar methodology have provided good results, being broadly correct in identifying trends. These long term forecasts do not attempt to identify cycles, so are sometimes too low and sometimes too high on a year by year basis.

3.11 Two-thirds of these jobs are expected to be generated in the boroughs of Inner London and a quarter in the three most central boroughs of Westminster, Kensington and Chelsea and the City of London.

3.12 This analysis takes into account not just output projections but a view of site availability and transport connections. It therefore incorporate constraints as well as opportunities. The projections themselves depend on releasing policy constraints where necessary, including the development of Opportunity Areas such as VNEB.

The Central Activities Zone

3.13 The Central Activity Zone includes the whole of the City of London and the majority of the City of Westminster and much of the Royal Borough of Kensington and Chelsea. It also includes parts of other Inner London boroughs including , Islington, Camden, Lambeth, Southwark and Wandsworth. It is shown in Figure 3.1, where the area of study, VNEB, is also highlighted.

Figure 3.1 London's Central Activities Zone (VNEB Highlighted in Red)

3.14 The importance of the Central Activities Zone to the economies of London and the UK as a whole is highlighted through its contribution to overall output. While GVA data is not available at a district level, it is available for slightly larger regions, designated as NUTS3 across the EU. In Inner London, it is broken down by Inner London East and Inner London West.

3.15 As shown in Table 3.1, Inner London as a whole accounts for 70% of London's GVA (or 15% of the UK's total) and over 65% of the output in Inner London is due to Inner London West. However, Inner London East has been catching up with its share of Inner London's output rising from 32% to 35% over the past ten years, much of which came through a boost in productivity related to the growth of Docklands, where significant transport improvements have taken place, including the last significant tube extension in central London, the Jubilee line extension.

Table 3.1 Output Shares and Productivity Levels

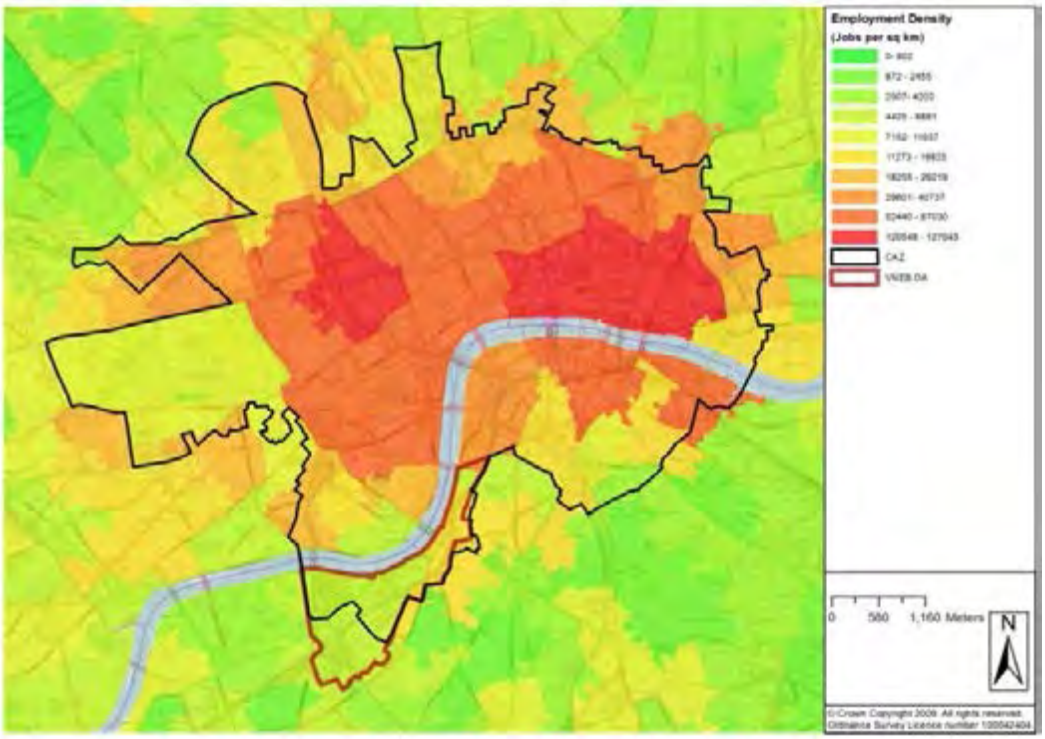
	GVA Total, £ millions	Share of Total, %
Inner London - West	127,730	45.1
Inner London - East	67,359	23.8
Inner London Total	***195,090***	***68.9***
Outer London - East and North East	23,704	8.4
Outer London - South	20,679	7.3
Outer London - West and North West	43,499	15.4
Outer London Total	***87,882***	***31.1***
Greater London	***282,971***	***100***

3.16 In terms of relative productivity improvements in the period 2001 to 2011, Inner London East was the second best performer out of all NUTS3 regions in the country and Inner London West ranked in fourth place.

3.17 While Inner London is not strictly the same as the CAZ, the boundaries of the latter are all contained within Inner London boroughs so it closely reflects the importance of the CAZ. Employment in the CAZ accounts for half of Inner London's total.

3.18 It also has more productive jobs than the other parts of Inner London, with the City of London and City of Westminster generally designated as the most productive districts in London and the country as a whole. Indeed, the designation of London's CAZ is intended to relate to the area with the greatest economic activity. Figure 3.2 shows that the CAZ is characterized by a considerably higher density of employment than its hinterland.

Figure 3.2 Employment Density of Central London



3.19 The VNEB area is, however, conspicuously less densely occupied than much of the rest of the CAZ, with the exception of the parks. This is not surprising, given its lack of accessibility and its dereliction over a number of years.

3.20 Density of occupation is associated with higher wages and higher productivity. Below a threshold, earnings do not respond to the level of activity but as it rises, earnings rise too. This in turn enables the provision of better facilities and higher rents. Indeed, the evidence of higher productivity in parts of Inner London East such as Canary Wharf shows the potential for a similar transformation in the VNEB OA.

The VNEB Opportunity Area

VNEB OA in the London and CAZ contexts

3.21 The GLA's Opportunity Area Planning Framework recognises the scale of the development opportunity in central London and sets out the land use scenario for the VNEB Opportunity Area:

- 200,000 sq.m. of mixed use development, including 16,000 additional dwellings;
- 60,000 sq.m. of retail;
- 160,000 sq.m. of new office; and

- 80,000 sq.m. of other employment-related uses at Battersea.

3.22 This mixed use development is forecast to provide an additional 16,000 homes and create an additional 20,000-25,000 new jobs within the OA. The employment target for the VNEB OA as stated in the VNEB OAPF represents a significant but achievable contribution to London's projected employment growth, being a little less than one year's growth in employment requirement at the London level.

3.23 London's employment growth over the past decades has been accomplished through a combination of increasing the density of the existing CAZ and pushing out its boundaries. More tall buildings have been built but fringe areas have been brought into higher density occupation as capacity became constrained in the core part of the CAZ. Given its proximity to the core part of the CAZ and its capacity for high density development, VNEB represents a valuable opportunity for the further expansion of the CAZ.

3.24 The first such expansion was to Canary Wharf and to Broadgate at Liverpool Street. More recently, Paddington Basin and the King's Cross/St Pancras redevelopments have created new business centres closer to central London. The redevelopment of Earls Court, and the spread of high tech around Old Street is adding to the sense that the fringe is being incorporated.

3.25 South of the river, there are successful developments along the water front from Tower Bridge (More London) through to a revitalised South Bank. The VNEB area fits into this trajectory. It is noticeable that all of the sites mentioned are close to transport hubs. Mainline termini and good interchange make it easier to exploit agglomeration benefits and thus in turn attract investors.

3.26 By contrast, Canary Wharf and the expansion of Docklands have required an extension of transport connections to create the capacity needed to make possible this high density development. Studies have analysed the impact of the Jubilee Line Extension (JLE) which serves Docklands, which show how development has intensified around its stations, creating both employment and residential opportunities[18]. Like the NLE, the case for the JLE was based on the development opportunities that it opened up.

3.27 The NLE will increase the accessibility and transport capacity in the area. The Vauxhall interchange exists at one end of the VNEB area,

[18] For example, The Impact of the Jubilee Line Extension (JLE), University of Westminster.

with buses, main line rail, and underground. The NLE makes it possible for people travelling to and from the VNEB area to go direct to central London and through to other parts of London without needing to interchange at Vauxhall. At the western end of the OA are Battersea Park and Queenstown Road National Rail stations.

3.28 Despite additional planned investment, and given the development in the VNEB OA, crowding will exist on NR links in the VNEB OA, and Clapham Junction to London Waterloo is expected to remain crowded, including between Queenstown Road and Vauxhall. While the eastern and western ends of the VNEB OA are served by rail and Underground, the middle section of the OA are comparatively poorly served.

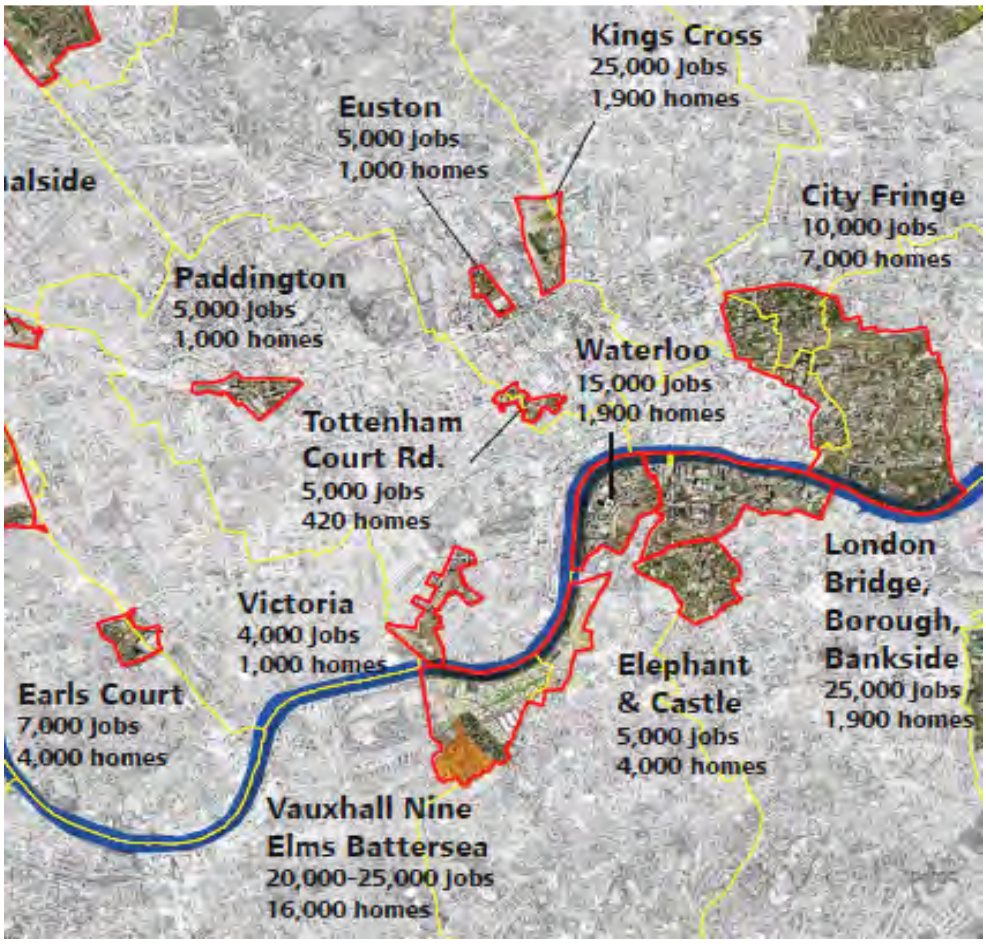
3.29 In the heart of the VNEB area is the Battersea Power Station. This iconic landmark will be a major trip attractor. The King's Cross redevelopment currently underway uses a mix of station architecture, new buildings and refurbished ones to create a location with character. The Power Station is likely to have the same effect.

3.30 In summary, London employment is projected to grow and will need to open up more central London locations will need to be opened up to make this possible. This growth is high productivity, and extending the CAZ will therefore serve to raise average productivity levels. The VNEB OA is central to London's planning policy framework.

3.31 The scale of potential development associated with the VNEB OA and other OAs in central London is shown in Figure 3.3. This shows that, in terms of jobs, the VNEB OA has the potential to deliver a similar number to each of King's Cross and London Bridge/ Borough/ Bankside, both already highly accessible locations, and the potential to deliver more housing than other central London OAs. Overall it is therefore the largest OA in central London.

3.32 The proximity of the VNEB area to central London underpins its strategic role in supporting the growth of the London economy. It is in this context that this assessment is carried out and the assumptions that underpin the analysis are made.

Figure 3.3 Central London Opportunity Areas



Source: London's Opportunity Area Planning Frameworks, Mayor of London/ GLA, September 2011

4 Economic Benefits

4.1 The economic and business case benefits and impacts are underpinned by detailed planning assumptions that reflect the likely economic development impacts of the NLE. The transport modelling of the NLE is based on this future demand and transport schemes that are committed and funded.

4.2 The forecasting of demand and benefits has been based on London Plan forecasts and has used TfL's suite of strategic transport models.

Development of With and Without NLE Scenarios

4.3 A With NLE Scenario has been developed that has been compared against a Without NLE Scenario to estimate the economic benefits and to inform the cost-benefit appraisal. The approach to developing these is described below.

Scenarios - Overview

4.4 The modelling of both the With and Without NLE scenarios reflects the central regeneration and economic development objectives of the scheme, and ensures alignment between the forecast transport impacts of the scheme and its economic benefits.

4.5 These are developed to reflect two key elements that are central to the core regeneration and economic development objectives of the scheme:

- **The NLE is essential to deliver higher density development that underpins the economic growth generated by the VNEB OA.** The NLE will provide the capacity and accessibility required to deliver the higher density development in the VNEB OA that will fulfil the growth objectives for the area. Accordingly, a Without NLE Scenario with a lower level of development and a With NLE Scenario that reflects the additional development enables by the With NLE Scenario has been developed.
- **Delivering higher development density in the VNEB OA will deliver additional growth (jobs and productivity) at the London-wide & UK level.** Opportunity Area policy has been developed not just to deliver local regeneration, but also as the means by which London's wider economic development objectives can be met through the development of brownfield land that is required to support the delivery of London's planned population and jobs

growth. The VNEB OA (along with other central area OAs such as King's Cross) plays a critical role in supporting the expansion of London's CAZ – the NLE provides the necessary transport accessibility that enables the VNEB OA to perform this role.

4.6 As the VNEB planning scenarios assume a higher level of jobs and population in the VNEB area with the NLE (as shown in Table 4.2 and Appendix B), an assumption needs to be developed for the purposes of the economic and transport modelling about where future jobs (all but the 13% assumed to be 'net additional') would be displaced or redistributed from.

4.7 The central scenario reflects what is considered to represent a likely and realistic scenario in terms of the economic impact of the scheme. This is that the additional VNEB jobs and population would be redistributed from Outer London. This scenario reflects a view of the 'end state' economic activity, as the expansion of the CAZ (facilitated by NLE and the development of the VNEB OA) supports the long-term trend for higher-value service based firms to increasingly locate in the central area. The scenario reflects the rationale underpinning OA policy in helping enable the CAZ to expand and in supporting the overall expansion of activity in the CAZ.

4.8 We have also considered a scenario where jobs are assumed to be displaced from both Outer London and the rest of the South East, the results for which are presented at the end of this Chapter.

VNEB OA Development Assumptions

4.9 The central assumptions outlined above have informed the development of the scenarios that underpin the business case for the scheme. Two development scenarios (a With NLE Scenario and a Without NLE Scenario) for the VNEB OA are considered for each of the 2020 and 2031 forecast years.

4.10 The development scenarios rest on both planning and transport system analysis. An original study which informed the OAPF showed which development scenarios could be supported with and without significant additional investment. At that time, a set of scenarios were established to guide the consideration of deliverability and the supporting facilities that would be required. These scenarios included both residential and employment capacity and cover the whole of the VNEB area.

4.11 These initial scenarios are shown in Table 4.1 and indicate the basis for analysis of the accessibility required to enable their delivery. An Option described as Revised Option 5, with 20,000-25,000 new jobs and 16,000 new homes was identified as the preferred option. The transport analysis conducted showed that this scenario could not be delivered without the NLE, without which their judgement was that only Option 2 could be delivered.

Table 4.1 Original Development Scenarios

Development Scenarios	Number of Jobs	Number of Homes
Option 1 – Low Density Residential	8,000	4,200
Option 2 – Medium Density Residential	8,000	8,500
Option 3 – High Density Residential	8,000	16,000
Option 4 – High Density Residential and Retail	12,000	16,750
Option 5 – High Density Residential, Retail and Office	27,000	16,750
Revised Option 5 – High Density Residential, CAZ Frontage and Office	25,000	16,000

Developments in the VNEB OA

4.12 Since the initial studies relating to potential at the VNEB OA, a number of developments have come forward and have subsequently been approved by the relevant planning authorities. Quod carried out a review of planning applications on submissions up to February 2013. This review considered the baseline assumptions of population and employment associated with consented planning applications as at January, 2013.

4.13 Across the VNEB area, there are over twenty five sites that have been the subject of planning applications. As a result, many of these have been subject to transport and environmental assessments as part of their planning application, and been reviewed by the local planning authorities, the GLA and TfL. In addition, the planning authorities are aware of a number of other sites that are likely to come forward for development in the relatively near future. These sites have all been reviewed by Quod and are outlined in Appendix B.

4.14 Together, these sites have capacity for over 18,000 new homes and an increase of 24,000 new jobs. These figures are broadly similar to those in the "Revised Scenario 5" shown in Table 4.1 above, namely 25,000 new jobs and 16,000 new homes.

4.15 Quod also carried out a review of the application documents, planning committee reports, GLA reports, S106 agreements and planning conditions to understand the extent to which they are related to, or dependent on, the NLE coming forward.

4.16 This review found that the only scheme that includes a condition that is specifically tied to the NLE is Battersea Power Station. The consent includes a Grampian Condition which means that only phase RS-1 and the residential areas within the Power Station can be built prior to the implementation of the NLE. The remaining phases of the development therefore cannot come forward under the current consent without the NLE.

4.17 Without the NLE the following components of the BPS site cannot come forward:

- 2,419 residential units;
- 160,932sqm (GEA) of Business (B1);
- 51,348sqm (GEA) of Retail (A1/A2);
- 32,292sqm (GEA) of Serviced Apartments (C1);
- 21,638sqm (GEA) of Hotel (C1);
- 16,149sqm (GEA) of Community and Culture (D1) and Assembly and Leisure (D2);
- 15,789sqm (GEA) of Event and Conference (D1/D2); and,
- Various other Food and Drink, Leisure and Culture floor spaces.

4.18 Elements of the BPS scheme that can proceed without the NLE (all of phase RS-1), include:

- 847 residential units (incl. student housing);
- 5,866sqm (GEA) of Hotel (C1);
- 5,641sqm (GEA) of Community and Culture (D1) and Assembly and Leisure (D2);
- 2,2778sqm (GEA) of Food and Drink (A3/4/5); and,
- 1,840sqm (GEA) of Serviced Apartments (C1).

4.19 From this assessment, it is clear that the majority of the BPS scheme is tied to the NLE. Of particular note is the quantum of employment space that is subject to the delivery of the NLE, which would generate over 13,000 jobs. Without the NLE, the consented employment space, primarily Food and Drink, Hotel and Community / Culture space, would generate 273 jobs. Similarly, 2,400 homes could not be built without the NLE.

4.20 In addition to the planning condition there are also constraints on the viability of BPS without the NLE. The site has a troubled history, with a number of consents having been granted but not implemented.

4.21 For the current planning application, the NLE is particularly important to securing office tenants and to ensuring the retail centre is able to function properly.

4.22 The level of VNEB development with and without the NLE is thus based on the following:

- The Without NLE Scenario includes all consented development up to February 2013.
- The With NLE Scenario includes all consented development (as per the Without NLE Scenario) plus:
  - Additional development at Battersea Power Station that is dependent on the NLE
  - Additional housing and employment associated with remaining (i.e. currently unconsented) development sites that would be more likely to come forward with the NLE.

4.23 Further details about this process can be found in Appendices D and E Further information about the status of these development sites can be found in the Environmental Statement documentation[19].

4.24 The total development in the With NLE and Without NLE scenarios is presented in Table 4.2. It should also be noted that many of the consented schemes included in the Without NLE Scenario have, in fact, been consented on the assumption that the NLE would come forward. For example, the Wandsworth Planning Committee Report for Riverlight Tideway and Market Towers states that:

"The Northern Line Extension (NLE) is inextricably linked to the development of the Opportunity Area and the densities proposed may not be sustainable without such a mass transport system"

4.25 The scenarios are likely to be conservative in that it is assumed that all the consented sites will be completed even if the NLE does not come forward and only the capacity of the currently unconsented sites is additional.

[19] Northern Line Extension (NLE), Transport and Works Act Order Application - Environmental Statement Volume I Chapter 2

Table 4.2 Additional VNEB Development – with NLE vs. Without NLE Scenarios

	Employment (Jobs)	Homes (Units)	Population (People)
VNEB Development Without the NLE	9,822	12,778	22,647
of which BPS Phase 1	*273*	*847*	*2,030*
Additional BPS Development with NLE	13,086	2,419	5,795
Remaining Sites assumed to come forward with NLE	937	3,168	5,924
Total additional VNEB Development with NLE	***14,023***	***5,587***	***11,719***
Total VNEB Development with NLE	***23,845***	***18,365***	***34,366***

4.26 The availability of the Northern Line Extension will therefore enable an additional 14,000 jobs at standard density assumptions for this type of development.

4.27 An equivalent exercise has been undertaken for the 2020 opening year. This has been undertaken by looking at the 2031 'end state' development and using available information on phasing to assess the proportion of development in place by 2020. In 2020 the total level of development is significantly lower, and there is only a small difference in the level of development between the With NLE and Without NLE scenarios.

4.28 More information on the development of both the 2031 and 2020 VNEB area planning assumptions is provided in Appendix B.

Assessing the Benefits of the NLE

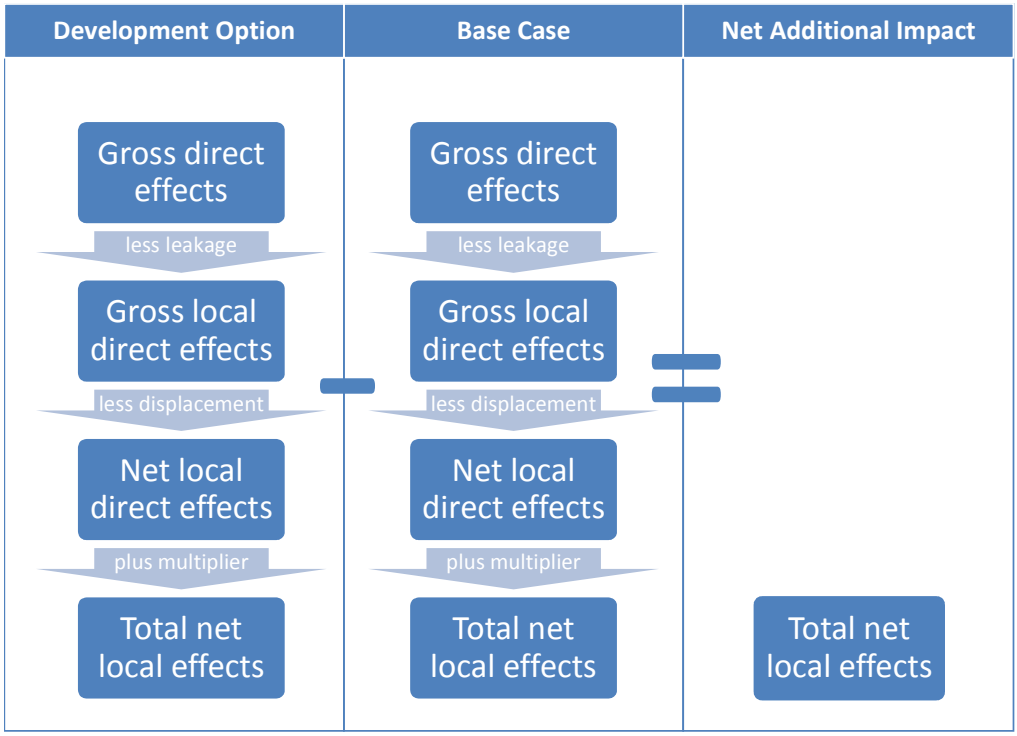
4.29 The NLE allows an increase in the density of development in the VNEB OA, allowing an additional 14,000 jobs to be generated. An initial valuation of these can be undertaken using the guidance developed by English Partnerships for DCLG. This takes the output that would be created by such an addition to employment and then adjusts it for the potential for such additions to be displaced from elsewhere. The guidance includes rules for estimating such leakage.

4.30 The key components of the methodology for assessing the additional impact of interventions include the following:

- **Direct effects** - an estimate of the overall impacts of implementing a certain scheme, including immediate, consequential and induced effects;
- **Leakage effects** - an estimate of the effects on those outside of the target area. These should be deducted from the direct effects at the assumed proportion of leakage for each case. It is important to note that impacts outside the target area should not be ignored, but must contain the caveat that they are not related to the desired area;
- **Displacement effects** - an estimate of those impacts that are transferred from elsewhere within the target area. These should be deducted from the direct effects at the assumed proportion of displacement for each case;
- **Substitution effects** - when one activity is a replacement for a similar one. Impacts which have been substituted should be deducted from the direct effects. For example, when an employee is hired but another loses their job; and,
- **Multiplier effects** - activity associated with additional local income, local supplier purchases and longer term development, such as through supply chains and expenditure on other activity. These need to be added to the direct effects.

4.31 These are summarised in Figure 4.1.

Figure 4.1 Detailed Overview of the Methodology (Adapted from the Additionality Guide)



4.32 It is not necessary that every intervention (or development) encompasses all of these effects. Instead, the English Partnership's guidance allows for the identification of the effects that are relevant to the specific intervention.

4.33 The detail of these calculations are shown in Appendix D, The results show that the gross value of the additional jobs in the With NLE Scenario is around £1.3 billion per annum. Allowing for displacement and multiplier effects as set out in the English Partnership Guidance, the With NLE Scenario delivers a net additional value of £400 million per year over the Without NLE Scenario – once displacement and multiplier effects are accounted for. This is equivalent to a Present Value of £6.7 billion to the London and UK economies over a 60 year period discounted at the rates set out in Treasury Guidance of 3.5% for 30 years and 3% thereafter.

4.34 The displacement estimate used for this investment is taken to be 'high' in the guidance. This means that some 25% of the jobs are taken to be additional.

4.35 In subsequent analysis a more conservative assumption has been used, in conjunction with DfT guidance on treatment of economic benefit. This is based on an estimate of the scale of Foreign Direct Investment (FDI) . On this basis, 13% of the jobs are taken to be additional.

4.36 The significance of FDI is twofold. First of all, London is one of the world's leading cities and the UK's major global investment location. A recent report by Ernst & Young[20] showed that FDI projects in London accounted for 45% of total foreign investment in the UK in 2012. In addition, when stripping out reinvestments into existing projects - that is taking only new investments – London's share of total FDI projects in the UK rises to 60%. This is the highest of any European region. In total, notwithstanding cyclical fluctuations, FDI is worth around £52 billion a year to the capital, accounting for over a quarter of its economy.

4.37 FDI is a major consideration when assessing potential tenants for the completed VNEB OA development. Therefore, it is reasonable to expect FDI to follow previous patterns and lead to additional jobs being created, on top of those already established in London.

[20] Ernst & Young's Attractiveness Survey, UK 2013, No Room for Complacency

4.38 Second, decisions on FDI are primarily made on a range of factors, including:

- The size of the economy;
- The strength of the business environment;
- The availability of skills;
- The availability of well-connected land/office space; and, importantly,
- The quality of infrastructure.

4.39 The NLE is and VNEB OA developments are likely to improve all of these factors making it an essential part of the CAZ and increasing the attractiveness of the area (and the CAZ as a whole) as an FDI location.

4.40 The VNEB area has the potential to provide many of these qualities. For a start, it has a large and well-educated workforce nearby. What's more, following the construction of the NLE, it will have the necessary excellent accessibility (as measured by PTAL) and a location with high employment density and strong business presence. VNEB can also work with other fringe CAZ developments to enhance London's central offering. In addition to this, VNEB is likely lead the way internationally on a number of criteria:

- it will be a part of the London's CAZ, and therefore of somewhere which is recognised worldwide as a leading city in which to do business;
- it will provide a large space in a newly developed area, allowing businesses that invest there both the physical space they need and the chance to help shape the future characteristics of the area; and,
- it will allow businesses the opportunity to be associated with the world-famous Battersea Power Station, the new US Embassy and New Covent Garden Market in the new modern and high-quality environment that will be created there.

4.41 Using this information, the best figure used to reflect the central assumption of net additionality has been determined. This is fundamentally through the number of jobs that are generated by FDI in London.

4.42 Research by Cushman and Wakefield[21] and relied upon by Think London[22] has shown that London has the highest levels of FDI of any city in the world, reflecting its importance to the city's economy. FDI has been a key driver of economic growth in London, generating 42% of the city's economic growth between 1998 and 2004, as well as 29% of its increase in earnings and the majority of its new jobs. Overall, FDI has generated more than 500,000 jobs, or 13% of all employment, in the city.

4.43 Accordingly, for the central scenario, a figure of 13% is considered to be an appropriate estimate for the proportion of net additional jobs in the VNEB OA due to the NLE. Sensitivity tests around this assumption, at 0%, 5% and 20% of net additional jobs, are presented later in this Chapter.

Wider Economic Benefits

4.44 A different route to considering the benefits of the NLE looks at the role of transport systems in economic development. This goes beyond the standard transport appraisal methodology that are described in the DfT guidance, and which is considered in the next section. These are typically used to value the benefits of time savings, frequency improvements, and reductions in delays and accidents to users as a result of improvements to an investment in transport infrastructure.

4.45 If perfect markets existed, these methods would be able to fully capture any and all benefits brought about by development. However, since real world scenarios do not involve perfectly competitive conditions, we must explore other appraisal methods to ensure schemes' full economic benefits are captured. Wider Economic Impacts (WEIs) were developed by the DfT to serve this purpose.

4.46 Guidance from the DfT on WEIs is intended to quantify the potential economic impacts of transport improvements upon business and workers' productivity and the resulting increase in output. WEIs are completely additional to standard transport user benefits. Accordingly, including WEIs in the appraisal of a transport scheme can therefore substantially adjust the Benefit to Cost Ratio (BCR) of a project.

4.47 There are a variety of WEIs, including:

- Pure Agglomeration;
- Move to More Productive Jobs (M2MPJ);

[21] Cushman and Wakefield (2011) Winning in Growth Cities 2011/12

[22] London Focus, Think London, 2006

- Increased output in imperfectly competitive markets; and,
- Improved labour force participation.

4.48 Experience of other transport projects shows that the first two of these impacts are the most significant and are the focus of analysis.

- **Pure Agglomeration:** The concept of 'effective density' is a measure of the employment density of a place and the other places around it, scaled by the distances between them. Effective density can increase either because employment increases or because distance between places decreases. There is a positive relationship between effective density and productivity. Therefore if a scheme results in increased effective density, this increases productivity in the place, leading to 'pure agglomeration' benefits.
- **Move to More Productive Jobs (M2MPJ):** This relates directly to transport investment which results in additional capacity on an already constrained route. This will enable more workers to access city centre jobs where they will be more productive.

Pure Agglomeration

4.49 'Pure agglomeration' values the productivity benefits of firms being 'effectively' closer together. Firms can be effectively closer together both through more jobs being created in a productive location and by improving accessibility around and between jobs. Pure agglomeration is a small improvement in productivity applied to large amounts of (existing and new) employment.

4.50 Agglomeration manifests itself in high densities of employment in advanced, knowledge-intensive sectors such as professional, financial and business services, design, science and creative industries. These act in support of other sectors and also generate trade and international activity as these are sectors in which the UK trades more heavily than other countries.

4.51 High density development is dependent on good accessibility. This is partly because of the need to create effective labour markets, but also the need to connect to customers and suppliers.

Move to More Productive Jobs (M2MPJ)

4.52 M2MPJ measures the productivity benefits of existing workers being able to move into more productive forms of employment as a result of a transport investment. In order to estimate any benefits that result from existing workers moving into more productive forms of employment, we measure where workers would be located and how

productive they would be both with and without the transport investment.

4.53 As the title implies, the analysis crucially assumes that the workers relocate from a job where they were less productive to a job where they are more productive. This means that this values the net increase in productivity of a worker and does not allow for any of the jobs to be completely new, or gross. In essence, M2MPJ is a large improvement in productivity applied to a relatively small number of workers.

Further information about these concepts and their estimation are set out in Appendix D.

Modelling of Transport Benefits and Impacts

4.54 Turning to the transport benefits, TfL has a long-established suite of integrated models that are employed to inform policy and assess the impacts of major transport schemes and policies in London.

4.55 For the NLE, strategic modelling has been undertaken using the London Transportation Studies (LTS) model. This model is underpinned by representations of the demand-side (population, employment, floor space) and supply side (public transport and highway networks).

4.56 The planning inputs for the two forecast years (2020 and 2031) are based on GLA population and employment forecasts. The forecasts are based on two forecast years, 2020 and 2031. The 2020[23,24] forecast shows demand and benefits shortly after opening and the 2031 forecast represents the 'end-state' level of development in the OA. The planning inputs have been refined at a detailed level to better reflect the VNEB area assumptions described above, and to reflect the displacement assumptions that underpin the With NLE Scenario.

4.57 LTS adopts the traditional 4-stage modelling approach process comprising trip generation, distribution, mode choice and assignment. The key output of LTS is demand matrices that provide the demand inputs into TfL's established public transport model (Railplan), and the Central London Highway Assignment Model (CLoHAM). These

[23] The first full year of NLE operation is 2020. However, TfL's strategic modelling includes forecast years for each 5-year period up to the London Plan horizon year of 2031. A first forecast year of 2021, with 2020 data for the transport network and OA population and employment levels has therefore been selected as the best representation of the scheme opening year.

[24] A detailed review of planning information was undertaken to determine the level of development that is likely to materialise by 2020. Further information about the planning assumptions is set out in Appendix B.

models are used to estimate the public transport benefits and impacts of the NLE.

4.58 Both the public transport and highway models include funded and committed schemes for each future year. These include schemes such as Crossrail, London Underground upgrades and train lengthening. The 2020 forecast year assumes that only NLU1 is completed (see Chapter 2) and NLU2 is assumed to be in place from 2022, so is represented in the 2031 future year scenario.

4.59 In addition, specific network enhancements in the VNEB area are also included in both the With and Without NLE scenarios. These include station upgrades at Vauxhall LU and NR stations (which are committed and funded) and the provision of local bus enhancements to provide additional capacity and accessibility to serve the planned development. These improvements are consistent with the recommendations contained within the OAPF.

4.60 The economic and business case uses forecasts for two time periods - morning peak and inter-peak. The only difference between the Without NLE Scenario and the With NLE Scenario networks is the addition of the NLE. The NLE has been coded within the transport models on the basis of the service pattern, frequency and journey time assumptions set out in Chapter 2.

4.61 Further information on the public transport and highway models can be found in Appendix C.

5 Cost Benefit Analysis

Approach to Cost Benefit Analysis

5.1 Cost benefit analysis is an approach used to assess the overall value of proposals, and critically to establish whether the benefit of a proposal justifies its cost.

5.2 Cost benefit analysis is used to inform decisions on public sector investment across a range of activities. The Green Book[25], issued by HM Treasury, provides over-arching guidance on the principles of cost benefit analysis and sets out best practice to ensure consistency of approach across Government departments and agencies.

5.3 The Department for Transport (DfT) issues detailed guidance[26] on the appraisal of transport schemes. This is consistent with the principles of the Green Book. It provides more detail on how to forecast and value transport benefits, while employing the same core assumptions (e.g. use of discount rates, treatment of risk).

5.4 Transport for London also has its own appraisal guidance, the Business Case Development Manual (BCDM)[27], which sets out the process, techniques and parameter values to be used for appraisal of transport schemes in London. The BCDM is broadly aligned with the principles and approach set out in the Green Book and DfT Guidance.

5.5 The economic appraisal has been prepared in accordance with the principles set out in the Green Book. A central assumption is that the NLE will enable additional employment in the VNEB , through enabling the area to develop to CAZ densities, resulting in net additional jobs and output at the London and UK level.

5.6 It is assumed that remaining development that is not additional at the UK level may otherwise take place in Outer London. This is because the growth of CAZ (which accounts for the majority of employment in Inner London) is constrained and the realistic alternative for prospective VNEB businesses would be Outer London. The economic benefits have been estimated on this basis, and sensitivity testing has

[25] The Green Book - Appraisal and Evaluation in Central Government, HM Treasury. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/179349/green_book_complete.pdf.pdf

[26] The guidance is issued on-line as a series of documents (TAG Units) - http://www.dft.gov.uk/webtag/

[27] Business Case Development Manual, Transport for London, 2013

been undertaken to assess the impacts of an alternative job redistribution assumption.

5.7 The assessment of transport benefits reflects both the benefits of the NLE scheme (journey time and accessibility), and also captures the crowding impacts on the wider network associated with the additional VNEB development.

5.8 The estimation of economic and transport user benefits are therefore internally consistent, and the measurement and valuation of transport user impacts is consistent with TfL business case guidance.

NLE Economic Appraisal – Benefits Overview

5.9 The economic appraisal reflects the benefits that the With NLE Scenario would deliver compared to the Without NLE Scenario. There are three main sources of benefit that the NLE will deliver:

- The benefits of **new additional jobs** at CAZ levels of productivity;
- Productivity benefits arising from the economic development impacts of the scheme, through generating jobs at higher level of productivity, known as **Move Towards more Productive Jobs** (M2MPJ) and increasing the productivity of the existing CAZ, known as **Pure Agglomeration**; and
- The **benefits to transport users** in the form of time savings as the NLE improves journey times for a number of movements. The transport analysis also includes the crowding impacts caused by the additional and relocated jobs.

5.10 The assessment of benefits and impacts has been undertaken for the With NLE Scenario compared to the Without NLE Scenario.

Wider Economic Impacts

New Jobs and the Move to More Productive Jobs

5.11 The M2MPJ component of WEIs measures the productivity benefits of existing workers being able to move into more productive forms of employment as a result of a transport investment. In the case of the NLE, the benefits arise from the 13% additional jobs (of the total additional employment in VNEB with the NLE), and the fact that the productivity of jobs in VNEB is higher than if they were to be located in Outer London. In order to estimate any benefits that result from existing workers moving into more productive forms of employment, it measures where workers would be located and how productive they would be both with and without the transport investment.

5.12 This analysis looks at the differential between productivity in other locations where growth could potentially occur and the CAZ. This values the net increase in productivity of the role on the assumption that as many jobs exist as people want and does not allow for there to be any completely new jobs.

5.13 The productivity differential used us that between Inner London and Outer London, since the new development is part of the CAZ. A productivity estimate is not available for CAZ itself, so Inner London has been used, which is a wider area and is therefore a conservative assumption. In essence, M2MPJ is a significant improvement in productivity applied to a relatively small number of workers.

5.14 On the basis that the VNEB will become part of CAZ when the NLE is in place, the new jobs in the VNEB OA are assumed to have productivity index equivalent to Inner London. A sensitivity test has also been carried out using the productivity index of LB Wandsworth. More information can be found in Appendix D.

5.15 The estimate of these benefits, on a present value basis is £4.1bn, including the element for Foreign Direct Investment.

Agglomeration Impacts

5.16 The WEI 'Pure agglomeration' values the productivity benefits of firms being 'effectively' closer together. Firms can be effectively closer together both through more jobs being created in a productive location and by improving accessibility around and between jobs. Pure agglomeration is a small improvement in productivity applied to large amounts of (existing and new) employment.

5.17 The benefits of high density locations in central locations (such as VNEB) are generally described as agglomeration. One way to think about this is through the ability to generate economies of scale and develop businesses in new markets. Although most firms are small, London firms are bigger than the average in the UK. Alongside this, is the ability to be efficient in business, generate new ideas and create knowledge transfer.

5.18 Finally, a larger labour market is more likely to match jobs effectively with workers and a larger market will also be more competitive. All of these themes explain why larger centres are more likely to be more productive. Indeed, as a centre grows it will increase the productivity of existing members as well as offer opportunities to new entrants.

5.19 The argument for the importance of agglomeration was put forward and accepted as part of the case for the investment in Crossrail, because Crossrail enabled the delivery of more people into central London. Thus the additional productivity is part of the benefit of the investment

5.20 Agglomeration manifests itself in high densities of employment and small increases in productivity spread across a large number of people. It applies to those in advanced, knowledge-intensive sectors such as professional, financial and business services, design, science and creative industries, but also across supporting sectors.

5.21 The estimate of pure agglomeration is, in Present value terms, £600m.

Summary of WEIs

5.22 The M2MPJ and Pure Agglomeration were calculated based on planning data and change in transport costs from the Railplan model. Further details of the calculations can be found in Appendix D.

5.23 The results for the WEIs is presented in Table 5.1. This shows that the total WEIs are forecast to be in the order of £4.7 billion over 60-years from when the NLE opens.

Table 5.1 Summary of WEIs (60 year PV in £ millions in 2010 prices)

Impact	Wider Economic Impacts (£m PV)
Pure Agglomeration	600
M2MPJ	4,100
Total	***4,700***

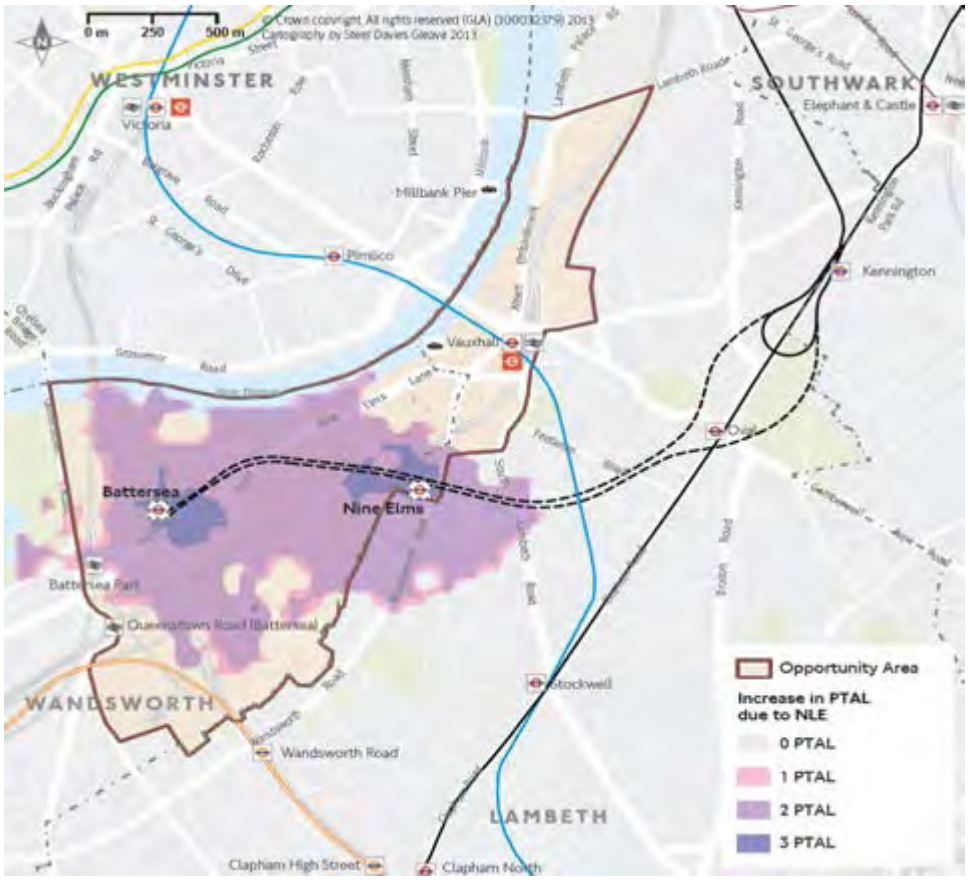
Transport User Benefits

Transport user benefits represent the improvement in overall travel times arising from the NLE, and also take account of network crowding impacts. The key transport user benefits of the scheme are shown in Figure 5.1, which shows the reduction in overall journey times for public transport users travelling to and from the OA and Figure 5.2, which shows the change in accessibility to the public transport network (PTAL)[28] resulting from the NLE, both in 2031.

[28] Public Transport Accessibility Level (PTAL) is a simple measure of accessibility based on the distance to the nearest public transport stop and the service frequency at that stop. This is adopted by Transport for London as a standard measure for public transport access in London. It should be noted that PTAL does not take account of the other destinations that the public transport service connects to and the demand for travel to and from those destinations.

Figure 5.1 Forecast Change in Public Transport Generalised Journey Time From Battersea Resulting From the NLE, 2031

Figure 5.2 Change in Accessibility (PTAL) with NLE, 2031



5.24 It is the increased capacity, connectivity and accessibility that underpins the ability of the VNEB to accommodate and attract additional development activity that enables it to fulfil its potential as part of the CAZ, and hence underpin the benefits from the M2MPJ and from agglomeration.

5.25 The figures above show the direct benefit of the NLE in improving access to the transport network to / from VNEB and improving journey times between VNEB and Central London, as well as to north, east and southeast London. With the NLE in place, passengers travelling between VNEB and Central London will benefit from a reduction in travel time between 10 and 20 generalised minutes[29].

5.26 The transport user benefits included within the appraisal reflect the following elements:

- **Time saving benefits** to users on NLE who gain from reduced journey times and enhanced accessibility, as per Figure 5.1 and Figure 5.2.
- Impacts upon the wider public transport network in the form of **crowding**. The NLE will relieve crowding on key sections of the network, including the Northern line south of Kennington and the Victoria line between Vauxhall and Victoria. The additional demand attracted to the NLE will also result in increases in crowding on some sections, such as the Northern line north of Kennington on the Bank Branch[30].
- The overall increase in public transport demand on the network, resulting from the development additionality, also results in minor crowding impacts (imperceptible for an individual passenger) across the wider network. These small impacts, however, apply to a large number of people and this 'dis-benefit' has been valued in the economic appraisal.
- **Time savings to highway users**. While an increased concentration of development in the VNEB area will generate some additional traffic, the redistribution of activity from Outer London (that is less accessible by public transport) results in a net reduction in highway demand that, in turn, leads to decongestion benefits for remaining users across the wider network. The accident and

[29] Generalised time is a standard measure of accessibility which includes the perceived impedance associated with walk, wait times and crowding. This is described in further detail in Appendix E.

[30] The crowding impacts of the NLE on the transport network are assessed as part of the Environmental Statement - Northern Line Extension (NLE), Transport and Works Act Order Application - Environmental Statement Volume I Chapter 6, and the Environmental Statement Addendum

emissions benefits resulting from the reduction in overall highway kilometres on the network have also been valued.

5.27 In addition to benefits to transport users, we have also forecast the benefit to transport providers in the form of **additional revenues** to TfL from additional public transport trips on the network. The NLE attracts additional public transport trips, and the redistribution of activity from Outer London (with a lower public transport mode share) to VNEB (with a higher mode share, reflecting its more central location) also increases the total number of public transport trips.

5.28 The detailed approach and demand and benefit forecasts are set out in Appendix E. Further impacts of the NLE on the future public transport and highway networks is reported in the Environmental Statement[31].

Economic Appraisal Results

5.29 The appraisal of the NLE has been undertaken in line with Green Book Guidance. The economic appraisal includes all the monetisable costs and benefits of the scheme, and profiles these over a 60-year appraisal period. These costs and benefits are then discounted to a current price base and together provide the basis for the calculation of the Benefit to Cost Ratio (BCR).

Appraisal Assumptions and Parameters

5.30 The following key assumptions underpin the economic appraisal:

- The NLE service commences in January 2020. The appraisal period is 60 years covering the first full year of operation (2020) through to 2079;
- All monetary values are presented in a 2010 price base and are discounted to 2010 present values. This is DfT standard practice so that schemes can be compared against one another;
- A discount rate of 3.5% is used for the first 30 years from opening and 3% thereafter;
- Productivity values (used to value movement to more productive jobs and agglomeration benefits) are based on DfT guidance, with appropriate values adopted for VNEB;

[31] Northern Line Extension (NLE), Transport and Works Act Order Application - Environmental Statement Volume I Chapter 6

- Value of times and growth in value of time (used to value transport benefits) is based on the TfL Business Case Development Manual; and
- Growth is interpolated between 2020 and 2031 to reflect the assumed development phasing in the VNEB area.

5.31 Transport benefits from 2022 onwards also reflect the higher service frequency (the same as that in 2031) that would operate from 2022.

5.32 The economic appraisal results are set out in Table 5.2. The table shows the present value costs and benefits over the 60-year appraisal period.

Table 5.2 Economic Appraisal of NLE (£m PV, 2010 Prices)

	Economic costs and benefits over 60-years (£m, Present Values), 2010 prices)
Financial Impacts	
Capital costs	810
Renewal Costs	90
Operating and maintenance costs	210
TfL Revenues	-400
National Rail Revenues	-90
Financial Impacts *(1)*	***620***
Economic Impacts	
Economic benefits – M2MPJ	4,100
Agglomeration benefits	600
Public transport benefits	290
Highway benefits	50
Accidents, GHG and Air Quality	40
Total Benefits *(2)*	***5,080***
Net Present Value *(2)-(1)*	***4,470***
Benefit to Cost Ratio (BCR) *(2)/(1)*	***8.2 : 1***

Note: The capital cost of £810m PV is in 2010 prices, and is discounted by 3.5 per cent per annum, in line with guidance. The cost is consistent with the £998.9m out-turn capital cost presented in Chapter 2. More detail on capital cost is presented in Appendix A.

Interpretation

5.33 The largest economic benefit accrues from the M2MPJ, which is estimated at £4.1bn. This reflects the productivity associated with additional jobs enabled by the NLE, and the productivity benefits of accommodating this additional activity in the CAZ (of which VNEB is a part).

5.34 Agglomeration benefits account for £600m in present value terms (PV). There are two drivers of the agglomeration benefit. First, reduced transport costs due to the NLE increase the 'effective density' of firms, improving productivity.

5.35 Public transport benefits amount to £290m PV. It should be noted that these comprise significant benefits to users of the NLE, but also takes account of the additional crowding impacts that results from the additional jobs (and additional public transport trips) in the With NLE Scenario. TfL revenues account for an additional £400m PV over 60 years – these are also driven by the additional public transport demand as a result of the NLE. National Rail revenues are also projected to increase by £90m. These are netted off the costs of the investment to provide a net cost of £620m PV.

5.36 The highway benefits are largely driven by the displacement assumptions underpinning the With NLE Scenario. Highway mode shares are typically higher in Outer London, so that redistributed transport activity to the VNEB / CAZ has the effect of reducing the overall number of highway trips. This outweighs the impacts of additional highway trips in the VNEB area that are associated with the additional development that will be enabled by the NLE and results in highway decongestion benefits.

5.37 The costs of the scheme are as presented in Chapter 2. The capital cost of £810m PV includes £100m PV in Estimating Contingency, the P50 QRA value (£40m PV) and Optimism Bias (£80m), in line with guidance. The operating, maintenance and renewal costs have been estimated by London Underground and TfL, and are detailed in Appendix A.

5.38 The BCR for the NLE is 8.2:1, demonstrating that the value for money assessment of the NLE is very high.

5.39 It should be noted that this assessment is based on the total scheme costs and does not consider any private sector contributions. The BCR to the public, based only on public sector financial impacts, is considered in the next section.

Economic Appraisal – Public Sector's Perspective

5.40 The economic appraisal described above represents the economic performance of the scheme taking account of the full costs and benefits of the scheme, irrespective of whether these are borne by the public or private sector. An appraisal based on the costs borne by the public sector has also been presented.

5.41 The NLE scheme is being financed and delivered by the public sector, but the up-front scheme costs will be recouped through development levy arrangements (CIL) and additional business rates that underpin the scheme financing, the detail of which is set out in the Funding Statement[32]. The out-turn capital cost of £998.9m will be funded this way.

5.42 The QRA P50 and Optimism Bias are included in the economic appraisal (in order to be consistent with Guidance), but not in this financing arrangement. While TfL will actively manage these risks to mitigate the overall cost exposure, it is prudent to assess the case for the NLE with these risks.

5.43 An illustrative appraisal based on the assumption that 15%[33] of the scheme capital costs in the economic appraisal would be borne by public sector has also been presented.

5.44 Table 5.3 sets out the economic appraisal from the perspective of the public sector financial impacts only. It shows that, once additional operating, renewal costs and revenues are taken into account, the net financial impacts to the public sector over the 60-year appraisal period is £26m. As the economic benefits remain constant (as per the full economic appraisal), the BCR is 196:1[34].

5.45 Evidently this represents exceptionally high value for money to the public sector and the tax payer. Should this 'optimism bias' element not be required then, on the basis of the assessment below, the full benefits could be delivered at no cost to the public sector. In either event, the financial contributions from the development can facilitate the delivery of net economic benefits worth over £5.0bn.

[32] Northern Line Extension (NLE), Transport and Works Act Order Application – Funding Statement, April 2013.

[33] 85% of capital costs in the economic appraisal represents the scheme costs for funding, and the remaining 15% of the scheme capital costs in the economic appraisal is associated with the QRA P80 cost of £110m PV that TfL will actively mitigate and the additional costs associated with an extra vehicle currently funded under NLU2.

[34] Note the BCR for this sensitivity is quite sensitive to small changes in cost. The benefits numerator in the equation is £5bn, at relatively insensitive to small changes in value. The 'financial impacts' denominator is a net of positive and negative costs, and results in a net cost close to zero (£26m over 60 years). Small change in this would result in large changes in the BCR, so the BCR value should be viewed in this context.

Table 5.3 Public Sector Appraisal of the NLE (£m PV, 2010 Prices)

	TfL costs and benefits over 60-years (£m, Present Values), 2010 prices)
Capital costs (Public Sector / TfL only) *(1)*	125
Renewal Costs *(3)*	87
Operating and maintenance costs *(2)*	218
TfL Revenues *(4)*	-405
Total Public Sector Financial Impacts *(5)=(1+2+3+4)*	***26***
Total Benefits *(6)*	***5,080***
BCR to the Public Sector *(6)/(5)*	***196 : 1***

5.46 Furthermore, the incremental revenues to TfL outweigh the operating, maintenance and renewal costs, suggesting the NLE will be financially sustainable to its operator in the longer-term.

Sensitivity Tests

Sensitivity Tests on Wider Economic Impacts

5.47 Given that the principal aim of the project is to support economic development in the VNEB OA, the M2MPJ benefits account for a large proportion of overall economic benefits. As such, the sensitivity tests undertaken focus on how different assumptions affect the WEIs and the overall value for money of the NLE. The two main areas assessed for sensitivity include:

- The proportion of net additional jobs assumed; and
- The redistribution of jobs growth assumed.

Net Additionality Sensitivity Tests

5.48 The economic appraisal above assumes 13% of jobs created in the VNEB will be net additional jobs. Around this central scenario, a range of potential outcomes has been assessed based on sensitivities around this assumption. The results are set out in Table 5.4.

5.49 Guidelines for WEIs produced by the DfT suggest that no additionality should be assumed, although we discuss in Appendix D why this is not deemed appropriate in this instance. Nevertheless, the WEIs based on this guideline of 0% additional employment would still deliver

M2MPJ benefits of £3bn, and the overall case remains compelling under this test.

Table 5.4: Additionality Sensitivity Tests (£m PV)

Additionality Sensitivities	M2MPJ (£m PV)
0%	3,000
5%	3,400
13%	***4,100***
20%	4,700

5.50 This means that even if all jobs in the VNEB area enabled by the NLE were displaced from Outer London boroughs (and none were additional), we would still see total WEIs of around £3.6 billion.

Productivity Assumption Sensitivity Test

5.51 The valuation of M2MPJ benefits uses an adjusted productivity index for Wandsworth, reflecting the fact that VNEB will fulfil its potential as part of CAZ when NLE is in place.

5.52 A sensitivity test using DfT's productivity data (i.e. an unadjusted productivity index for London Borough of Wandsworth) has been carried out. The central 13% additionality M2MPJ falls from £4.1 billion to £2.9 billion when using the DfT productivity for Wandsworth, which is the weighted average of Inner London's productivity. This still represents excellent value for money.

Growth Redistribution Assumption Sensitivity Test

5.53 The economic appraisal assumed that the 87% jobs and all the population added to the VNEB OA will be redistributed from Outer London. However, in absence of the NLE some of the growth may otherwise locate outside Greater London in the South East.

5.54 A sensitivity assuming that half of VNEB jobs (the 87% that are not additional, and hence the growth is redistributed from elsewhere) would be redistributed from Outer London, and the other half from the rest of the South East has been undertaken. The results are set out in Table 5.5. When rounded to the nearest £100m, the location from which growth is redistributed does not affect the M2MPJ estimate. This is because the productivity of Outer London is similar to that in the rest of the South East.

Table 5.5 Redistribution Sensitivity Test (£m PV)

Redistribution Sensitivities	M2MPJ (£m PV)
Redistributed from Outer London	4,100
Redistributed from Outer London/South East	4,100

Economic Appraisal Results of Sensitivity Tests

5.55 The detailed economic appraisal results of these tests are set out in Table 5.6. It should be noted that given the WEI component accounts for a large proportion of benefits and have been subject to sensitivity testing. For these tests the transport benefits have been assumed to be the same across all tests – the time savings for trips to and from the VNEB will be similar, but the crowding impacts will depend on the redistribution and additionality assumptions. However, small potential changes in transport benefits are not material to the conclusions from the sensitivity tests.

5.56 As shown in the results, the BCR ranges between 6.3:1 and 9.2:1, all representing very high value for money and demonstrating that the case for NLE remains robust under the scenarios tested.

Table 5.6 Economic Appraisal Sensitivity Tests (£m PV, 2010 Prices)

	Central Case 13% Net Additionality	Net Additionality Tests			Productivity Assumption Test	Redistributed from Outer London and SE Test
		0%	5%	20%		
Financial Impacts						
Capital Costs	810	810	810	810	810	810
Renewal Costs	90	90	90	90	90	90
Operating and Maintenance Costs	210	210	210	210	210	210
TfL Revenues	-400	-400	-400	-400	**-400**	**-400**
National Rail Revenues	-90	-90	-90	-90	**-90**	**-90**
Financial Impacts	***620***	***620***	***620***	***620***	***620***	***620***
Economic Impacts						
Economic Benefits – M2MPJ	**4,100**	**3,000**	**3,400**	**4,700**	**2,900**	**4,100**
Agglomeration Benefits	600	600	600	600	600	600
Public Transport Benefits	290	290	290	290	290	290
Highway Benefits	50	50	50	50	50	50
Accidents, GHG and Air Quality	40	40	40	40	40	40
Total Benefits	***5,080***	***3,980***	**4,380**	***5,680***	***3,880***	***5,080***
Net Present Value	***4,470***	***3,370***	**3,770**	***5,070***	***3,270***	***4,470***
BCR with Full Costs	***8.2:1***	***6.5:1***	**7.1:1**	***9.2:1***	***6.3:1***	***8.2:1***
BCR with Public Sector Costs Only	***196:1***	***153:1***	**169:1**	***219:1***	***150:1***	***196:1***

6 Regeneration Benefits

6.1 As well as supporting the delivery of the London Plan targets for VNEB, the NLE will support the regeneration of London Borough of Lambeth (LBL) and London Borough of Wandsworth (LBW), with a particular impact on residents of the wards within the OA and immediately surrounding.

6.2 The NLE will serve an area of existing population that will benefit enormously, particularly around the two stations. It will give access to the transport network for local people and allow people from elsewhere in the borough to get into the area to access jobs. It also enables local jobs to be created and opens up the area for local people.

6.3 The local impact area has been defined as the seven surrounding wards which include (as illustrated in Figure 6.1):

- Bishops ward (LBL);
- Oval ward (LBL);
- Prince's ward (LBL);
- Stockwell ward (LBL);
- Larkhall ward (LBL);
- Clapham Town ward (LBL); and
- Queenstown ward (LBW).

Population

6.4 This area as a whole has a population of 101,190 people, with a high proportion of them (81%) being of working age (aged 16 – 74 years). This compares to 78% in LBL, 79% in LBW and 75% in London a whole.

6.5 The population of the area has increased by 18% over the 10 years since the last census. This level of growth is higher than the London wide average over this same period. London's population grew by almost 1 million between 2001 and 2011, representing a 14% increase. LBW's population grew by 18% to 307,000 and LBL grew by 14% to 303,000.

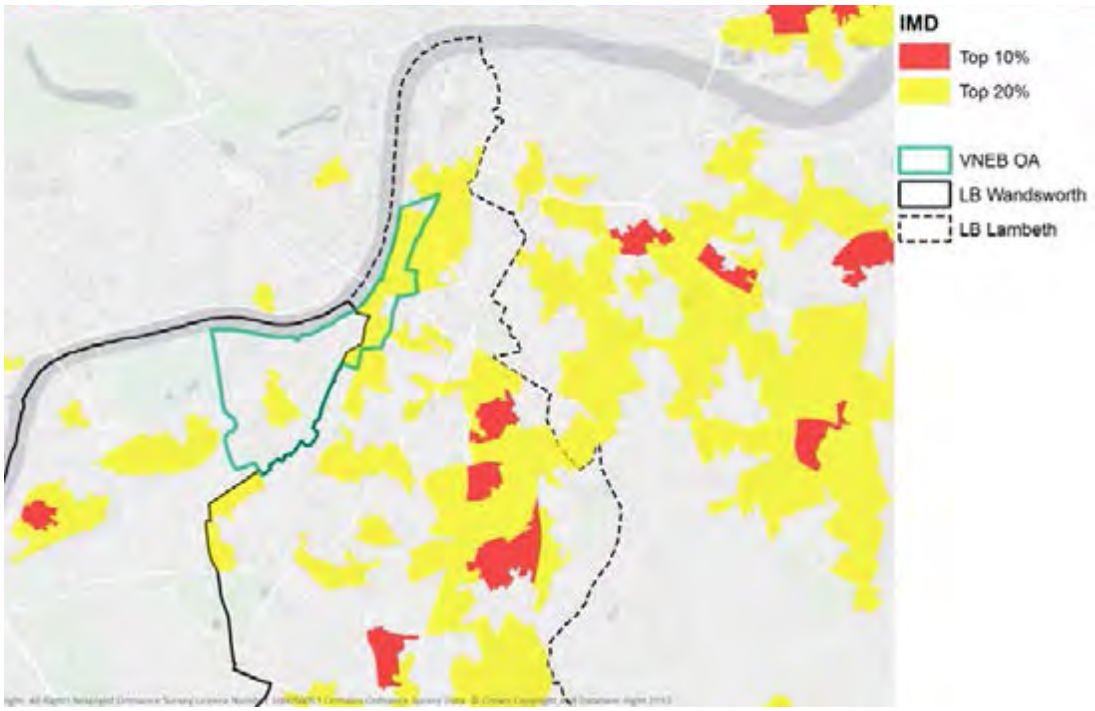
Figure 6.1 Local Spatial Context

Deprivation

6.6 The Index of Multiple Deprivation provides a measure of deprivation based on a combination of domains including employment, income, health, education and skills, crime, living environment, and barriers to housing and services. Figure 6.2 illustrates the areas which fall within the 20% most deprived in the UK shown, in yellow and the areas experiencing higher levels of deprivation, within the 10% most deprived, shown in red.

6.7 There are a number of pockets of deprivation within the surrounding local area, including some parts of the Impact Area which are within the 20% most deprived in the country. These areas include the locations of the two new stations.

Figure 6.2 Index of Multiple Deprivation



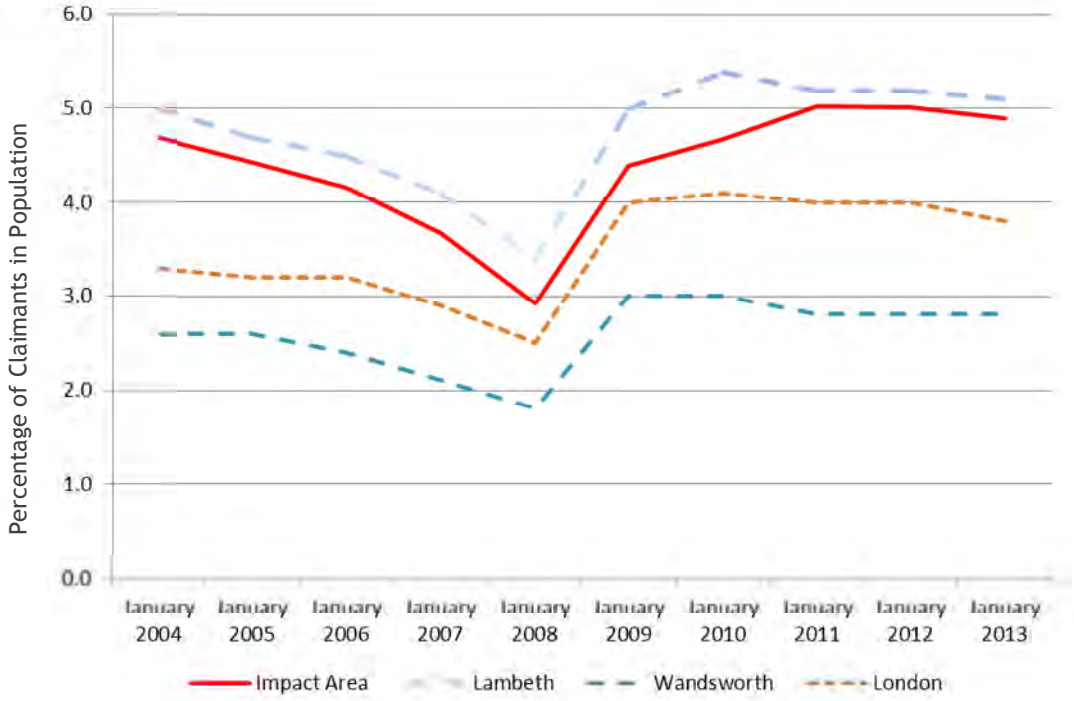
Unemployment

6.8 Whilst overall the level of economic activity is relatively high in this area, there are over 4,500 economically active residents who are currently unemployed, as recorded by the 2011 Census. There are particularly high levels of unemployment in Stockwell, Larkhall and Princes wards, where the proportion of unemployed economically active residents increases to 8% or 9% compared to 6% in Queenstown, Oval and Clapham Town wards.

6.9 According to claimant count data, which provides a measure of the number of people who are claiming unemployment related benefits whilst actively seeking employment, there were over 3,500 claimants living within the Local Impact Area (May 2013). The claimant count does not include those unemployed people who are not actively seeking employment or may not be eligible for unemployment related benefits.

6.10 Figure 6.3 illustrates the increase in claimant count rates over recent years. Lambeth has a substantially higher level of unemployment, Stockwell ward has a claimant count rate of 6.1% whereas the average rate for the impact area is 4.9%. This is significantly higher than the London average of 3.8% and LBW's low rate of 2.3% (although the rate in LBW's Queenstown ward is higher, at 4.3%).

Figure 6.3 Claimant Count 2004-2013



6.11 According to Claimant Count Data for June 2013 over 58% of those seeking employment are looking for entry level and low skilled employment in the Impact Area. In particular retail, leisure and hospitality create high levels of these kinds of jobs. There are over 1,800 people living in the impact area currently seeking employment within these sectors.

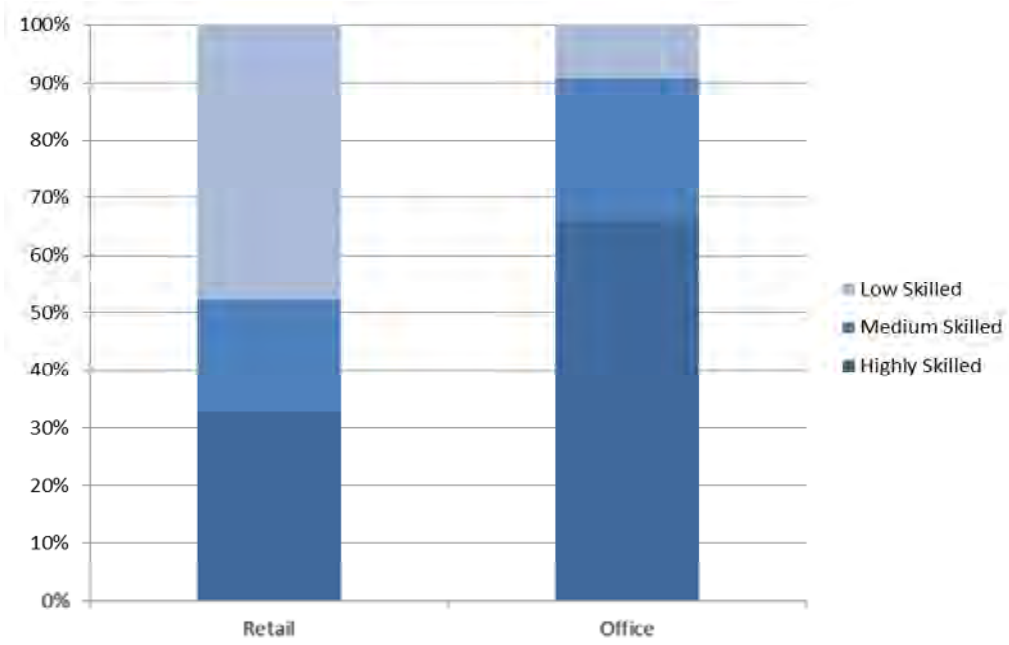
Employment Impacts

6.12 The development of the VNEB OA could accommodate update up to 24,000 additional jobs compared to the current number of jobs in the area. The range and mix of employment opportunities coming forward here are not only significant in terms of London's overall economic growth, but create a substantial opportunity for the local labour market.

6.13 Research into the general skills profile of occupations in London's retail and office industries, demonstrated in Figure 6.4, shows that almost half of the retail jobs in London are made up of low skilled jobs, whereas over 66% of office jobs are highly skilled. It is notable that whilst the majority of office jobs are highly skilled, a significant proportion, approximately one third, are low and medium skilled. From this we can establish that whilst office spaces will yield predominantly high skilled employment, they will also generate jobs for people at the medium and low skill level who are seeking employment. This

indicates that significant opportunities will be created through employment growth in the VNEB area for people within the local labour market who are seeking entry level jobs.

Figure 6.4 London Skills Retail vs. Office



6.14 By applying the London wide skill profile to the broad mix of jobs coming forward within the VNEB, it can be estimated that there could be around 5,340 entry level and low skilled jobs created within the commercial floorspace proposed.

6.15 This type of employment tends to be held by people living within close proximity of their place of employment as such jobs do not typically have long commuting patterns. Retail jobs are particularly important for local employment; research into 2001 Census data shows that 30% of l employees across all sectors live within 5km of their workplace, while in the retail, wholesale, hotel and restaurant sectors more than 41% of people live within 5km of their place of employment.

Table 6.1 Proposed Employment Skills Breakdown

	Retail, leisure, hospitality & Community	Office	Total
Highly Skilled	2,660	10,460	13,120
Medium Skilled	1,580	3,960	5,540
Low Skilled	3,880	1,460	5,340
Total	***8,120***	***15,880***	***24,000***

6.16 The skills profile across the jobs created here would make a positive contribution towards addressing local unemployment issues and meeting the requirements of job seeks living in the surrounding area.

6.17 In addition to creation of new jobs within the OA, the delivery of the NLE will improve accessibility of the existing communities in the area to the rest of the CAZ and further afield by significantly reducing travel times, thereby increasing the access to employment opportunities. The travel time savings have been described in detail in Appendix E.

Employment and Skills Support

6.18 The NLE will improve local residents' physical access to jobs, and the local authorities are committed to working together with local stakeholders (including TfL) and land owners to maximise the local benefits arising from employment within VNEB for the wider labour market within both boroughs. This will be centred on both the construction phase of the development of the area as a whole and the end uses of the commercial floorspace proposed here. This could make a significant impact to local labour markets and reduce unemployment.

6.19 It is estimated that the construction of the NLE could require an over 600 construction jobs on average per annum. The operational phase of the NLE is estimated to create 79 direct jobs in train operation, station staffing and maintenance. TfL will aspire to meet the requirement so of the Nine Elms Vauxhall Employment, Training and Business Charter which aims to maximise local employment benefits and procurement.

6.20 The wider development of VNEB will result in extensive employment opportunities some of which will be directly related to the delivery of the NLE, such as the commercial development proposed at BPS as

previously discusses. It is estimated the overall VNEB could deliver over 23,800 new jobs.

6.21 As part of the Nine Elms Vauxhall Partnership, LBL and LBW will deliver an Employment and Skills Framework for the OA. An Employment and Skills Plan is required for developments within the OA, the terms of which are set out in the S106 agreements for the consented applications.

6.22 Employment brokerage within the area will provide an interface between the various stakeholders and service providers. This initiative aims to create links between Jobcentre Plus, Work Programme, South Thames College, Lambeth College, apprenticeships providers, voluntary and community organisation and vacancies and training opportunities within the borough. LBL and LBW have existing partnerships and brokerage arrangements; however the boroughs bring these together to deliver a single integrated service for VNEB.

6.23 This creates a single point of contact for landowners and employers in a dedicated unit specific to VNEB. This will handle job brokerage and recruitment for opportunities created through the construction and end uses within the OA. A major focus will be to ensure that fair proportion of LBL and LBW residents from various backgrounds have access to these opportunities.

6.24 Support and training will be provided to prepare jobseekers for recruitment. This will include identifying skills gaps, training requirements and providing advice and support on key issues such as interview and CV preparation etc. This will provide contractors and employers operating in the OA with access to a pool of job ready candidates.

6.25 Nine Elms Employment Brokerage will link employers demand and the training provider network to ensure the available local labour possess the correct skill required to meet need. Lambeth College and South Thames College have agreed a Memorandum of Understanding to work together within the OA.

6.26 Each borough has links with community outreach and referral partners who will promote opportunities arising within the OA, with a particular focus on communities in and around the boundary.

6.27 Support and funding will be provided by development in the OA, through section 106 agreements to commit to an Employment and

Skills Plan; in addition the Development Infrastructure Funding Study (DIFS) tariff includes provision for employment and training initiatives.

Sustainable Communities

6.28 The NLE is one component of a comprehensive plan to deliver a high quality environment for more people to live in. Although the majority of the land within the OA is currently in industrial use, there are also established resident communities within the boundary as well as in the areas surrounding it. Some of these communities experience high levels of deprivation. The regeneration benefits arising from the development of VNEB (supported by the NLE) will have a significant positive impact on the existing local communities. Benefits will include increasing access to opportunities such as employment, skills and training, and the provision of new, and improvement of existing, social and physical infrastructure.

6.29 The OAPF seeks to ensure that any development within the OA does not adversely impact the existing communities or impede their access to existing social infrastructure.

6.30 The OAPF along with the DIFS has assessed the demand for social infrastructure arising from the new population to ensure additional provision is delivered to serve need as it comes forward over the development period. This assessment includes a range of elements including:

- Education, nurseries, primary and secondary schools;
- Healthcare;
- Libraries;
- Emergency services;
- Community centres;
- Libraries;
- Youth provision;
- Arts and Culture;
- Public open space, sport and playspace;
- Employment and training; and
- Utilities.

6.31 The demand for infrastructure has been assessed on the basis of the number of residents projected to live within the OA and requirements were identified in consultation with key stakeholders and service providers. Social infrastructure will be delivered through a combination of on-site delivery and funded through planning conditions included in

the planning permissions which have been consented. Many of the proposals include the Use Class D1 floorspace which could deliver community facilities as demand arises. In addition financial contributions collected through the DIFS tariffs, Section 106 agreement and CIL secure funding for the delivery of facilities.

6.32 The OAPF has set out a clear masterplan for the area which will improve the physical environment within the area. The dominance of large scale industrial uses results in physical severance which impedes movement from the communities along the southern edge of the OA northwards towards the river.

6.33 The OAPF includes the provision of a strategic linear park and improved Thames Path. This and the series of open spaces which are proposed on each site will create a network of open space and improved public realm across the OA. This will have a substantially beneficial impact on local communities by improving the physical environment and creating new links through the area.

6.34 Overall the regeneration of VNEB will help to create a sustainable community comprised of the existing population and new residents. This will be supported by social infrastructure, improved open space and public realm, good access to employment and town centre functions such as retail and leisure. All of this will be facilitated by excellent access to public transport through the NLE.

7 Conclusions

7.1 The business case sets out how the NLE will deliver the regeneration and wider economic development objectives that fully align with the London Plan objectives of accommodating employment and population growth and promoting the development of the Central Activities Zone (CAZ). This scale of regeneration in VNEB and wider economic development would not take place without the NLE.

7.2 The economic appraisal has valued the overall benefit of the NLE in terms of transport benefits and its role in delivering additional economic productivity and jobs to London, and the UK as a whole. The economic appraisal demonstrates that the NLE scheme will deliver a BCR of over 8:1, meaning that every £1 spend will deliver at least £8 in benefits.

7.3 The economic appraisal does not distinguish private and public costs. If the economic appraisal only considered public sector costs, then the full benefits of the scheme worth £5.0bn would be delivered at virtually no net cost to the public sector (£26m over 60 years). This represents exceptional value for money to the public sector and the tax payer.

7.4 The regeneration of the OA as a whole will have a beneficial effect on the existing local communities within and surrounding the VNEB OA. Improvements to the physical environment will include the creation of new links, breaking down the physical severance created by the existing industrial uses, introduction of new open space, and social infrastructure provision.

7.5 The delivery of the NLE and the overall development of the VNEB OA will bring substantial employment opportunities to this area, with an additional 23,800 new jobs across a range of sectors and skill levels. The construction phase of the NLE and the developments within VNEB also create employment opportunities for local people. LBL and LBW are committed to ensuring the employment benefits arising from the regeneration of the OA are maximised at the local level through the implementation of employment and training initiatives.

Northern Line Extension

Economic & Business Case Appendices

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APPENDICES

A Scheme Costs

B VNEB Area Planning Assumptions

C Transport Modelling Overview

D Wider Economic Impacts

E Transport Benefits Analysis

F Annualisation Factors

G Summary of Changes Since the 2012 Economic Case for the NLE

APPENDIX

A

SCHEME COSTS

A1 SCHEME COSTS

A1.1 This Appendix sets out the scheme costs for the Northern Line Extension (NLE), comprising:

- Capital costs, including risk, contingency and optimism bias;
- Operating and maintenance costs; and
- Renewals costs estimates.

Capital Costs

A1.2 The scheme costs presented in this Appendix are consistent with the costs set out in the NLE Transport and Works Act Order (TWAO) Funding Statement and Estimate of Cost (April 2013).

A1.3 It should be noted that the capital costs employed in the Economic and Business Case cannot be directly compared against the funding statement or Estimate of Cost[1] for the following reasons:

- In line with TfL's appraisal practice, the Business Case adopts a common price base of 2010 real prices (i.e. with background CPI inflation removed) for both costs and benefits; and
- The capital cost in the Estimate of Cost includes an Estimating Contingency allowance in each cost component, while the Estimating Contingency has been treated separately in this document. For appraisal purposes, the Business Case includes costs relating to the Quantified Risk Assessment (QRA) in addition to the Estimating Contingency.

A1.4 The costs represented in this document reflect the scheme as submitted as part of the NLE TWAO and it is recognised that these costs will continue to evolve over time as the detailed design progresses.

Background

A1.5 Corderoy, on behalf of Treasury Holdings, provided an estimate in July 2010 based on the then RIBA Stage C design for the NLE at a value of £730m (outturn), assuming private sector procurement and delivery of the extension. This included general contingency allowances of 5% on all costs, and design and construction contingency levels of 5% each on construction costs, trains and stabling.

[1] Northern Line Extension (NLE), Transport and Works Act Order Application – Estimate of Costs (April 2013)

A1.6 In preparation for the TWAO submission due in April 2013, a review of costs was undertaken to ensure that the costs reflected the April 2013 Scheme Design. This took into account a number of scope changes such as deletion of the Claylands Road shaft and the Nine Elms crossover and included additional costs omitted from previous estimates. The revised out-turn cost was estimated to be £998.9m.

A1.7 In line with TfL guidance, a Quantified Risk Assessment (QRA) process has been undertaken to determine the additional allowance for risk to be applied in the economic appraisal.

Capital Cost Components

A1.8 The project capital cost estimates for the NLE Business Case comprise the following components:

- Construction Costs - Infrastructure costs[2];
- Vehicle Costs – rolling stock and stabling;
- Other Costs - Preparatory, land and commissioning costs;
- Risk – QRA and management contingency; and
- Optimism Bias for appraisal purposes only.

Construction Costs

A1.9 The total construction cost is estimated at £582.2m, in Q1 2010 prices[3]. Table A.1 sets out the construction costs by cost category.

A1.10 The appropriate level of contingency to accommodate cost variations was determined to be 22%. The overall level of estimating contingency added to the capital cost is £128.1m.

Vehicle & Stabling Costs

A1.11 Five additional Northern line trains will be required to operate the extension in 2020[4].

A1.12 The cost of procuring these trains is estimated at £66.7m in current prices, equivalent to £67.6m in Q1 2010 prices.

[2] Including the construction of additional cross passages at Kennington station

[3] 2010 price base is used, consistent with DfT guidance

[4] Five Northern Line trains will be required to operate the frequency of 16tph in 2020. When NLU2 is complete in 2022, the NLE frequency will increase to 28tph and one extra train will be required on top of the initial five. This extra train is currently funded through the NLU2 programme and as such has not been costed in the NLE funding to avoid double counting. However, to maintain internal consistency in the economic appraisal, the vehicle capital costs in the appraisal have been factored up to include this extra train.

A1.13 This is based on a supplier estimate and assumes that the NLE vehicles will be procured in isolation from any other future rolling stock procurement such as the Northern Line Upgrade Phase 2. Should the rolling stock be procured as part of a larger rolling stock order for NLU2 the incremental cost of vehicles for the NLE would reduce. Table A.2 summarises the vehicle costs.

A1.14 Stabling costs have been estimated at £1.1m (current prices).

Appendix Table A.1 Scheme Construction Cost Summary

Cost element	Cost £m (Q1, 2010 prices)
Overrun Tunnel	27.0
Running Tunnels	135.5
Running Tunnel Cross Passage	8.5
Trackwork	29.1
Temp shafts & Reception Chamber	10.0
Step Plate Junction	27.4
Battersea Station	105.4
Battersea Crossover	32.0
Nine Elms Station	117.8
Kennington Park Shaft	6.1
Kennington Green Shaft	8.5
Lineside Systems	62.6
Kennington Station Additional Cross Passages	12.2[5]
Total Construction Costs	***582.2***

Appendix Table A.2 Rolling Stock and Stabling Costs

Cost element	Cost £m (Q1, 2010 prices)	Cost £m (Current prices)
Rolling Stock	67.6	66.7
Stabling	1.1	1.1
Total Rolling Stock and Stabling Costs	***68.7***	***67.8***

[5] Kennington Station additional cross passage costs is in current prices

Land Costs

A1.15 The allowance for land purchase required for the scheme is estimated to be £22.5m in current prices[6].

Other Costs

A1.16 In addition to the base construction costs, other costs including preparatory cost and insurance have been estimated. These are presented in Table A.3.

Appendix Table A.3 Other Scheme Costs

Cost element	Cost £m (Q1, 2010 prices)	Cost £m (Current prices)
Design and project management	26.9	26.5
Pre & post TWAO	11.3	11.1
Insurance	10.1	10.0
TfL resources	20.3	20.0
Total Other Costs	***68.6***	***67.7***

Quantified Risk Assessment (QRA)

A1.17 Risk provision is an allowance within the total project budget or forecast that is to be used (in accordance with operating business procedures) to deal with anticipated events of uncertain outcome. This provision is estimated based on the Quantified Risk Assessment (QRA) of identified risks.

A1.18 A QRA process has been undertaken to assess the potential risks and challenges associated with delivering the NLE. The QRA process produces an expected probability distribution for costs, which form the basis for the risk allowance and level of optimism bias.

A1.19 The risk provision based on the P50 QRA[7] is estimated at £48.7m in Q1 2010 prices based on the target value with risk mitigation. This has been included into the cost estimate within the economic appraisal.

[6] This is the net land purchase cost estimated by TfL and takes into account the future sale of development rights above Nine Elms station.

[7] A P50 QRA cost means that there is a 50% likelihood that the final cost will be at or lower than the QRA cost.

Optimism Bias

A1.20 Optimism bias is a risk allowance to be added to costs in the business case to take account of systematic cost estimation bias shown by past projects in the transport and other sectors.

A1.21 In accordance with TfL guidelines, optimism bias (referred to as budgetary management contingency within TfL's guidance) is estimated as the difference between the QRA P80 and P50 cost estimate. The optimism bias level, based on the P80 minus P50, is £96.4m in current prices, equivalent to £97.7m in Q1 2010 prices. The optimism bias represents an additional of 10.6% to the capital costs in the economic appraisal.

A1.22 This optimism bias has been included in the scheme cost for the purposes of the economic appraisal in line with TfL and DfT guidance. It does not form part of the estimate for funding.

Cost Indexation

A1.23 Costs have been inflated on the basis of cost phasing assumptions consistent with scheme development and construction programme, up to the assumed opening date of 2020.

A1.24 The indexation assumptions are based upon TfL's tender price inflation (TPI) guidance. The guidance requires that BCIS tender price inflation is used to forecast out-turn costs. The August 2012 Building Cost Information Service (BCIS) All-in TPI assumes TPI inflation of:

- 0% in 2011/12;
- -1.4% in 2012/13;
- 2.3% in 2013/14;
- 3.2% in 2014/15;
- 3.5% in 2015/16;
- 4.7% in 2016/17;
- 4.0% in 2017/18, 2018/19, 2019/20; and
- 3.5% thereafter.

A1.25 With the application of assumed inflation applied to the capital cost spend profile the out-turn cost of the scheme, not including the QRA or optimism bias, is £998.9m. This is the TfL cost for funding. TfL is actively managing the cost risks to ensure the cost-effective delivery of the project.

Base Capital Cost Summary

A1.26 The base cost estimate for funding is £868.3m in current prices. When the costs are rebased to Q1 2010 prices and other appraisal-related costs are included[8], the total scheme cost to be used in the business case is £1,032.5m. The key components are set out in Table A.4.

Appendix Table A.4 Scheme Capital Cost Summary

Cost element	Cost Estimate £m	Base Cost Estimate for Funding £m	Cost for Appraisal £m (Q1, 2010 prices)
Construction Costs	582.2	582.2	582.2
Vehicle and stabling Costs	67.8	67.8	82.3
Allowance for Land Purchase	22.5	22.5	22.9
Other Project Costs	67.7	67.7	68.6
Estimating Contingency	128.1	128.1	129.9
Total Capital Cost Excluding QRA	***868.3***	***868.3***	***886.1***
QRA (50% target level)	48.0	0	48.7
Optimism Bias (QRA P80 - P50)	144.4	0	97.7
Total Capital Cost		***868.3***	***1,032.5***

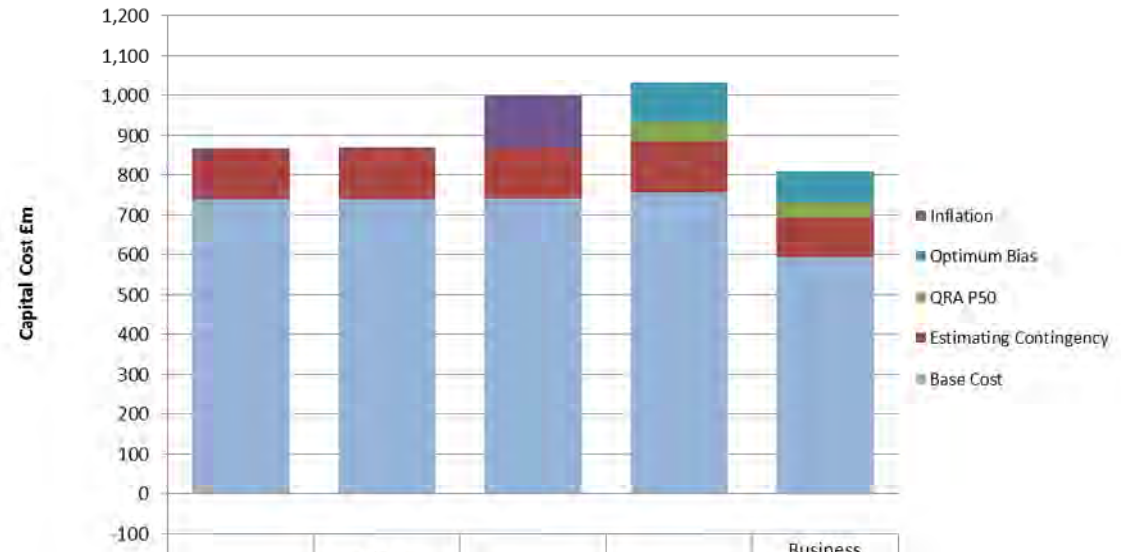
Summary of Capital Costs

A1.27 Figure A.1 sets out the composition of capital cost in the Business Case and in TfL's funding paper as submitted in the TWAO. For budgetary purposes, the overall level of risk and contingency is assumed to be at the value of the Estimating Contingency (but not QRA), so that the overall out-turn cost is estimated at £998.9m.

A1.28 When the business case cost in 2010 prices is discounted at 3.5% per annum, the discounted present value capital cost becomes £809m.

[8] The appraisal related costs include the QRA P50, optimism bias (equivalent to the difference between the QRA P80 and P50, and the extra train required post NLU2 that is currently funded through the NLU2 programme

Appendix Figure A.1 Summary of Capital Costs



	Base Estimate	Base Estimate (2010 Prices)	Funding (Out-turn Prices)	Business Case (2010 Prices)	Business Case (2010 Discounted Present Values)
Total	868.3	872.5	998.9	1032.5	809.0
Inflation	0.0	2.4	126.3	0.0	0.0
Optimum Bias	0.0	0.0	0.0	97.7	76.2
QRA P50	0.0	0.0	0.0	48.7	37.9
Estimating Contingency	128.1	129.9	129.9	129.9	101.2
Base Cost	740.2	740.2	742.6	756.1	593.6

Operating and Maintenance Costs

A1.29 The incremental annual operating and maintenance costs associated with operating the NLE has been estimated by LU. These estimates are based on current operating costs and practices of LU.

A1.30 The operating and maintenance cost estimates have been developed by LU under the following three cost groups:

- Maintenance Costs;
- Train Operators; and
- Station Staffing

A1.31 The operating costs for the proposed NLE operating with a peak frequency of 28 tph and an off-peak frequency of 24 tph is estimated at £8.22m per annum in Q1 2010 prices, with the breakdown presented in Table A.5.

A1.32 The operating costs are in 2012 prices and rebased to real 2010 prices by employing the GDP deflator set out in the Business Case

Development Manual (BCDM) for 2011 and 2012 and a real cost inflation of 1.15% per annum.

A1.33 In the early years of operation, it is assumed that the operating and maintenance (O&M) costs and station staffing costs are constant when the frequency has not reached its end-state. (power being a small component of the overall cost). However, the costs associated with train operators will be lower, reflecting a reduced number of train operators required to operate the lower NLE service frequency. TfL has provided train operator costs for each scenario as set out in Table A.6.

A1.34 A total of 41 additional train operators will be required to operate the NLE by 2031. In addition 29 staff will be required to staff the extension, comprising 10 staff per station at Battersea and Nine Elms, one additional staff member at Kennington and eight reserve staff (who operate flexibly across a group of Northern Line stations including those on the extension).

A1.35 The overall annual operating and maintenance costs by frequency scenario is set out in Table A.7.

Appendix Table A.5 NLE Annual Operating Costs (28 tph Peak / 24 tph off-peak)

Cost Element	Quantity and Cost Driver Unit	Cost £m (2012/13 prices)	Cost £m (Q1, 2010 prices)
Maintenance Cost Breakdown:			
Track	6.6 km	0.77	0.72
Signals	6.6 km	0.46	0.43
Power	6.6 km	0.03	0.03
Civils	6.6 km	0.15	0.14
Vent shafts	4	0.02	0.02
Fleet	5	1.56	1.45
Escalators	10	0.45	0.42
SMVT Lifts	4	0.08	0.08
Stations	2	0.76	0.70
Risk and contingency	10%	0.43	0.40
Maintenance Costs Sub-Total		***4.71***	***4.38***
Train Operators	41	2.74	2.55
Station Staffing	29	1.40	1.30
Total		***8.84***	***8.22***

Appendix Table A.6 NLE Annual Train Operator Costs by Frequency Scenario

Frequency Scenario	Cost £m (2012/13 prices)	Cost £m (Q1, 2010 prices)
16 peak / 20 off-peak (2020)	1.96	1.82
28 peak / 24 off-peak (2022)	2.74	2.55

Appendix Table A.7 NLE Annual Operating Costs by Frequency Scenario

Frequency Scenario	Cost £m (2012/13 prices)	Cost £m (Q1, 2010 prices)
16 peak / 20 off-peak (2020)	8.06	7.50
28 peak / 24 off-peak (2031)	8.84	8.22

Phasing of Operating Costs

A1.36 It is assumed that 50% of the full end-state operating costs will be incurred in 2019, reflecting the operating costs associated with pre-operational training and testing.

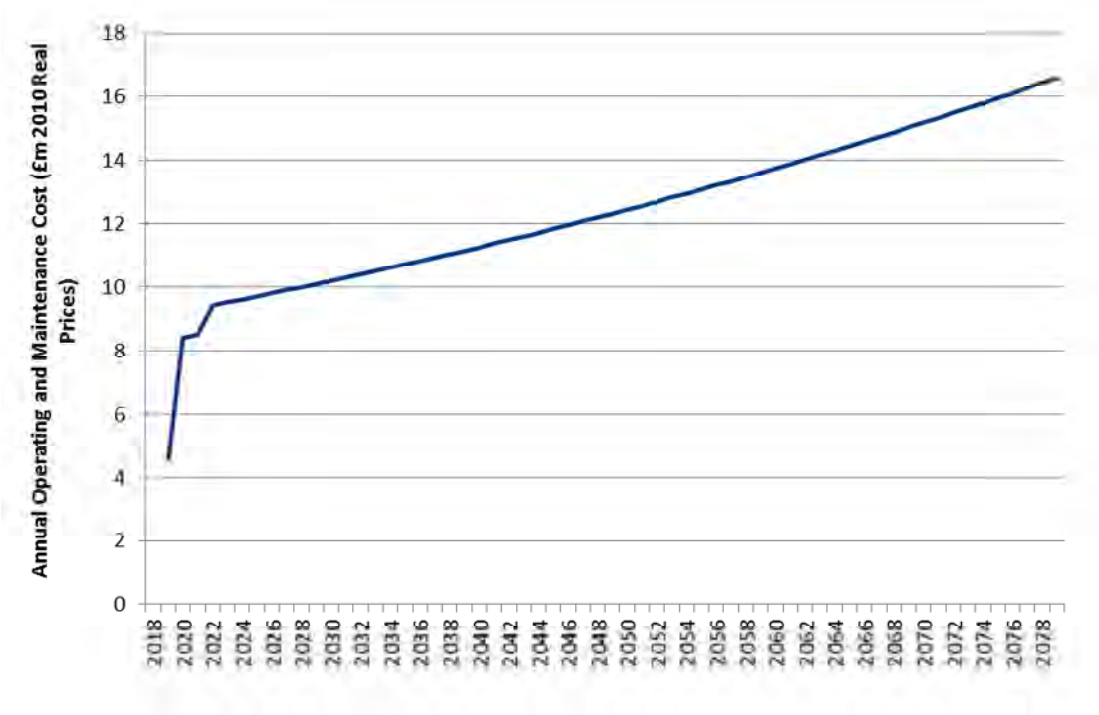
Real Growth in Operating Costs Over Time

A1.37 Operating cost estimates are required for the duration of the appraisal period. Staff wages are assumed to increase at 1.15% pa in real terms (3.65% per annum in nominal terms, based on historical operating cost inflation informed by TfL) between 2010 and 2021, and 1% per annum in real terms thereafter for the remaining duration of the appraisal.

Operating and Maintenance Cost Profile

A1.38 Figure A.2 sets out the incremental operating and maintenance costs in 2010 real prices over the appraisal period.

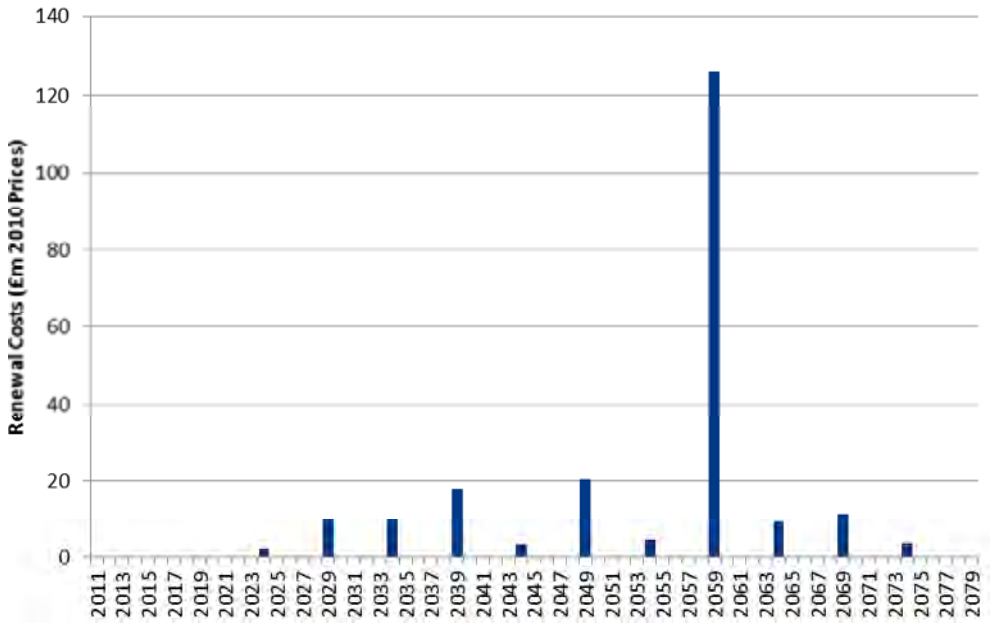
Appendix Figure A.2 Incremental Operating and Maintenance Cost Profile (£m Per Annum in 2010 Real Prices)



Renewal Costs

A1.39 Renewal cost estimates have been based on benchmarked costs for relevant renewal activities. The life-cycle renewal intervals and total renewal costs assumed over the 60-year appraisal period are set out in Figure A.3. The NLE trains and signalling are assumed to be replaced after 40 years, hence the peak in the renewal cost profile in 2059.

Appendix Figure A.3 Renewal Cost Profile (£m 2010 Prices)



A1.40 The costs presented exclude contingency which is applied as a 20% addition to the renewal cost estimates, on the advice of LU. Based on the assumed renewal intervals, the renewal cost spend profile is shown in Table A.8 overleaf.

Real Growth in Renewal Costs Over Time

A1.41 The renewal costs are assumed to be escalated in line with the Tender Price Inflation assumptions, with 1% per annum in real terms (3.5% per annum in nominal terms) assumed beyond 2020. This is consistent with the cost indexation assumptions set out in paragraph **Error! Reference source not found.**.

Appendix Table A.8 Renewal Costs (£m in 2010 Prices)

Asset	Renewal Interval by Renewal Type (Years)				Total Renewal Cost (£m in 2010 prices) Excluding Contingency
	Interim	Mid Life	Whole Life	Replace	
Rail				10	21.5
Conductor Rail		1		10	9.8
Lubricators			10		0.4
Track Drainage					0.0
Points & Crossings				50	1.2
Switches				5	3.9
Point Motors			10		2.9
Signalling System				40	25.3
Area VCC			15		0.2
SMC Servers			5		0.1
Inductive Loop			20		1.3
Axle Counters			15		0.8
Signalling UPS	5	10		20	0.3
Controller Sub Systems					0.0
Rolling Stock	5	10	20	40	80.8
Vent Shaft Fans		20		40	4.2
Pumps		5		10	0.4
Air Con		10	20	40	6.0
Communications		15		30	9.1
Fire	5	10		15	3.6
Electrical LV systems		35			1.1
Station UPS	5	10		15	0.6
Lifts	5	10	15	30	7.1
7m Escalators	5	10	15	40	3.2
13m Escalators	5	10	15	40	3.0
22m Escalators	5	10	15	40	4.2
Station Décor Public		15			11.4
Station Décor non public		20			3.2
Total Renewal Costs					***205.6***

APPENDIX

B

VNEB AREA PLANNING ASSUMPTIONS

B1 VNEB AREA PLANNING ASSUMPTIONS

B1.1 This Appendix sets out the approach employed in developing the planning input assumptions for the Vauxhall Nine Elms Battersea (VNEB) Opportunity Area (OA), for the Without Northern Line Extension (NLE) Scenario and With NLE Scenario, for each of the forecast years of 2020 (NLE opening) and 2031 ('end-state').

2031 Forecast Year

Without NLE Scenario

B1.2 The Without NLE Scenario represents the lower level of development that can be supported without the NLE in place, as set out as part of consented planning permissions for developments in VNEB, including the Grampian conditions[9] for Wandsworth's approval of the Battersea Power Station planning application.

B1.3 The planning data used to support the NLE Business case is based on the actual levels of consented developments of residential units and employment floorspace (in each planning application submission) in the opportunity area, rather than the targets provided in the Opportunity Area Planning Framework (OAPF).

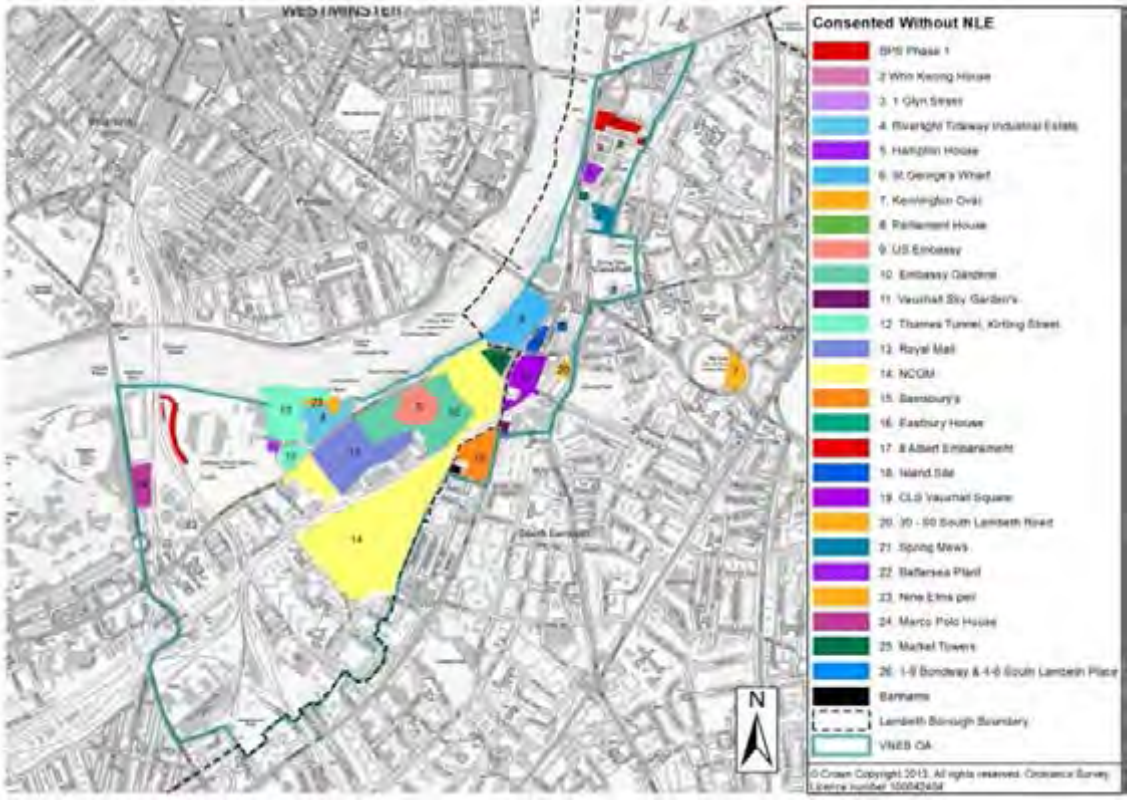
B1.4 A review of planning applications was carried out by Quod for submissions up to February 2013. The Planning review considered the baseline assumptions of population and employment associated with consented planning applications to the end of January 2013.

B1.5 The locations of key consented developments in the VNEB area and the boundary of the opportunity area are presented in Figure B.1. The potential future development and consented development contingent upon the NLE is presented in Figure B.2.

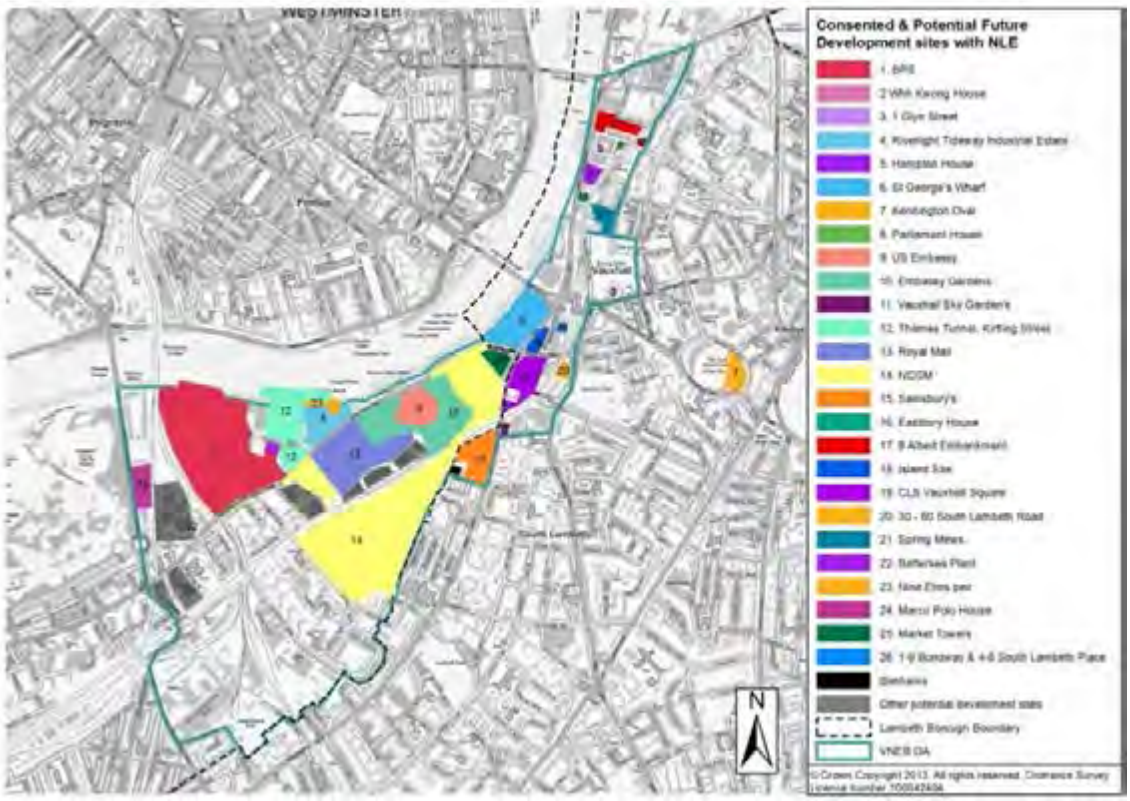
B1.6 The development sites consented for the London Boroughs of Wandsworth and Lambeth by the end of January 2013 are shown in Table B1. These sites have been identified using information from the two councils, from LB Wandsworth's Site Specific Allocation Document and available development briefs for the Christies, National Grid (Gas Holders) and Sleaford Street sites.

[9] These are a set of planning conditions that requires the NLE to be delivered if the Battersea Power Station site is to be developed beyond Phase 1.

Appendix Figure B.1 Consented Developments in the VNEB OA (Without NLE)



Appendix Figure B.2 Potential Developments in the VNEB OA (With NLE)



B1.7 The Without NLE Scenario therefore includes all consented development (those marked 'yes' in Table B.1) within the planning assumptions that underpin the transport and economic modelling.

Appendix Table B.1 Developments with Consented Planning Applications

LB Wandsworth developments	Consented as at 31/01/2013?
BPS	Yes
Tideway	Yes
CGMA	Yes
Embassy Gardens	Yes
Royal Mail	Yes
US Embassy	Yes
49-59 Battersea Pk Rd	Yes
Marco Polo	Yes
Market Towers	Yes
National Grid	No
Patcham Terrace	No
Bookers C&C	No
Brooks Court	No
Cable & Wireless	No
Christies	No
Dairy Crest	No
Gov. Car & Dispatch	No
Met Police Warehouse	No
Securicor	No
Sleaford	No

LB Lambeth	Consented as at 31/01/2013?
Sainsbury's	Yes
Wah Kwong House	Yes
Hampton House	Yes
St Georges Wharf	Yes
Sky Gardens	Yes
Fire Station	Yes
Vauxhall Square	Yes
Glasshouse Walk	Yes
Bondway	Yes
143 Wandsworth Road	No
Blackhorse Road	No
Queensborough House	No
Keybridge House	No
Camelford House	No
5-20 Miles St	No
10-20 Wyvil Road	No
IMO	No
38-46 Albert Embankment	No

B1.8 The level of development included in the Without NLE Scenario is summarised in Table B.2. Figures presented are for the net new development and thus where these developments displace existing residential units and / or jobs.

Appendix Table B.2 Without NLE Scenario – Net New Jobs and population based on Consented Development

	Jobs	Residential units	Population
VNEB OA Development	9,822	12,778	22,647

B1.9 It should also be noted that many of the consented schemes included in the Without NLE Scenario have, in fact, been consented on the assumption that the NLE would come forward. As such, the amount of development that is assumed in the Without NLE Scenario is considered optimistic.

With NLE Scenario

B1.10 The With NLE Scenario includes all consented schemes (as per the Without NLE Scenario), plus the Battersea Power Station development that is contingent upon the NLE to come forward through part of the Grampian Planning Conditions that form part of Wandsworth's Planning approval for the scheme. This additional development permitted with the NLE is shown in Table B.3.

Appendix Table B.3 BPS – Additional Development with NLE

	Jobs	Residential units	Population
Battersea Power Station (Development permitted only with NLE – included in With NLE Scenario only)	13,086	2,419	5,795

B1.11 The With NLE Scenario also includes the remaining sites which have yet to come forward with planning applications (those marked 'No' in Table B.1 and with shaded in grey in Figure B.2). The inclusion of these sites reflects the greater likelihood that these developments will come forward, and at a higher density, with the NLE in place.

B1.12 As baseline assumptions for the remaining sites were not available, employment and population figures were not estimated within the application documents. Therefore assumptions have been made

based on available development briefs by applying standard employment densities to floor space by use class and/ or average household size. Quod has assumed 1.8 persons per unit, - which has been derived by estimating the average household size of the consented schemes.

B1.13 The total VNEB development with and without the NLE is presented in Table B.4.

Appendix Table B.4 Additional VNEB Jobs and population – With NLE vs. Without NLE Scenarios

	Employment (Jobs)	Homes (Units)	Population (People)
VNEB Development without the NLE (from Table B2)	9,822	12,778	22,647
of which BPS Phase 1	*273*	*847*	*2,030*
Additional BPS Development with NLE (from Table B3)	13,086	2,419	5,795
Remaining Sites assumed to come forward with NLE	937	3,168	5,924
Total additional VNEB Development with NLE	14,023	5,587	11,719
Total VNEB Development with NLE	23,845	18,365	34,366

2020 Forecast Year

B1.14 A similar approach has been adopted to the forecasting of 2020. The key difference is that the differential development assumed in the Without NLE and With NLE scenarios is considerably smaller.

B1.15 The development that is expected to take place by 2020 has been assessed as a proportion of the 2031 “end-state” development.

B1.16 The phasing assumptions for each development, based on a phasing study carried out by BNP Paribas (BNPP) Real Estate (February 2012) was used to inform the development of the 2020 development scenario. The BNPP assumptions were only used where other information was not available. For example for Battersea Power Station (BPS), where detailed phasing or Grampian conditions are attached to the planning consent, these were used instead of the BNPP phasing information.

B1.17 The factors were aggregated to LTS model zone. The factors used in the phasing of 2031 developments are provided in Table B.5.

Appendix Table B.5 Summary of 2020 Phasing Factors by LTS Zone

LTS Zone	Major Development in Zone / Area	Jobs	Residential Units
		% of 2031 development in 2020	% of 2031 development in 2020
1300	CGMA	80.2%	23.5%
1301	BPS North	9.3%	39.8%
107	Vauxhall (north)	100.0%	81.1%
1206	Vauxhall (south)	100.0%	65.4%

B1.18 Based on these assumptions, the 2020 development estimates are provided in Table B.6.

Appendix Table B.6 Summary of 2020 Development Assumptions

Scenario	Net Additional Employment (Jobs)	Population (People)
2020 Without NLE	5,576	10,872
2020 With NLE	5,663	13,229
2020 - Additional with NLE	***87***	***2,357***

APPENDIX

C

TRANSPORT MODELLING OVERVIEW

C1 TRANSPORT MODELLING OVERVIEW

C1.1 TfL has a long-established suite of integrated models that are used to inform policy and assess the impacts of major transport schemes and policies in London. The key strategic models TfL supports are:

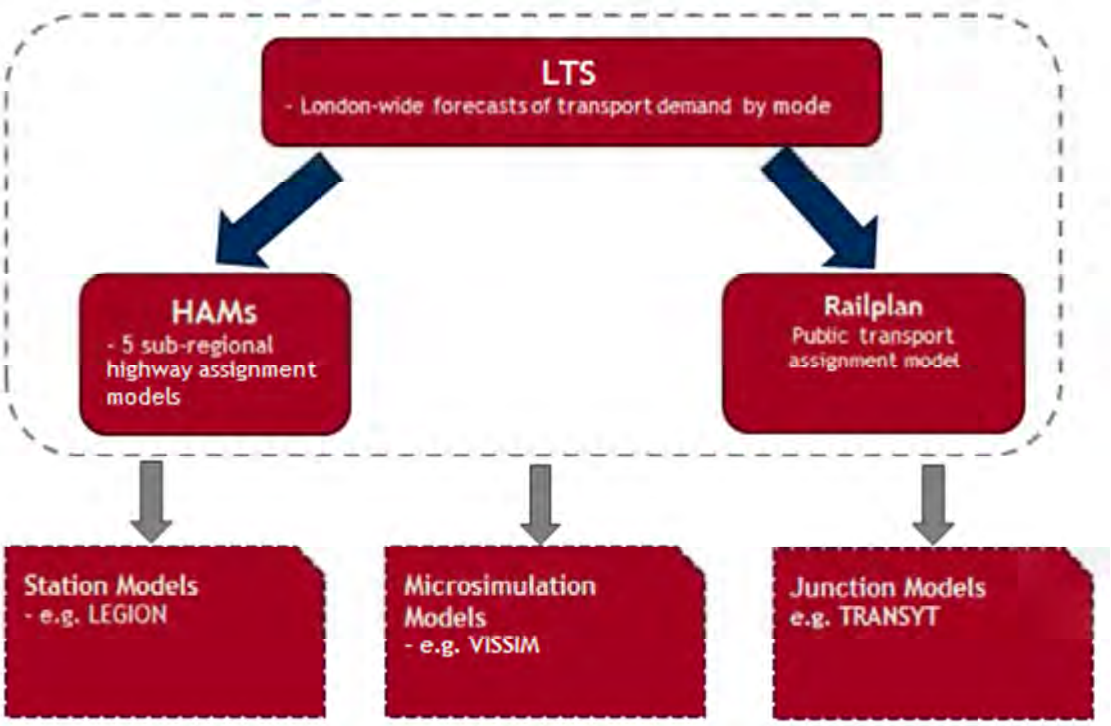
- The London Transportation Studies (LTS) multi-modal model;
- Railplan public transport assignment model; and
- SATURN sub-regional Highway Assignment Models (HAMs).

C1.2 Where appropriate these high-level models provide the key inputs to other localised models for detailed micro simulation modelling, for example LEGION (for pedestrian modelling) and VISSIM/TRANSYT (for detailed highway modelling).

Modelling Framework

C1.3 Figure C.1 shows TfL's suite of integrated models and illustrates the forecasting process for assessing transport interventions,

Appendix Figure C.1 Structure of TfL's Suite of Integrated Models



C1.4 Scheme-specific variants of these models are often developed in order to meet the particular requirements of a specific model application. For example, in the case of NLE, an enhanced version of Railplan has been developed and adopted with additional zoning detail in the VNEB area to reflect the variety of developments that are proposed in the area.

C1.5 The enhanced version of Railplan used for the NLE includes a local area validation to ensure that the base year better reflects observed travel volumes and patterns. The future year models include a more detailed representation of zones and transport connections to ensure the VNEB developments are represented in a sufficient level of detail.

LTS Model

C1.6 The LTS model is a bespoke **strategic-level multi-modal model** developed by TfL. LTS was first developed in 1962. The model has been continuously developed and updated ever since. LTS has been used in the assessment and appraisal of major schemes and policy changes across London e.g. Crossrail, Thameslink, Congestion Charging and River Crossings in east London.

C1.7 LTS is a well-established model framework which reflects all main mode choices. The base year LTS model (2007) includes a detailed representation of the current highway and public transport networks which is frequently updated to reflect current conditions, such as new schemes. For the LTS forecast year models, the representation of future year highway and public transport networks is regularly updated to include all committed future schemes in line with the TfL Business Plan and other spending review elements including any National Rail elements.

C1.8 The “core LTS area” covers Greater London and the remaining areas within the M25 (labelled as “Annulus Area” in Figure C.2). The external model area comprises a “buffer” region covering the Rest of the South East (RoSE) region, alongside a high-level representation of the rest of Britain.

Appendix Figure C.2 LTS Core & External Area Definitions

Source: TfL

C1.9 LTS is underpinned by planning data, using GLA projections of employment and population up to a planning horizon year of 2031. For the rest of the UK, TEMPRO growth projections (based on the latest dataset National Trip End Model (NTEM) version 6.2 which considers the effects of the recent economic recession) have been employed. These are used as planning inputs to the model.

C1.10 LTS has been adopted as the strategic high-level model for the NLE modelling, to ensure consistency with the population and employment assumptions prepared by the GLA (and consistent with the London Plan). In addition, the model includes a representation of future funded and committed transport schemes. This enables the assessment of the impact of the NLE at a London-wide level.

C1.11 The LTS model is a typical multi-modal transport model that comprises the following:

i) Representation of **transport supply** in the form of a **network**. Highway and public transport supply is represented in two separate networks as they support separate assignment processes. For the highway network, a series of interconnected

links represents the road system, where each link comprises a representation of a road's characteristics, including speed, distance and capacity. The public transport network adopts a similar principle, but with additional representation of public transport services, where each service traverses a sequence of links.

ii) In addition, each network also includes a set of **zones**, representing the geographical start and end points of individuals' journeys (e.g. places of employment, homes). The LTS demand model has 1285 zones.

iii) In the LTS highway and public transport models, each zone is connected to the network by one or more centroid connectors.

iv) **Transport demand** is represented in the form of a **demand matrix** i.e. a table that outlines the number of trips made between each pair of zones during a defined time period. Again, highway and public transport demand is represented separately. Also, different types of trips are represented separately e.g. journeys to work, to school, to leisure, etc.

v) An **assignment process** is carried out to **load the matrices (demand) onto the network (supply)**. This process evaluates all feasible routes between each pair of zones before allocating the demand across each viable route. Separate assignment processes are undertaken for highway and public transport. The Highway assignment model takes private vehicle trip matrices (car, taxi, light goods vehicles and other goods vehicles), along with information on bus services and the highway network itself, to estimate the time taken for each journey to be completed. The initial network costs[10] are then updated to take account of network congestion, and then the trip matrices are reassigned in

[10] In modelling terms "costs" refer to generalised journey times (or generalised costs) which are a weighted measure of the individual elements of a particular journey. These consider all elements of the journey - walking to a stop, waiting for a bus or train, in-vehicle travel time, any time spent interchanging and walking from this stop to a final destination). Different elements of the journey are 'weighted' to reflect people's preferences; for example in general people perceive time waiting as les enjoyable that time travelling. The weighting also includes a penalty for time spent in crowded conditions, again reflecting the poor perception, or disutility, that this has for passengers. Generalised costs are used to help calibrate transport models so that models better reflect actual behaviour, as peoples' travel choices (of route, mode) reflects their preferences for different elements of travel. It also underpins the estimation of benefits, where overall utility (the welfare benefit to passengers), reflect their perception of travel costs and the extent to which they value improvements. Changes in generalised journey times are used to estimate benefits for the economic appraisal.

an iterative manner. This process is repeated through a further 39 iterations (i.e. 40 in total) to ensure a stable solution.

vi) Similarly, the Public Transport assignment model uses the public transport person trip matrices, public transport service and network information and bus journey time information (obtained from the Highway model), to estimate the time taken for each public transport journey to be completed. The resultant level of crowding is assessed and the matrices reassigned iteratively. This process is repeated (iterated) a further four times (i.e. five in total).

vii) In addition to the assignment processes, the LTS model includes **mode choice**, where a mathematical formulation (a logit-based equation) is used to forecast the allocation of demand between highway and public transport, and "slow" (walk and cycle) modes - by shifting trips from one matrix to the other based on changes in the relative cost of travel of using each mode. It is this mode choice model, with the aid of the Person-Vehicular Conversion (PVC), that provides the private vehicle and public transport person trip matrices for the assignment models as outlined above.

viii) As noted earlier, the highway and public transport processes are run iteratively (40 times for highway and five times for public transport). In addition, the entire LTS modelling process comprising the demand and assignment models is also executed iteratively through seven full cycles.

C1.12 The assignment processes in LTS are somewhat less detailed than the specialised public transport and highway assignment models (Railplan and the HAMs respectively).

C1.13 The purpose of the LTS assignment process is to provide a reasonable representation of routes taken and generalised costs for the purposes of generating forecasts of demand by mode from LTS. For the detailed public transport and highway demand forecasting, it is necessary to use the more detailed Railplan and HAMs models.

C1.14 A key output of LTS is the provision of demand matrix inputs into the HAMs and Railplan models (outlined later):

- For Railplan, the demand matrix from the LTS public transport assignment is disaggregated into the Railplan zoning system and then adopted into the Railplan model

- For the HAMs, the base year matrix is calibrated independently of LTS with the aid of additional survey data. LTS then provides the increment between base and forecast demand. This difference (or "delta") matrix is converted to HAM zoning, and then from 3-hour peak (0700-1000) period to a single peak hour (0800-0900) demand. The resultant hourly delta matrix is then added to the HAM base year matrix to give the forecast HAM demand matrix for the HAM forecast assignment.

Railplan and CLoHAM Models

C1.15 Detailed forecasts of the impact of NLE on London's wider public transport network were prepared with the aid of a variant of the Railplan model developed for the specific requirements of forecasting NLE. Railplan is a detailed public transport assignment model based on an EMME software platform. The demand used in the variant of Railplan developed for NLE is based on LTS outputs, and is represented in the form of a demand matrix covering 4019 Railplan zones (the standard version of Railplan comprises 4004 zones). The network includes a representation of National Rail, London Underground, London Overground, DLR, bus and tram services within Greater London, alongside a strategic representation of the National Rail network across the rest of Great Britain. The demand matrix is assigned to the network, and the model calculates (through a series of algorithms) the most efficient routing of trips. The addition of a new scheme such as NLE changes the routing options for a number of zone-to-zone movements.

C1.16 The impacts of crowding are represented in Railplan. The seating and standing capacities of public transport vehicles are represented in the model. When demand on a particular service approaches a certain level, Railplan will shift some demand onto alternative less-crowded feasible routes.

C1.17 Railplan is regularly updated and enhanced. The forecasting for the NLE adopted Railplan version 6.2.4.

C1.18 Detailed forecasts of the impact of NLE on London's highway network were prepared with the aid of CLoHAM (Central London Highway Assignment Model). CLoHAM is one of five sub-regional detailed Highway Assignment Models (HAMs) based on a SATURN software platform, development of which commenced in 2010. The five sub-regional HAMs were created for each of the following sub-regions of

London – East, West, North, South and (as adopted for NLE), Central. These models have been calibrated at a local and strategic level. The highway network was also modified to reflect the committed local junction enhancements set out in the BPS TA.

NLE Modelling Overview

C1.19 The modelling of the NLE with the aid of LTS, Railplan, and CLoHAM has been based on:

- Base year models that represent the distribution of population and employment for the base year, and associated travel patterns:
  - The base year is 2007 for LTS and Railplan, and 2009 for CLoHAM. These represent the latest available versions of the model.
  - The NLE base year models for Railplan and CLoHAM have been subject to additional local model validation and calibration, to ensure they represent travel volumes and patterns in the Vauxhall Nine Elms Battersea (VNEB) Opportunity area which is the area of interest.
- The development of the Future Year for the Without NLE scenario: This scenario reflects a future scenario without the NLE, accounting for increases in populations and employment, consistent with the planning application information as set out in Appendix B as well as other planned transport infrastructure improvements, against which the impact of adding the NLE is assessed. This scenario is also referred to as the Without NLE Scenario.
- The development of a With NLE Scenario: The With NLE scenario represents the addition of the NLE scheme to the Without NLE Scenario, plus assumptions on the additional development that will occur if NLE is built, consistent with the planning application information as set out in Appendix B. (and also of the redistribution of forecast future population and employment from London[11] to the VNEB area). The transport benefits of the scheme are estimated by comparing the With NLE Scenarios against the Without NLE Scenario, in the form of changes in generalised travel time.

[11] Further details on the redistribution assumptions is outlined in the Economic & Business Case Main Report, Chapter 4.

C1.20 The NLE demand and benefit forecasts are based on:

- Two forecast years – 2020 representing the NLE opening year[12] and 2031 representing the 'end-state' have been used.
- Forecasts for the morning peak, inter-peak, and evening peak periods. The modelled periods for both LTS and Railplan are:
  - Morning peak – 07:00 -09:59
  - Inter-peak - 10:00 – 15:59
  - Evening peak – 16:00 -18:59
- The modelled periods in CLoHAM are each represented by a single hour. The morning peak model represents the 08:00-08:59 peak hour, the inter-peak is an average hour from the 10:00-15:59 period, and the evening peak model represents the 17:00-17:59 peak hour. In line with DfT guidance, the AM and inter-peak models have been used for the Economic and Business Case.

NLE Scenario Network Assumptions

C1.21 The impacts and benefits of the NLE are determined by the way in which it interacts with the wider transport network. The assessment of NLE needs to take account of the current transport network as well as changes in the transport network that are assumed to have taken place by 2020 and 2031 respectively.

C1.22 The base network in 2020 comprises:

- London-wide network assumptions, reflecting committed and funded transport schemes across London as outlined in the TfL Business Plan that are scheduled to open before 2020. These include, for example, Crossrail and elements of the London Underground investment programme. In particular, Crossrail 1, Northern Line Upgrade 1 and Thameslink upgrade are assumed to be in place by 2020. These are likely to have a significant impact on local and strategic travel patterns.

[12] LTS and Railplan models are available for 5-year intervals up to 2031. The 2021 model has therefore been used as the most appropriate base to represent the 2020 opening year. Forecasts for the year 2021 form a reasonable representation of the transport impacts of the scheme in 2020 on the basis that:

- No major new schemes are proposed to be implemented in 2020 or 2021. For example, Phase 2 of the Northern Line upgrade is scheduled to open in 2022.
- All developments in the VNEB area are consistent with the planning application data for 2020.

- Specific local schemes and enhancements that are assumed to be implemented to support and integrate the development of the VNEB area both with and without the NLE. In particular, the committed station upgrades at Vauxhall LU and NR stations are assumed to be in place prior to the opening of the NLE as they are committed and funded. With regard to unfunded schemes, the key assumption surrounds the provision of local bus enhancements to provide additional capacity and accessibility to serve the planned development. These improvements are consistent with the recommendations contained within the OAPF and BPS planning consent and represent what is required to allow the consented VNEB development to take place in absence of the NLE.

C1.23 The base Network in 2031 comprises all schemes adopted in the 2020 network, and additionally the Northern Line Upgrade 2 (which is expected to open in 2022). It has been assumed that with Northern Line Upgrade 2 in place, the frequency provided on the NLE will increase to 28 tph in the morning peak.

C1.24 A summary of schemes included in the current year, London Plan and With and Without NLE scenarios is provided in Table C.1.

Appendix Table C.1 Network Assumptions

		With London Wide committed schemes		Without NLE		With NLE	
Schemes	**Base**	**2020**	**2031**	**2020**	**2031**	**2020**	**2031**
London-Wide Network Assumptions							
London-wide committed schemes (Crossrail, PPP etc.)	N	Y	Y	Y	Y	Y	Y
NLU Upgrade 1	N	Y	Y	Y	Y	Y	Y
NLU Upgrade 2	N	N	Y	N	Y	N	Y
Walk & Cycle							
Improvements to pedestrian connectivity and severance in the OA;	N	N	N	Y	Y	Y	Y
Improved walk connections to /from NR stations (Vauxhall and Battersea Park)	N	N	N	Y	Y	Y	Y
Pedestrian and cycle bridge	N	N	N	Y	Y	Y	Y
Bus							
Service level increases 20% on all existing OA bus routes	N	N	N	Y	Y	Y	Y
3 New Routes:							
— SW-NE (Balham - Nine Elms - WC1)	N	N	N	Y	Y	Y	Y
— SE-W (Kensington - Battersea - London Bridge)	N	N	N	Y	Y	Y	Y
— NW-SE route using 'Market Link' (an extension of Route P5)	N	N	N	Y	Y	Y	Y
LUL							
NLE Extension	N	N	N	N	N	Y	Y

C1.25 The Without NLE Scenario is the baseline used to assess the impacts of the NLE. In addition to network differences, It should also be noted that the Without NLE Scenario also assumes a lower level of

development, reflecting the fact that part of the consented development in VNEB is contingent upon the NLE. This is set out in Appendix B.

NLE Operational Assumptions

Service Pattern and Frequency

C1.26 NLE services will be provided by extending Charing Cross Branch services that would, as they would do in the future after NLU1 (in the absence of NLE), terminate at Kennington, through to Battersea via a new station at Nine Elms.

C1.27 Prior to the Northern Line Upgrade 2 the assumed frequency provided on the NLE in 2020 will be 16 tph in the AM and PM peaks and 20 tph in the inter-peak. Figures C.3 and C.4 illustrate the AM and inter-peak modelled Northern Line service patterns in 2020.

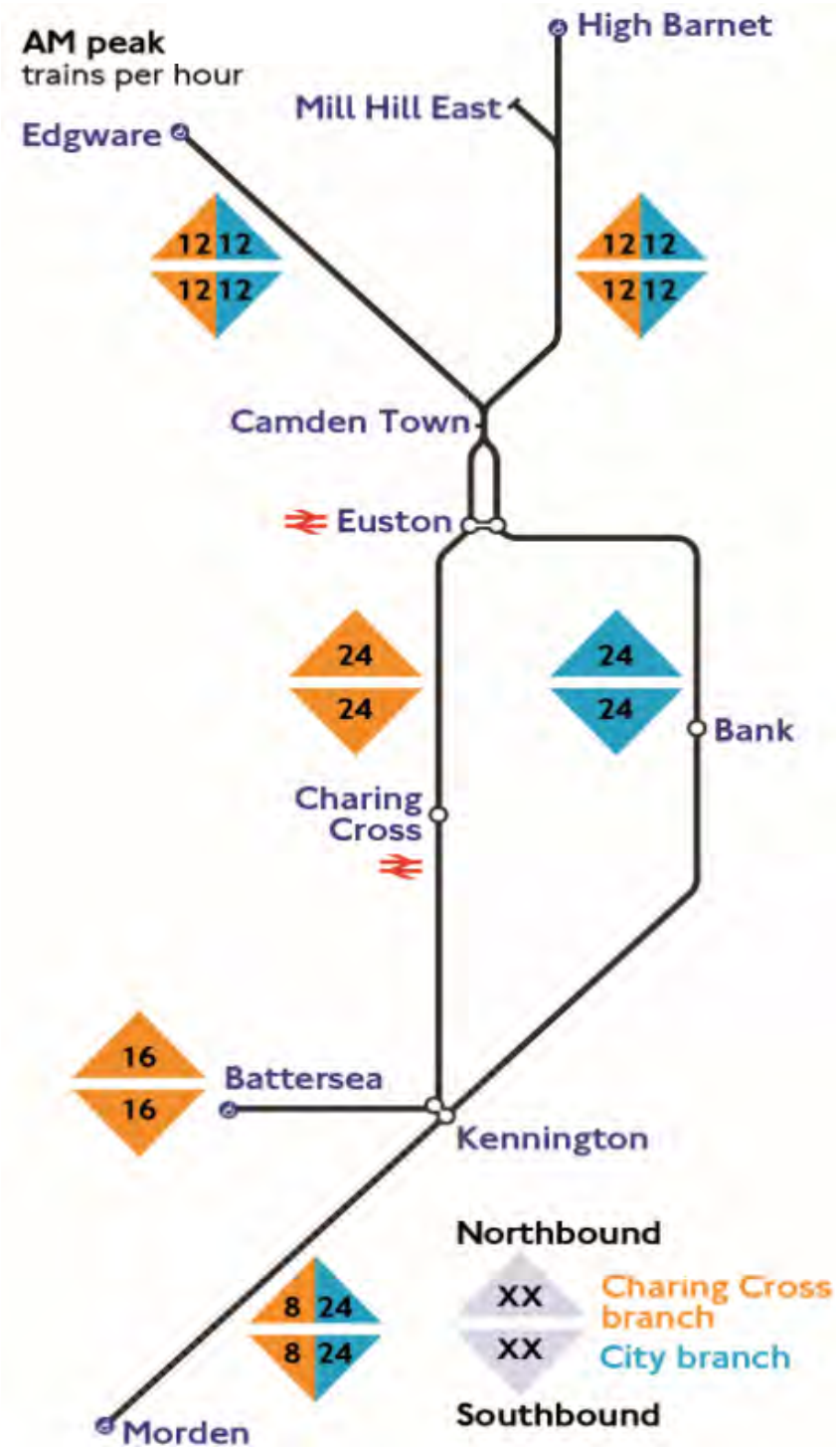
C1.28 With the provision of the Northern Line Upgrade 2, the NLE will in 2031 be able to provide 28 tph in the AM and PM peak and 24 tph in the inter-peak. Figures C.5 and C.6 illustrate AM and inter peak the modelled Northern Line service patterns in the 2031 end-state. Table C.2 summarises the assumed NLE frequencies.

Appendix Table C.2 Assumed NLE Service Frequencies to Battersea

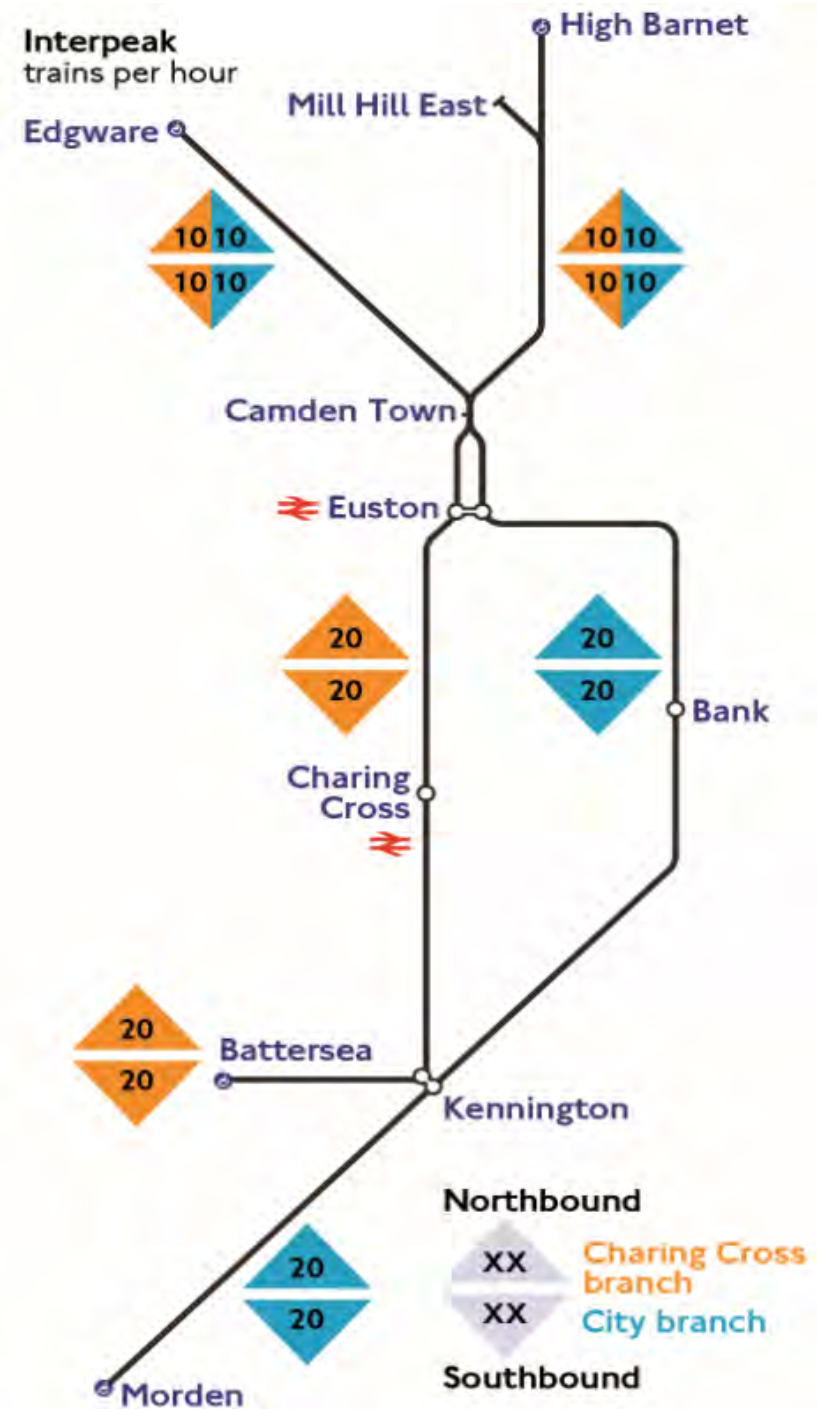
	Peak Period (Trains Per Hour)	Off-Peak Period (Trains Per Hour)
2020 (Opening Year)	16	20
2031 (End-state)	28	24

C1.29 When NLU2 is completed in 2022, it has been assumed that the end-state Northern Line service will be operated.

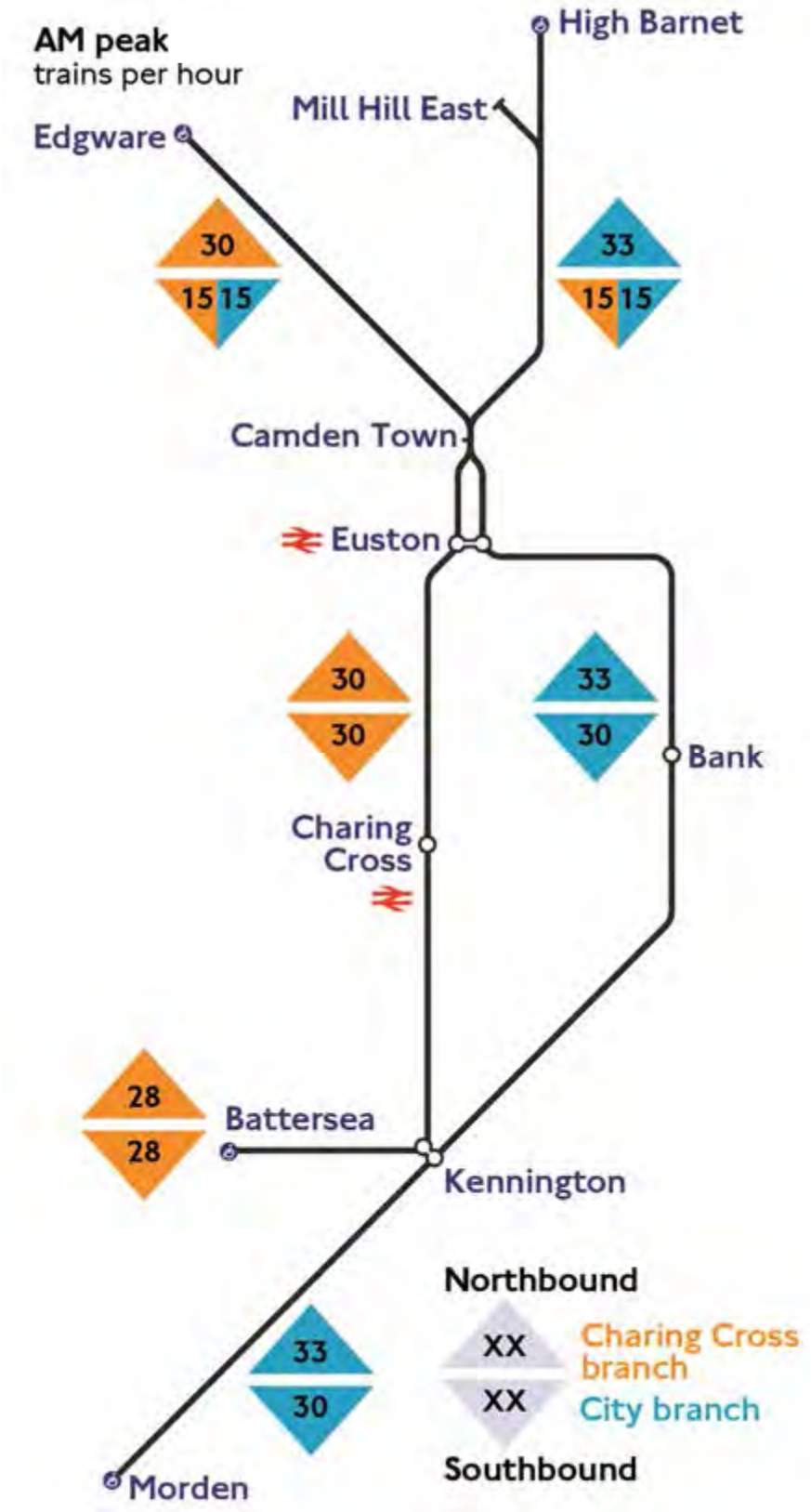
Appendix Figure C.3 NLE Service Pattern and Frequencies in 2020 – AM Peak



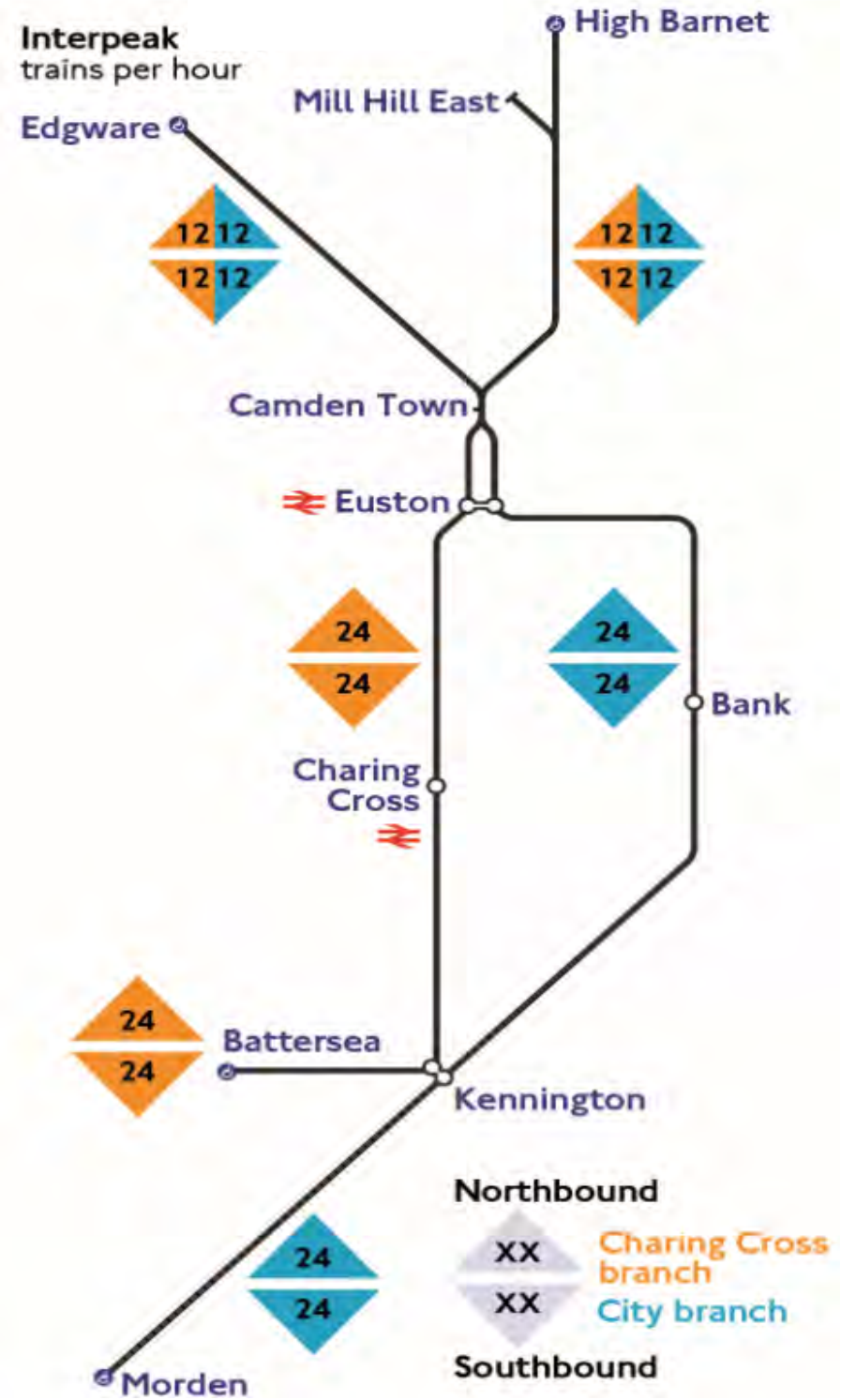
Appendix Figure C.4 NLE Service Pattern and Frequencies in 2020 – Inter-Peak



Appendix Figure C.5 NLE Service Pattern and Frequencies in 2031 – AM Peak



Appendix Figure C.6 NLE Service Pattern and Frequencies in 2031 – Inter-Peak



Journey Times

C1.30 The expected journey times on the NLE are set out in Table C.3 below. These are based on the latest analysis undertaken by London Underground Limited in March 2013. These journey times have been adopted in both 2020 and 2031.

Appendix Table C.3 NLE Journey Times (minutes)

Direction	From	To	Morning Peak (mins)	Inter-peak (mins)
Inbound	Battersea	Nine Elms	2.3	2.2
	Nine Elms	Kennington	3.3	3.3
	TOTAL:		**5.5**	**5.4**
Outbound	Kennington	Nine Elms	3.5	3.3
	Nine Elms	Battersea	2.1	2.1
	TOTAL:		**5.5**	**5.4**

Boarding Penalties

C1.31 The version of Railplan used for NLE (Railplan 6.24) adopts a series of standard boarding penalties by public transport mode, as follows:

- Rail & Underground: 5 generalised minutes
- Bus: 7.65 to 9 generalised minutes

C1.32 At some individual stops, the penalties were varied from the standard modal values outlined above to reflect specific local conditions. For example, some Underground stations adopted lower values to reflect the greater attractiveness of the station environment and the ability to get a seat, particularly in the northbound direction.

C1.33 The two new NLE stations (Nine Elms and Battersea) adopted values of 3.5 generalised minutes each, to reflect the fact that the stations will be brand new, constructed and designed to modern standards.

C1.34 The boarding penalties employed for nearby London Underground stations are as follows:

- Kennington: 2.5 generalised minutes
- Stockwell: 2.0 generalised minutes
- Oval: 3.5 generalised minutes

C1.35 When compared against the adopted boarding penalties for surrounding stations in the VNEB area, the value of 3.5 generalised minutes for the two new NLE stations is considered conservative. This

is on the basis that the penalties at the new stations are no lower than the penalties given to nearby existing stations, despite the superior station environment and facilities.

APPENDIX

D

WIDER ECONOMIC IMPACTS

D1 INTRODUCTION

D1.1 This Appendix outlines the process for estimating the economic impacts of the Northern Line Extension (NLE) in relation to the strategic context of the economic development and regeneration of the Vauxhall Nine Elms Battersea (VNEB) Opportunity Area (OA), a planned new sustainable residential, business and leisure district. It has been informed by the guidance from HM Treasury, the Department of Communities and Local Government (DCLG) and the DfT for estimating economic impacts. The document explains how these have been applied.

D1.2 The document shows how the NLE achieves its primary aim of encouraging economic growth in London and the wider UK economy through the extension of London's Central Activities Zone (CAZ).

D1.3 The primary aim of the expansion of London's CAZ is also reflected in the economic assessment of the NLE, in that it informs the assumptions that underpin the modelling approach. This will be discussed in more detail later in this Appendix.

D1.4 Throughout this document, the assessment of the economic impacts in the two approaches that have been used is based on a Without NLE scenario compared to a With NLE . The definition of the With and Without NLE scenarios is based on the analysis of planning applications as described in Appendix B. This assesses the assumed level of VNEB development with and without the NLE, which is based on the following:

- The Without NLE Scenario includes all consented development up to February 2013.
- The With NLE Scenario includes all consented development (as per the Reference Case) plus:
  - additional development at Battersea Power Station that is dependent on the NLE via Grampian conditions imposed as part of the planning consent; and,
  - additional housing and employment associated with remaining (i.e. currently unconsented) development sites that would be more likely to come forward with the NLE.

D1.5 Further information about the status of these development sites can be found in the NLE Environmental Statement and Appendix B of the Economic and Business Case.

D1.6 The total development in the With NLE and Without NLE scenarios is presented in Table D.1. It should also be noted that many of the consented schemes included in the Without NLE Scenario have, in fact, been consented on the assumption that the NLE would come forward. The table shows that the NLE will enable an additional 14,000 jobs at standard density assumptions for this type of development.

Table D.1 Additional VNEB Development – With NLE vs. Without NLE Scenarios

	Employment (Jobs)	Homes (Units)	Population (People)
VNEB Development Without the NLE	9,822	12,778	22,647
of which BPS Phase 1	*273*	*847*	*2,030*
Additional BPS Development with NLE	13,086	2,419	5,795
Remaining Sites assumed to come forward with NLE	937	3,168	5,924
Total additional VNEB Development with NLE	**14,023**	**5,587**	**11,719**
Total VNEB Development with NLE	**23,845**	**18,365**	**34,366**

D1.7 The rest of this Appendix is structured as follows:

- Firstly, the economic value of the developments that are proposed in the VNEB OA is estimated using a planning-based approach as laid out in the DCLG's guidance;
- Secondly, a background of the DfT guidance relating to the estimation of Wider Economic Impacts (WEIs) of transport interventions is provided;
- Thirdly, the scenarios that will be assessed and the assumptions that underpin the WEI estimates and the background to the sensitivities is explained; and
- Finally, the results of the analysis - including the range of sensitivities that have been tested, is presented.

D2 PLANNING APPROACH TO ESTIMATING THE ECONOMIC VALUE OF THE DEVELOPMENTS AT VNEB

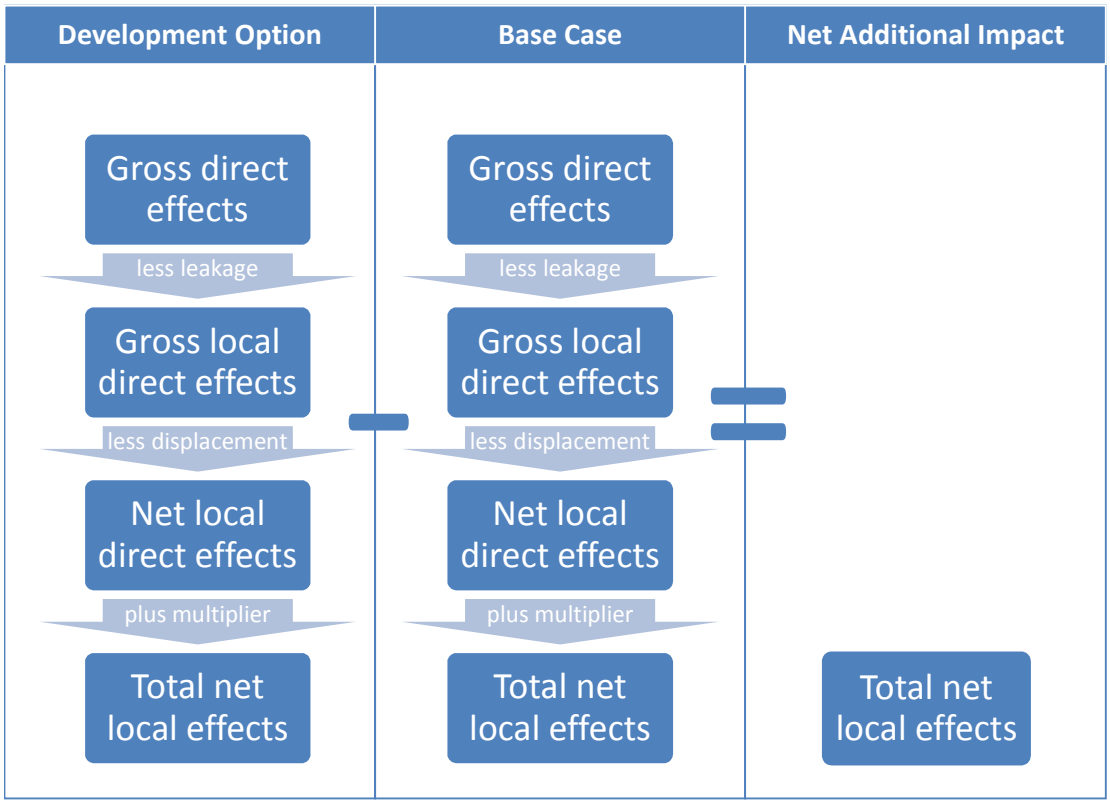
D2.1 One of the commonly-used approaches to analysing the impacts of a development is to consider economic benefits net of displacement. There is a standard methodology that is provided by the DCLG and set out in the English Partnership Guidance, which is widely used in socio-economic impact assessments as part of environmental statements.

D2.2 This provides one method of considering the additional economic benefit of the investment, and is a good sense check on more sophisticated approaches.

D2.3 The key components of the methodology for assessing the additional impact of developments or interventions include the following:

- **Direct effects** - an estimate of the overall impacts of implementing a certain scheme, including immediate, consequential and induced effects;
- **Leakage effects** - an estimate of the effects on those outside of the target area. These should be deducted from the direct effects at the assumed proportion of leakage for each case. It is important to note that impacts outside the target area should not be ignored, but must contain the caveat that they are not related to the desired area;
- **Displacement effects** - an estimate of those impacts that are transferred from elsewhere within the target area. These should be deducted from the direct effects at the assumed proportion of displacement for each case;
- **Substitution effects** - when one activity is a replacement for a similar one. Impacts which have been substituted should be deducted from the direct effects. For example, when an employee is hired but another loses their job; and,
- **Multiplier effects** - activity associated with additional local income, local supplier purchases and longer term development, such as through supply chains and expenditure on other activity. These need to be added to the direct effects.

Figure D.1 Detailed overview of the methodology (adapted from the Additionality Guide)



D2.4 It is not necessary that every intervention (or development) encompasses all of these effects. Rather, the English Partnership's guidance allows for the identification of the effects that are relevant to the specific intervention. Accordingly, the following assumptions in this assessment has been made:

- **Displacement:** a very conservative displacement figure of 75% has been assumed. This is based on the tables that are provided in the English Partnerships Guide. This figure is suggested when there is a high level of displacement expected due to the intervention. Table D.2 below shows the 'ready reckoners' that are related to displacement effects as per the English Partnerships guidance.
- **Multiplier:** given the strong supply chain linkages and connectivity in London, a multiplier of 1.7 has been assumed. This is based on the tables and analysis provided in the English Partnerships Guide. Table D.3 below shows the 'ready reckoners' related to multiplier effects as per the English Partnerships guidance.

No **leakage** effects are taken into account since in the context of property developments, these primarily relate to the leakage of earnings to outside of the study area. However, the impacts of the developments in the VNEB OA are assessed in relation to their contribution to the economies of London and the UK as a whole. Accordingly, it is not necessary to take account of the leakage outside of VNEB.

Table D.2 Displacement ready reckoners from the English Partnership Guidance (from the Additionality Guide)

Level	Displacement	Effect
None	No other firms/demand affected	0%
Low	There are expected to be some displacement effects, although only limited	25%
Medium	About half of the activity would be displaced	50%
High	A high level of displacement is expected to arise	75%
Total	All of the activity generated will be displaced	100%

Table D.3 Multiplier ready reckoners from the English Partnership Guidance (from the Additionality Guide)

Level	Multiplier	Regional multiplier
Low	Limited local supply linkages and induced or income effects	1.3
Medium	Average linkages	1.5
High	Strong local supply linkages and income of induced effects	1.7

D2.5 No **substitution** effects are taken into account given that there is no public investment required in the specific real estate developments in the VNEB OA. To complete the assessment, the following assumptions have been made:

- **GVA per worker:** £70,602 in 2021, which is in 2010 prices and projected into the future based on an increase 0.1% in 2011, -0.7% in 2012 and 2% per year thereafter (the same as the assumptions used for productivity growth in the DfT guidance). This is also based

on GVA per worker in London as a whole, not just Inner London, so this is a conservative assumption.

- **Phasing schedule**: operational period starts in 2021 and commercial developments are completed by 2026 – this is based on the analysis carried out by BNP Paribas, which also forms the basis of the assessments of the wider economic impacts and the transport user benefits.
- **Development scenarios:** reference case is Without NLE Scenario and the alternative case is With NLE Scenario – this is based on the analysis in the previous section and will also form the basis for the scenario analysis in the other assessments, including the wider economic impacts and the transport user benefits.

D2.6 Based on the above, the gross value of the additional jobs in the With NLE Scenario is around £1.3 billion per year compared to the Without NLE scenario. Taking into account the displacement and multiplier assumptions detailed above, the With NLE Scenario delivers a net additional value of £400 million per year over the Without NLE Scenario.

D2.7 The present value of this net additional benefit to the London and UK economies over a 60 year period is estimated to be £6.7 billion.

The estimate provides a more comprehensive valuation of the likely economic benefits from the developments at VNEB than the one provided in the appraisal sections that follow. The latter, based on the DfT's transport appraisal guidance (as set out in WebTAG) provides an estimate of the additional economic impacts due to a specific transport intervention that are not captured by the standard benefits to transport users, excluding any developments in the affected areas.

D3 THE DFT APPRAISAL APPROACH FOR ESTIMATING WIDER ECONOMIC IMPACTS

The DfT Guidance

D3.1 The analysis in this section is based on the transport appraisal methods that relate to the estimation of the Wider Economic Impacts (WEIs), described in the DfT guidance – WebTAG units 2.8: Wider Impacts and Regeneration and unit 3.5.14: The Wider Impacts Sub-Objective. The DfT guidance follows the HM Treasury's Green Book: Appraisal and Evaluation in Central Government.

D3.2 The DfT guidance explains that, in the presence of imperfect markets, WEIs are not captured by the transport user benefits and must therefore be estimated separately. In a perfect market, the value of the benefits of transport schemes can be captured through the impact on transport users, through time savings, frequency improvements, and reductions in delays and accidents. However, since real world scenarios do not involve perfectly competitive conditions, other methods of appraising the impact of a project have been explored.

D3.3 In its report Transport and the Economy (DETR, 1999), the Standard Advisory Committee on Trunk Road Assessment[13] (SACTRA) noted that markets are often imperfect, which means that Wider Impacts (WIs), positive and negative, may result via direct user impacts being amplified through the economy. Accordingly, appraising only the direct user impacts means that some economic impacts would be missing from the appraisal and the cost-benefit analysis might not give an accurate of full estimates of the costs and benefits of a scheme.

D3.4 The Eddington Transport Study (DfT, 2006) estimated these impacts and noted that in some cases they can be significant, and are therefore an important part of the overall cost benefit assessment. Such impacts would include productivity and welfare changes associated with the impact of transport on agglomeration and labour supply. The WEIs appraisal aims to capture these effects, positive or negative, that result from market failure.

D3.5 Guidance from the DfT on WEIs is intended to quantify the additional economic impacts of transport improvements upon business and workers' productivity and the resulting increase in output. WEIs are completely additional to standard transport user benefits. Therefore,

[13] SACTRA is an independent committee appointed by the Secretary of State for Transport to advise on issues related to the appraisal of trunk roads.

including WEIs in the appraisal of a transport scheme can completely alter the benefit-cost ratio (BCR) of a project.

D3.6 The WEI guidance emerged following a previous investment of a similar type to the NLE, namely Crossrail 1, which increased the accessibility to a single key business area (CAZ). The approach is most appropriate for assessing the benefits of relieving (commuting) capacity constraints into productive city centres or improving accessibility in poorly served locations.

D3.7 For this reason, it is very relevant in the context of the extension of the Northern Line since this will also relieve capacity constraints into central London. In addition to this, it opens up a part of London (VNEB) which has to date been constrained from becoming part of the Central Activities Zone (CAZ) as a result of its low accessibility. Figure D.2 illustrates the boundaries of CAZ and the VNEB OA.

Appendix Figure D.2 London's Central Activities Zone (VNEB highlighted in red)

D3.8 There are a variety of WEIs, including:

- Pure agglomeration;

- Move to more or less productive jobs;
- Increased output in imperfectly competitive markets; and,
- Improved labour force participation.

D3.9 Experience of other transport projects shows that the first two of these impacts are the most significant. For this reason, the analysis focuses on these.

Pure Agglomeration

D3.10 The concept of agglomeration refers to the concentration of economic activity over an area. Transport can act to increase the accessibility of an area to a greater number of firms and workers, thereby impacting on the level of agglomeration.

D3.11 The DfT guidance provides a methodology for estimating the impact of transport on agglomeration and the resulting impact on UK welfare. Agglomeration has an impact on UK welfare through its impact on productivity and UK Gross Domestic Product (GDP). Higher UK GDP would provide a means to allow for higher UK consumption, thereby impacting on welfare.

D3.12 As set out in the DfT guidance, the level of agglomeration in a location is a function of the proximity of businesses to one another and to workers, which means that the relevant measure of agglomeration (effective density) is the generalised cost for businesses and commuters. The first step in estimating agglomeration impacts is therefore to calculate the average generalised cost for the transport users.

D3.13 The generalised costs for the transport users should be estimated for the base case without the scheme intervention and for the alternative case, where the transport scheme has been implemented (i.e. the Without NLE and With NLE Scenarios). The generalised costs can then be used to estimate the effective density in each of the scenarios.

D3.14 Once this is done, the likely productivity response for the change in the level of agglomeration between the base and alternative case is estimated by applying an elasticity of productivity (with respect to effective density). This done by taking the relative changes in productivity by sector as a result of changes in agglomeration, the absolute changes in productivity are estimated according to the GDP and employment for the sectors in the areas being assessed.

D3.15 This gives an estimate of total output for each sector and each area. The resulting agglomeration impact is then summed across all origin

areas and sectors to give the total agglomeration impact across the modelled area for each modelled year.

D3.16 The equation below summarises the DfT's guidance on estimating pure agglomeration impacts:

$$WI1_i^{k,f} = \left[\left(\frac{d_i^{A,k,f}}{d_i^{B,k,f}} \right)^{\rho^k} - 1 \right] GDPW_i^{B,k,f} E_i^{B,k,f}$$

$$WI1^f = \sum_{i,k} WI1_i^{k,f}$$

Where:

$WI1_i^{k,f}$	are the sectoral agglomeration impacts for each area ***i*** and sector ***k***. They will vary depending on the forecast year, ***f***.
I	WI1 is estimated for each origin area ***i***, where ***i*** is the Local Authority District (LAD).
K	is the industrial sector, with the sectoral groups as defined by DfT to be Manufacturing, Construction, Consumer Services and Producer Services. Detail on the definition of these sectors in terms of Standard Industrial Classifications can be found in TAG Unit 3.5.14.
F	is the forecast year
$d_i^{A,k,f}$, $d_i^{B,k,f}$	are the effective densities of origin areas ***i*** sector ***k*** in the alternative case (A) and the base case (B) respectively, to be calculated. This will vary depending on the forecast year, ***f***.
ρ^k	is the elasticity of productivity with respect to effective density for sector ***k***. this will not vary with the forecast year. ρ^k is for the sectoral groups defined below.
$GDPW_i^{B,k,f}$	is the GDP per worker of LAD area ***i*** sector ***k*** in the base case (B). This will vary depending on the forecast year, ***f***.
$E_i^{B,k,f}$	is total employment in sector ***k***, origin area ***i*** in the base scenario (B). This will vary depending on the forecast year ***f***.
$WI1^f$	are the total agglomeration impacts for all sectors k and areas I, to be calculated for a specific forecast year.

Move to more productive jobs

D3.17 'Move to more productive jobs' (M2MPJs) measures the productivity benefits of existing workers being able to move into more productive forms of employment as a result of a transport investment. The role of a transport intervention in this case is that transport costs are likely to affect the overall costs and benefits to an individual from working in different locations and the benefits to business of operating and employing people in these different locations

D3.18 In order to estimate any benefits that result from existing workers moving into more productive forms of employment, it is necessary to measure where jobs could be located and how productive they would be both with and without the transport investment. Jobs could relocate from a location where they were less productive to a location where they are more productive but it could of course work the other way round where jobs could move to places where they could be less productive.

D3.19 In the case where they move to more productive employment, this means that this values the net increase in productivity of a worker and does not allow for any of the jobs to be completely new, or gross. In essence, M2MPJ is a large improvement in productivity applied to a relatively small number of workers.

D3.20 The estimation of the M2MPJs is carried out in two parts: first, by modelling the impact on the transport scheme on the location of employment; and second, by estimating the impact of the changes in employment location on productivity.

D3.21 An index of productivity differentials for Local Authority Districts (LADs) is used to estimate the productivity impact from modelled employment. For each LAD, the M2MPJs impact is estimated by multiplying the change in employment in the area resulting from the transport intervention with the indexed ‘GDP per worker’ in the area and summing across areas. The output of this step is the change in total output from the M2MPJs effect, for each year.

D3.22 The equation below summarises the DfT’s guidance on estimating M2MPJs impacts.

$$GP3^{f} = GDPW^{N,f} \sum_{i} \left(E_i^{A,f} - E_i^{B,f} \right) PI_i$$

Where:

$GP3^{f}$	is the move to more/less productive jobs impacts of the alternative case (A) compared with the base (B), to be calculated. This will vary depending on the forecast year, ***f***.
$GDPW^{N,f}$	is the national GDP per worker. This will vary depending on the forecast year, ***f***.
$E_i^{A,f} - E_i^{B,f}$	are total employment in the Local Authority District (LAD) ***i*** in the alternative case (A) and the base case (B). These will vary depending on the forecast year ***f***.
PI_i	is the index of productivity per worker in LAD area ***i***. this will not vary depending on the forecast year, meaning that it is assumed there is no technical progress.

D3.23 It should be noted that the DfT guidance recommends that WEI estimates should be carried out when a Land Use Transport Interaction (LUTI) Model is available. LUTI is a modelling framework which tries to estimate the impact of a particular transport investment on the demand for different land uses. It is recommended by the DfT as a way of looking at such impacts, although other methodologies are also under review.

D3.24 A model of this kind is available for London - known as LonLUTI. It uses the outputs from a transport model to define how land use might change given the existing economic characteristics of the area.

D3.25 However, the LUTI model is not considered to be appropriate in this case. This is because the developments and land use changes within the VNEB area (both with and without the NLE) are already well known so this precursor analysis has already been supplied. Accordingly, it would not make sense to use a modelling framework, such as a LUTI, to estimate outputs that are already available in the real world.

D3.26 In addition, the objective of the NLE investment is precisely to change the economic characteristics of the area and ensure that the VNEB area reaches the density and productivity of the CAZ. The approach used in LUTI largely ignores any such effects. It is primarily concerned with the movements of jobs and households due to the specific transport intervention rather than the other way round – where the scheme is specifically designed to enable development through improving accessibility to an area.

D4 THE ASSUMPTIONS UNDERPINNING THIS APPRAISAL

D4.1 To carry out this appraisal, the technical DfT guidance in conducting similar assessments has largely been followed. Guidelines set out in the HM Treasury's Green Book for appraising proposals have also been used. This is specifically related to the strategic case of proposals and the details of how this applies to the NLE are set out in the main body of the Economic and Business Case.

D4.2 As required by the DfT guidance, the data provided in WebTAG unit 3.5.14 and the equations described in section D.2 of this Appendix were used to carry out the estimation of the WEIs.

D4.3 However, in two specific areas, alternative assumptions have been used where the guidance was not considered entirely appropriate in the context of the NLE. As detailed in the Economic and Business Case, these fall within the Green Book's guidance for appraisals. In addition, the DfT guidance allows for the assumptions to be refined if there is a good reason to do so and that such refinements are clearly stated.

D4.4 The areas where it is appropriate to refine the assumptions in the DfT guidance are the following:

- The level of net additionality; and,
- The productivity of workers in VNEB.

D4.5 Sensitivity tests have been undertaken to assess the impact of these assumptions if 'net additionality' and productivity assumptions were compliant with the DfT guidance. In both cases the results of the sensitivity test does not change the conclusion of the economic appraisal.

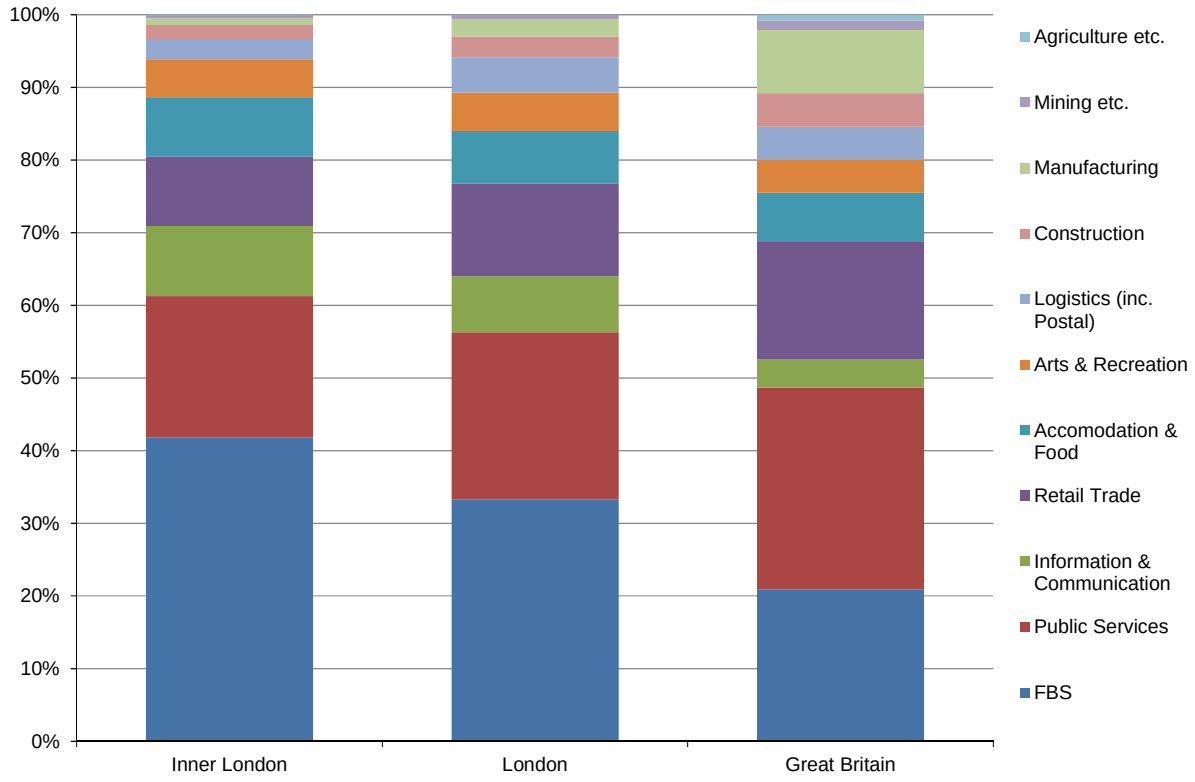
Net Additionality

D4.6 The DfT guidance stipulates that the economic impacts of transport intervention are not the result of a change in the size of an economy. This imposes the restriction that there is no additional employment due to the transport scheme that is being appraised.

D4.7 However, it is expected that a significant amount of the employment generated by the VNEB OA will come through inward investment. London is the UK's only global city and it competes with other major global centres for business and workers. As shown in Figure D.3, the characteristics of employment in London are fundamentally different to

those in the rest of the country, in particular having a higher proportion of workers in Financial and Business Services (FBS) and Information and Communication. Employment in the Inner London boroughs (where the CAZ is located) is also different to the capital as a whole.

Figure D.3 Employment by sector, %



D4.8 This is reflected in London's contribution to the UK's economy which accounts for over a fifth of the country's total output measured by Gross Value Added (GVA), but only 16% of total UK employment, highlighting the high productivity of the city's employees compared to other parts of the country.

D4.9 Central to London's economic performance are the activities in its Central Activities Zone. Its importance to the economies of London and the UK is a whole is highlighted through its contribution to overall output. While GVA data are not available at a district level, it is available for NUTS3 regions (defined as groups of upper tier authorities or lower tier authorities – such as unitary authorities or districts, including London boroughs). Inner London as a whole (where the CAZ is located) accounts for 70% of London's GVA, or 15% of the UK's total.

D4.10 The unique characteristics of London's economy suggest that a significant proportion of jobs could come from both inward investment

and the relocation of jobs from other parts of the world. Indeed, research by Cushman and Wakefield[14] has shown that London has the highest levels of foreign direct investment (FDI) of any city in the world, reflecting its importance to the city's economy. FDI has been a key driver of economic growth in London, generating 42% of the city's economic growth between 1998 and 2004, as well as 29% of its increase in earnings and the majority of its new jobs. Overall, FDI has generated more than 500,000 jobs, or 13% of all employment, in the city.

D4.11 Accordingly, for the With NLE central scenario, a figure of 13% was considered an appropriate estimate for the proportion of net additional jobs in the VNEB OA due to the NLE. However, and bearing in mind that such estimates are uncertain, a range of 0% to 20% of net additional jobs has been tested.

Productivity of workers in the VNEB OA

D4.12 As discussed earlier in this Appendix, a central theme of the VNEB OA is that it is an essential part of an extended CAZ. This has implications for the productivity assumptions that are used in the estimation of the WEIs for both the Pure Agglomeration and the M2MPJs.

D4.13 The DfT guidance provides assumptions on the productivity of each local authority, which are based on their current economic activities. These are presented as GDP per worker by sector for the Pure Agglomeration analysis and as a Productivity Index for the M2MPJs.

D4.14 The developments that are expected in the VNEB OA will change the economic characteristics of the area. Accordingly, it is not appropriate to consider the current productivity of London Borough of Wandsworth as an indication of the economic activities that will be present in the VNEB OA as productivity will increase upon completion of these developments.

D4.15 Indeed, the current mix of employment activity within VNEB does not reflect the type of businesses that are likely to be located within the OA following development with the NLE. Accordingly, a productivity estimate that is based on data provided by the DfT guidance for Inner London has been used. This would reflect more accurately the type of activities that will be present in the VNEB OA.

D4.16 It should be noted that this is not strictly CAZ since the DfT data are only available at borough level. This is therefore a conservative

[14] Cushman and Wakefield (2011) Winning in Growth Cities 2011/12

estimate since it is representative of Inner London (including central London) as a whole. The productivity of the CAZ itself is still even higher as shown by the productivity of City of Westminster and the City of London. Overall, Inner London should reflect CAZ productivity to a certain extent and is certainly more accurate than the values given for these individual boroughs.

D4.17 In relation to the M2MPJ analysis, the DfT's approach uses a Productivity Index (PI) which has been estimated by a method designed to pinpoint the productivity element which is purely impacted by location. The methodology uses a standard wage equation regression framework, which relates hourly earnings data to gender, age, skills, sector, location, etc. These impacts cannot be separated out in this way. This implies that skills and industries would still exist and be used elsewhere to the same effectiveness, thus narrowing the margin for place based impacts. However, as shown earlier, the nature of economic activities is fundamentally different across locations, such as the difference between the CAZ and other areas.

D4.18 Accordingly, an adjustment was made to the Productivity Index for Wandsworth based on the economic data provided by the DfT. A weighted-average of the Productivity Index that is derived from all the Inner London boroughs (weighted by employment) was used for Wandsworth where the VNEB OA is located. The underlying data are sourced from the DfT guidance.

D4.19 It must also be highlighted that because the values used to derive the CAZ productivity include the entirety of these boroughs, this figure includes contributions from areas which will be less productive than the VNEB OA and similar high productivity central locations. Only The City and Westminster are entirely inside the CAZ. This again means that any estimates derived in this manner should be viewed as conservative.

D4.20 Similarly, in relation to the Pure Agglomeration analysis, a weighted-average GDP per head for Inner London boroughs for each of the four industrial sectors was used. Nonetheless, in both cases, the exact data provided in the DfT guidance was used as a sensitivity.

Other Assumptions Related to the Pure Agglomeration Analysis

D4.21 In line with DfT guidance, the effective densities have been calculated for all local authorities and sectors in the With and Without NLE scenarios using generalised costs which have been aggregated up to LAD level from the modelled transport zones using appropriate

weights. These generalised costs are based on the NLE transport models for each of the scenarios.

D4.22 All data used in the modelling has been taken from the DfT economic dataset, version 2.4 (July 2012). This data includes:

- Employment by sector for manufacturing, construction, consumer services & producer services;
- GDP per worker for the same four sectors; and,
- Agglomeration elasticities & distance decay parameters.

Other Assumptions Related to the M2MPJ Analysis

D4.23 The M2MPJ impacts are calculated using the DfT formula set out in the previous section. Details of the required assumptions are set out below:

- Operational start year: 2020-21 and commercial developments completed by 2026;
- Development scenarios: Based on the Without NLE Scenario (for the base case) and With NLE' Scenario (for the alternative case); and,
- GDP per worker: £53,856 – as per DfT guidelines for the UK's GDP per worker in 2021 at 2010 prices.

Scenario Definition and Sensitivities

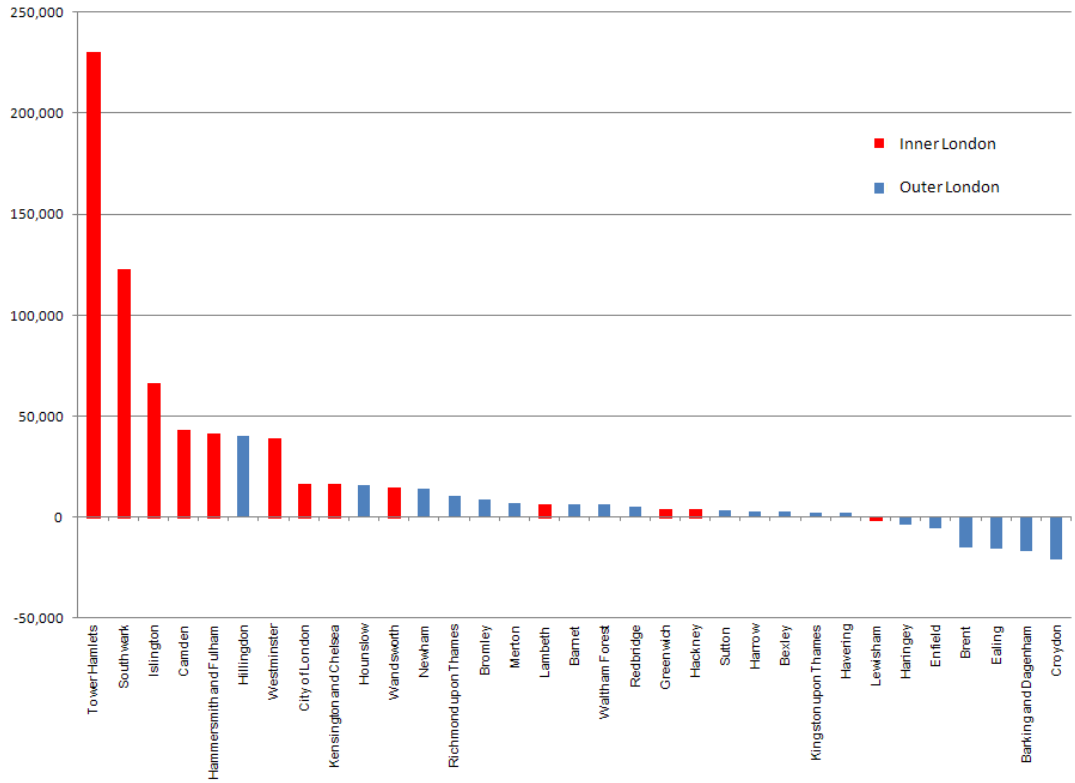
D4.24 In line with the assessment of the transport benefits, the economic impacts will consider scenarios where the displacement of jobs (apart from the 13% net additional) comes from districts that are not located in Inner London.

D4.25 The Central Scenario assumes that the VNEB will capture the other jobs through a higher proportion of the growth of employment in Outer London. The rationale behind this assumption could be explained within the context of the objectives of the VNEB OAPF, and the differences in the economic dynamics between Inner and Outer London boroughs. The VNEB OAPF clearly identifies the area as a central London location that is aimed at accommodating some of the future population and employment growth within the capital. In short, the objective of London's planning framework is that VNEB, alongside other opportunity areas within CAZ, will provide the capacity to accommodate future growth.

D4.26 The GLA expects that the number of employees in Inner London boroughs will grow by over 600,000 between 2011 and 2036, while

workers in Outer London will only expand by 50,000. This is shown in Figure D.4. Development activity within Inner London boroughs, specifically in the CAZ, will therefore need to be expanded to provide the required capacity. In total, the opportunity areas within Inner London are set to provide capacity for some 120,000 workers (only a fifth of London's projected growth) – the VNEB OA, one of the major opportunity areas, is expected to accommodate around 25,000 of these jobs.

Figure D.4 GLA Employment Projections by Borough to 2036



D4.27 In relation to the VNEB OA, the NLE is necessary to generate the level of employment activity that has been set out in the area's OA planning framework. The assessment of the NLE scheme assumes some displacement of economic (or employment) activity takes place – i.e. those VNEB jobs enabled by the NLE that are not considered net additional. That means that since growth in VNEB could have in theory occurred elsewhere, some of the jobs created in the area would be displaced from other locations.

D4.28 The central scenario reflects what is considered to represent a likely and realistic scenario in terms of the economic impact of the scheme. This is that the additional VNEB jobs and population would be redistributed from Outer London. This scenario reflects a view of the

'end state' economic activity, as the expansion of the CAZ (facilitated by NLE and the development of the VNEB OA) supports the long-term trend for higher-value service based firms to increasingly locate in the central area. The scenario reflects the rationale underpinning OA policy in helping enable the CAZ to expand and in supporting the overall expansion of activity in the CAZ.

D4.29 In practice the displacement could occur from outer London, the remainder of the South East or UK as a whole. The key point is that VNEB will facilitate the expansion of CAZ as a whole. Therefore, in addition to the scenario detailed above, an alternative scenario where 50% of the jobs are displaced from Outer London and 50% from the rest of the South East is also presented.

D4.30 Finally, sensitivity checks on the level of net additional jobs (13%), ranging from 0% (as per the DfT guidance) to 20% were also carried out. This provides a range of possible outcomes, which, given the uncertainty that surrounds these types of developments, is more appropriate than a single BCR figure.

D4.31 The results are presented in the next section.

D5 RESULTS OF THE ESTIMATION OF WIDER ECONOMIC IMPACTS

Summary of WEIs

D5.1 The table below summarises the ranges of results for the WEIs (figures rounded to nearest £100 million in 2010 prices). This shows that the total WEIs will come at around £4.7 billion in the With NLE Scenario.

Table D.4 WEI summary (60 year PV in £ millions)

Impact	Wider Economic Impacts (£m PV)
Pure Agglomeration	600
Move to More Productive Jobs	4,100
Total	**4,700**

Sensitivity Analysis (0% to 20% Additionality)

D5.2 Around this central estimate, a range of potential outcomes based on sensitivities in the assumptions has been calculated. The sensitivities involve the proportion of jobs created by the development that are assumed to be additional, and the effect these have on the Move to More Productive Jobs value.

Table D.5 Additionality Sensitivities for M2MPJs (£m PV)

Additionality Sensitivities	M2MPJs (£m PV)
0%	3,000
5%	3,400
13%	4,100
20%	4,700

D5.3 For the central scenario, an estimate of 13% additionality was used as discussed earlier in this report. In the sensitivity analysis, potential outcomes resulting from between 0% and 20% additional jobs has been explored.

D5.4 Guidelines for WEIs produced by the DfT suggest that no additionality should be assumed, however the case as to why this is not deemed appropriate in this instance was presented earlier. Nevertheless, the outcome of WEIs based on this guideline of 0% additional employment was calculated, and the positive result supports the case. This means

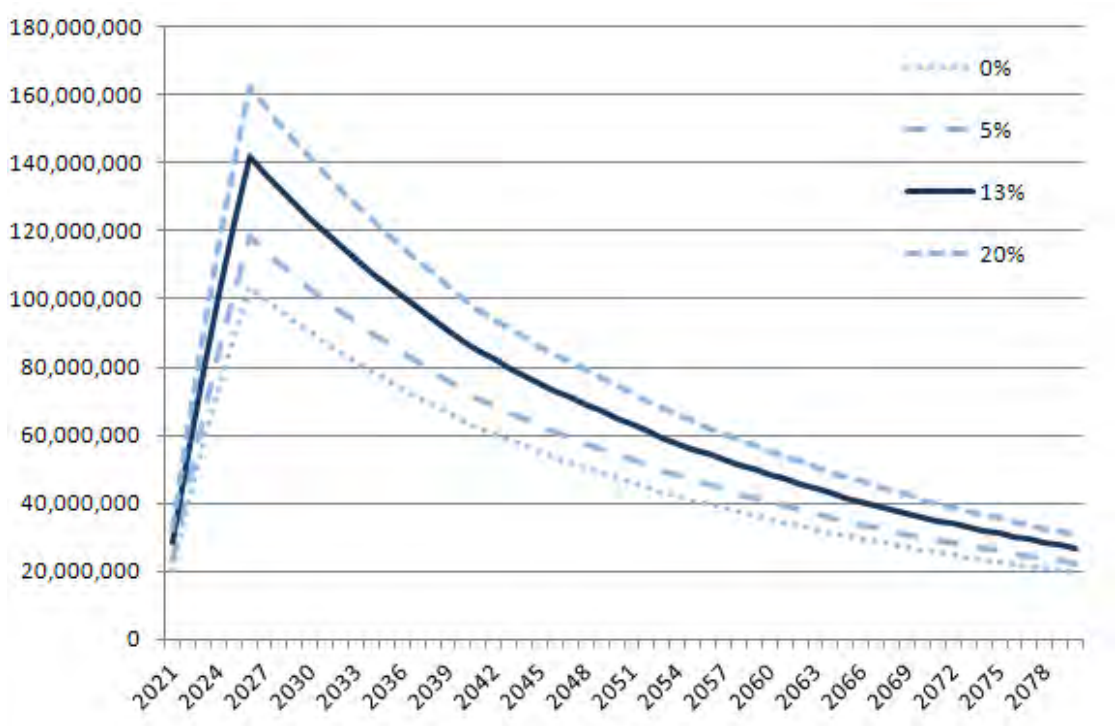
that even if the only jobs on the development site were those displaced from Outer London boroughs, the total M2MPJ benefits would be £3.0bn, and total WEIs of around £3.6 billion.

D5.5 As there will undoubtedly be some level of additional employment, two sensitivities either side of the central value have been included. These are at 5% and 20%. As shown in the table above, the results of these scenarios mirror the difference in the level of additional jobs.

D5.6 The most telling aspect of this analysis is that regardless of the level of additional employment as a result of the development, the WEIs still produce significant positive outcomes, which indicates that the project is economically viable and would bring significant economic benefits to the local and national economy.

D5.7 Figure D.5 below illustrates the annual WEIs in present value terms over the 60 year assessment period – varying by level of additionality in the case of M2MPJs. The central scenario is highlighted in a darker shade with the sensitivities around it.

Figure D.5 Time profile of WEIs, discounted annual M2MPJs



D5.8 As expected, this shows that the benefits for all scenarios increase throughout the construction period, peaking in the first year of full operation (2026) before tailing off as the benefits go further into the future and therefore contributing less towards the present value.

Sensitivity Analysis 2 (Productivity Assumptions)

D5.9 As an alternative to the central scenario using an adjusted productivity index for Wandsworth, the effect on the M2MPJ if the exact productivity data from the DfT guidelines were to be used was estimated.

D5.10 Clearly, the reduction in productivity leads to smaller M2MPJ benefits. Table D.6 set out the M2MPJ assuming the alternative productivity data. The central 13% additionality figure falls from £4.1 billion to £2.9 billion when using the DfT productivity for Wandsworth rather than the weighted average CAZ productivity.

Table D.6 M2MPJs for Alternative Productivity Scenarios (£m PV)

Additionality Sensitivities	M2MPJs (£m PV)
0%	1,400
5%	2,400
13%	2,900
20%	3,500

Sensitivity Analysis 3 (Sisplacement Locations)

D5.11 Our scenarios have also taken into account where jobs are likely to be displaced from. The central scenario assumes that jobs are displaced proportionately from all Outer London boroughs. An alternative scenario where half of the jobs are displaced from Outer London boroughs, and the other half from the South-East districts surrounding London was tested.

D5.12 The South Eastern districts have similar productivity levels to those in Outer London, albeit some of the districts in the South East have slightly higher productivities. Accordingly, the disparity is insignificant, meaning the M2MPJs benefits are almost identical in this alternative displacement scenario. As shown in Table D.7, these are identical to the 100% Outer London displacement scenario when the numbers are rounded to the nearest £100 million.

Table D.7 M2MPJs for Alternative Displacement scenario (£m PV)

Additionality Sensitivities	M2MPJs (£m PV)
0%	3,000
5%	3,400
13%	4,100
20%	4,700

D5.13 Adding the benefits to transport users (shown in the Economic and Business Case document and detailed in Appendix E) to the WEIs shows that the NLE scheme will deliver a Benefit to Cost Ratio of over 8:1 in the central case. This means it will deliver over £8 of benefit for every £1 of cost, representing excellent value for money. The single biggest source of benefit is the generation of more productive jobs, accounting for £4,100m of benefits. This benefit reflects the critical role of the NLE in supporting the expansion of the CAZ.

D5.14 Even when sensitivities were applied, the worst case scenario (using 0% additionality and the exact productivities for Wandsworth from the DfT guidance) results in a total of £2.4bn in benefits. In this case, the NLE scheme will deliver a BCR of 4:1, which still represents excellent value for money.

APPENDIX

E

TRANSPORT BENEFITS ANALYSIS

E1 TRANSPORT BENEFITS ANALYSIS

E1.1 This Appendix sets out the analysis that underpins the estimation of the transport benefits within the economic and business case appraisal. The Appendix covers:

- The key benefits of the NLE in terms of journey time and accessibility;
- The NLE model period and annual demand forecasts;
- The key drivers of the transport benefits in the business case; and
- The transport benefits and impacts to public transport and highway users.

NLE Transport Economic Benefits – Key Drivers

Reducing Journey Times - Actual Journey Times

E1.2 The NLE will significantly improve actual journey times for trips to and from Battersea and Nine Elms. It will also reduce the number of public transport interchanges and significantly improve the accessibility of the VNEB OA, and improve journey time reliability for existing residents and new users who may otherwise have taken the bus[15]. These journey time benefits underpin the demand and benefits for the scheme.

E1.3 Table E.1 compares the fastest journey times (and the associated number of interchanges) with and without the NLE for key movements to the West End, City and Canary Wharf based on TfL's Journey Planner.

E1.4 Without the NLE, many journeys from the VNEB area require a bus journey (or a long walk) to access Vauxhall station for an onward connection on the LU and National Rail networks.

E1.5 The comparison shows that actual journey times for all trips are typically reduced by five to ten minutes, or 20%-30%. The savings are the greatest for passengers travelling from Nine Elms to London Bridge and Bank, resulting in time savings of more than ten minutes (a reduction of 40% in actual time).

[15] While the additional development that is contingent upon the NLE will create a modest increase in traffic in the VNEB area, the likely reliability benefits to existing users of the NLE will more than outweigh any delays caused to the bus network by the generated traffic, particularly as bus lanes are in place for most key bus routes.

Appendix Table E.1 Journey Times with and without NLE

From	To	Journey Time Without NLE (mins) and number of interchanges*	Journey Time With NLE (mins) and number of interchanges**
Battersea	Charing Cross	23 (2)	18 (0)
	Tottenham Court Rd	26 (3)	21 (0)
	London Bridge	25 (2)	17 (1)
	Bank	27 (2)	19 (1)
	Canary Wharf	40 (3)	30 (1)
Nine Elms (Sainsbury's)	Charing Cross	18 (1)	16 (0)
	Tottenham Court Rd	27 (2)	19 (0)
	London Bridge	26 (2)	15 (1)
	Bank	29 (2)	17 (1)
	Canary Wharf	34 (2)	28 (1)

*Based on the TfL journey planner's fastest journey travelling at 8AM on a weekday

**Based on the TfL journey planner's fastest journey from SE11 4JQ (Kennington station) travelling at 8AM on a weekday, plus the journey time on NLE. This includes approximately 6 minutes station access time and interchange time where appropriate .

E1.6 Furthermore, in most cases, the number of interchanges required to make the journeys has been reduced. Journeys which previously required two interchanges would require one interchange or none at all. Journeys that involve a bus leg are also more susceptible to delays depending on the general road conditions.

Generalised Journey Time Benefits – From VNEB

E1.7 Benefits to public transport users are based on changes in passengers' generalised journey time (GJT). This incorporates the time components of a journey (access to a station / stop, waiting time, in-vehicle time, interchange and egress time to the final destination). It also includes a representation of crowding, whereby passengers experience of crowding is quantified (related to journey time, and is valued higher as crowding levels increase), so that reductions in crowding would deliver a passenger benefit. Individual elements of generalised cost are 'weighted' to reflect passengers' preferences[16].

[16] For example passengers, on average, would prefer to spend a minute travelling compared to a minute waiting for a service. Similarly, passengers would rather sit than stand. The preferences are reflected by applying a weighting to actual time for each component to reflect these preferences.

E1.8 The NLE will result in substantial reductions in overall journey times for public transport users travelling to and from the OA. Figures E.1 to E.4 show the decrease in generalised journey times (taking into account both travel time and crowding levels) to and from the new stations at Nine Elms and Battersea in the 2031 AM peak period. The benefits to the OA are marginally greater than the benefits from the OA because the NLE will provide a greater improvement in service levels to the OA.

E1.9 The key areas that benefit from reductions in journey time are central, north and east London as well as the area around Kennington. This is due to the route of the Northern line that provides easy access to these areas as well as the new interchange with Crossrail that will be provided at Tottenham Court Road reducing journey times to east and south east London.

Appendix Figure E.1 Forecast Change in Public Transport Generalised Journey Time From Battersea Resulting From the NLE, 2031

Appendix Figure E.2 Forecast Change in Public Transport Generalised Journey Time to Battersea Resulting From the NLE, 2031

Appendix Figure E.3 Forecast Change in Public Transport Generalised Journey Time From Nine Elms Resulting From the NLE, 2031

Appendix Figure E.4 Forecast Change in Public Transport Generalised Journey Time to Nine Elms Resulting From the NLE, 2031

Improving Accessibility (PTAL Benefits)

E1.10 A large proportion of the OA suffers from poor public transport accessibility, especially relative to other areas of central and Inner London. With the exception of Vauxhall and its immediate surroundings, the rest of the OA including the area around BPS has a low level of public transport accessibility.

E1.11 One way of measuring the relative public transport accessibility of particular sites or areas is through the Public Transport Accessibility Level (PTAL). PTAL is a measure of the accessibility of a point to the public transport network, taking into account walk access time and service availability. PTAL is used to provide information that informs planning applications and decisions, as a measure of the public transport accessibility and therefore the sustainability of developments.

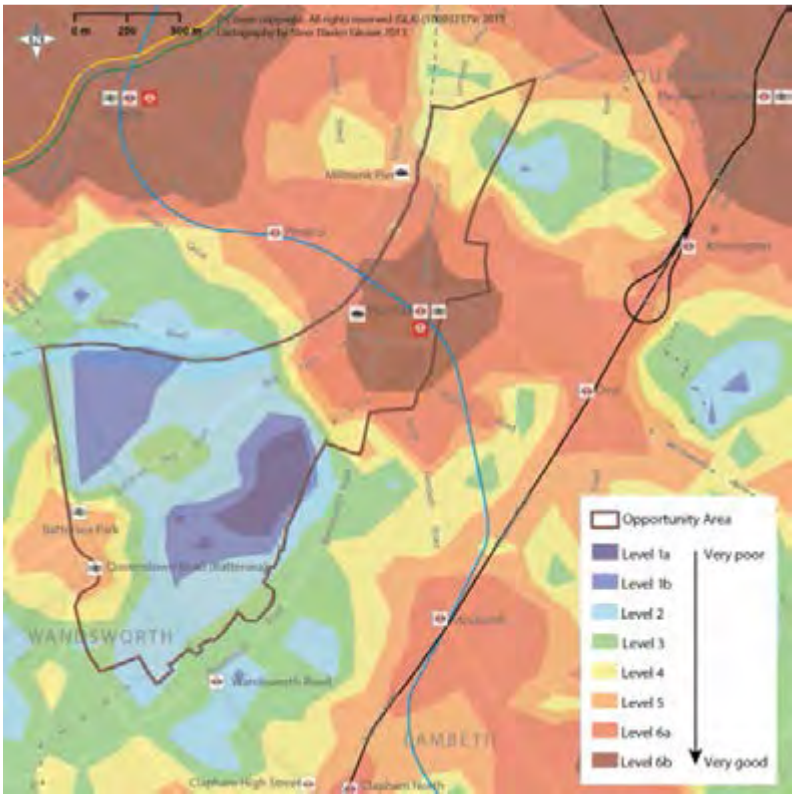
E1.12 A plan showing the existing and future baseline PTAL across the OA is shown in Figure E.5 and Figure E.6 respectively. While the PTAL of the OA is significantly improved in the future baseline compared to current levels, the future baseline still shows poor levels of accessibility (e.g. Levels 1a and 1b) in many parts of the OA despite bus enhancements.

E1.13 This is in stark contrast to much of the rest of central London that has excellent levels of accessibility. This is due to the constraints of the network, with the proposed bus service enhancements predominantly only being able to serve existing corridors which, with some limited exceptions, such as at BPS are unable to penetrate the new development sites. The high journey times and lower capacity provided by buses as opposed to Rail and Underground services also contribute to lower PTAL levels.

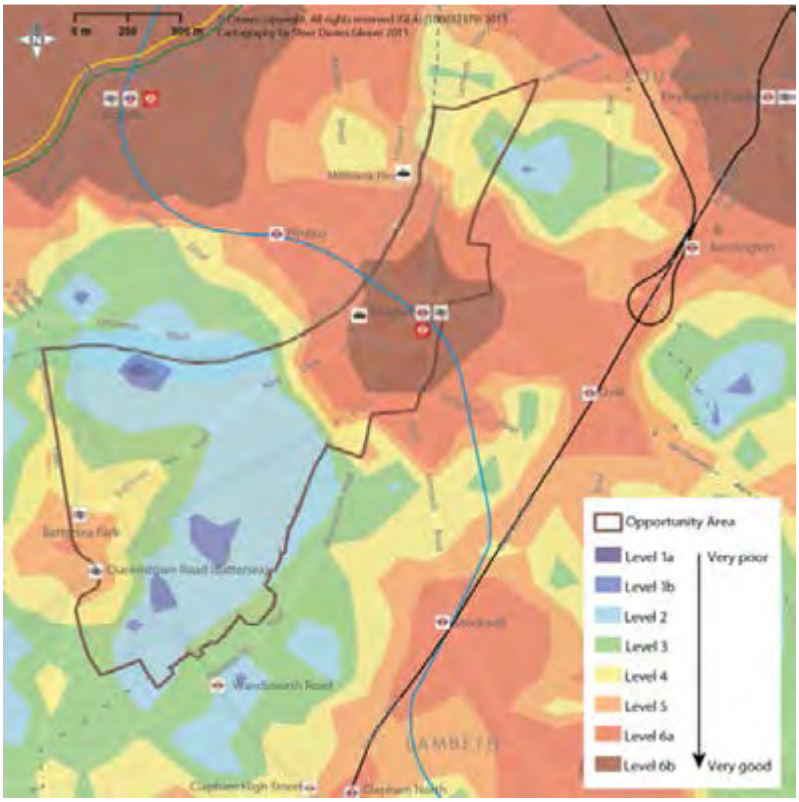
E1.14 The NLE will result in a large increase in public transport accessibility as defined by PTAL, both in the OA, particularly at the western end and central part and also in the existing communities in the areas surrounding the two new stations. With the NLE in operation, the future PTAL for the OA and areas around it is set out in Figure E.7.

E1.15 Figure E.8 shows the change in PTAL due to the NLE in 2031. The NLE will increase public transport accessibility levels by at least 2 PTALs in large parts of the OA and the adjacent local community. This shows that the NLE would increase the ease of public transport access and provide a new sustainable means of getting to and from the OA.

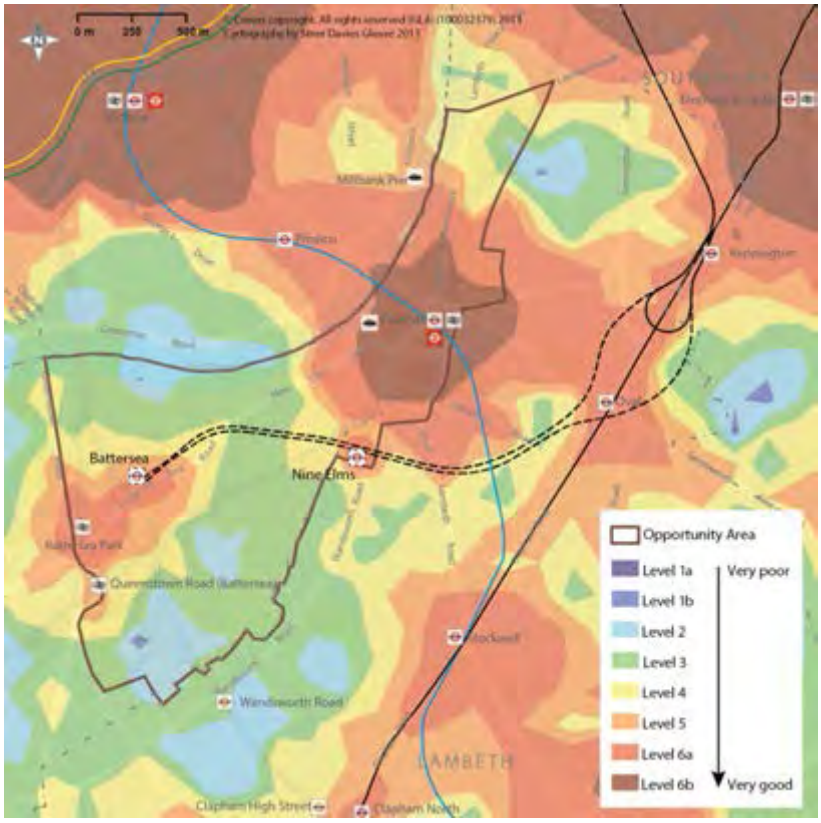
Appendix Figure E.5 Existing PTAL, 2013



Appendix Figure E.6 PTAL for the Future Baseline, 2031



Appendix Figure E.7 PTAL With NLE, 2031



Appendix Figure E.8 Change in PTAL with NLE, 2031

NLE Demand Forecasts

E1.16 The NLE demand forecasts are presented and described below. As outlined in Appendix C, only AM and inter-peak periods are used for the economic and business case.

AM Peak Period Demand (07:00 – 10:00)

E1.17 The three hour peak period Northern line demand forecast is presented in Table E.2.

Appendix Table E.2 Forecast Patronage on the NLE (0700-1000 AM Peak Period) Rounded to the Nearest 100 Passengers

From/To		2020	2031
Northbound			
Battersea	Nine Elms	1,400	4,200
Nine Elms	Kennington	4,000	8,300
Southbound			
Kennington	Nine Elms	3,400	6,300
Nine Elms	Battersea	1,300	4,200

Inter Peak Period Demand (10:00 – 16:00)

E1.18 The six hour inter-peak Northern Line demand forecast is presented in Table E.3.

Appendix Table E.3 Forecast Patronage on the NLE (1000-1600 Inter Peak Demand) Rounded to the Nearest 100 Passengers

From/To		2020	2031
Northbound			
Battersea	Nine Elms	1,600	4,300
Nine Elms	Kennington	3,300	7,400
Southbound			
Kennington	Nine Elms	3,200	5,800
Nine Elms	Battersea	1,400	3,400

E1.19 The impact of NLE demand on the local and wider transport network has been assessed within the Environmental Statement. This shows that the additional demand generated by the NLE and the wider VNEB

OA can be accommodated on the network without causing a significant increase in crowding levels. Overall the additional demand from the NLE creates very small (on a per trip basis) additional crowding impacts across the network that have been valued within the economic appraisal.

NLE Annual Demand Forecasts

E1.20 Annual demand has been prepared for the NLE, based on factoring up (annualising) model period demand to reflect full year demand. The annualisation assumption is set out below.

Public Transport Annualisation

E1.21 2010 LU station counts for six local stations (Vauxhall, Kennington, Oval, Stockwell, Clapham North and Clapham Common) were analysed to derive annualisation factors. These stations were considered comparable (in terms of demographic and propensity to travel) to the proposed stations on the NLE because of their proximity and their mixed-use functions.

E1.22 The annualisation factors for NLE demand, revenue and benefit forecasts are set out in Table E.4. Further detail on the derivation of annualisation factors can be found in Appendix F.

Appendix Table E.4 Public Transport Annualisation Factors

	Factor
AM peak period (3 hours) to peak annualisation	481
Inter-peak period (6 hours) to non-peak annualisation	920

NLE Annual Demand Forecasts - 2020 & 2031

E1.23 Employing the annualisation factors set out above, the annual NLE demand and revenues by time period are set out in E.5.

Appendix Table E.5 Summary of Annual NLE Demand Forecasts

	2020	**2031**
AM Peak 3-Hour Total (trips)	6,500	14,800
Inter-Peak 6-hours total (trips)	6,600	14,800
Peak Period Demand (million trips)	3.1	7.1
Non-Peak Demand (million trips)	6.2	13.0
Annual NLE Demand (million trips)	***9.3***	***20.0***

Transport Economic Benefits

Redistribution of Activity – Implications for Trips

E1.24 The VNEB planning assumptions assume a higher level of jobs and population in the VNEB area with the NLE, and all but 13% of these jobs are assumed to be 'net additional' in the With NLE Scenario. Modelling assumptions about where this activity is redistributed from has been made. The With NLE Scenario reflects what is considered to represent likely and realistic scenarios in terms of the economic impact of the scheme. This is that the additional VNEB jobs and population would be redistributed from Outer London.

E1.25 The pattern of benefits is influenced by the pattern of demand for the With NLE Scenario, relative to that of the Without NLE Scenario. Based on the planning assumptions and transport provision, LTS was used to forecast public transport and highway trips for a 24-hour period. Table E.6 shows the change in overall public transport and highway demand by geographical area[17].

Appendix Table E.6 NLE Demand Summary– Change from Without NLE Scenario (24 hour demand), 2031

	Change in 24 hour Demand with NLE
Public Transport Demand by Area	
All VNEB	23,400
All Central (except VNEB)	-1,900
All Inner (except VNEB. Central)	-2,700
Outer / external	-8,100
Total Public Transport	***10,700***
Highway Demand by Area	
All VNEB	10,100
All Central (except VNEB)	-3,200
All Inner (except VNEB. Central)	100
Outer / external	-18,700
Total Highway Trips	***-11,600***

[17] Central includes the following Boroughs: City of London, Westminster, Camden, Islington, Hackney, Tower Hamlets, Southwark, Lambeth, Kensington & Chelsea. Inner London includes: Lewisham, Wandsworth (excluding VNEB), Hammersmith & Fulham, Newham, Haringey. Outer includes: Greenwich, Waltham Forest, Redbridge, Havering, Barking, Bexley, Bromley, Croydon, Sutton, Merton, Kingston, Richmond, Hounslow, Hillingdon, Ealing, Brent, Harrow, Barnet, Enfield. External = rest of GB.

E1.26 The table shows that the With NLE scenario compared to the Without NLE scenario:

- There is additional public transport demand to and from the VNEB area of around 23,400 additional trips.
- The jobs and population redistribution can be seen in the relatively large reduction in 'out / external' trips (8,000) compared to redistribution from within other parts of central and Inner London (around 2,000 and 3,000 from each)
  The fact that this redistribution shifts activity from Outer London (where there is a higher car mode share) to VNEB (higher propensity to use public transport) accounts for there being an overall 11,000 additional public transport trips with the NLE, and a slightly greater reduction in car trips.
- Overall, the public transport mode share is higher in the With NLE Scenario than the Without NLE Scenario. This results in travel behaviour that is more sustainable, and further supports the rationale for higher development densities in areas with good public transport accessibility.

E1.27 The demand patterns described above influence the type, scale and pattern of benefits associated with the NLE.

E1.28 There are significant benefits for users of the NLE through improved journey times and accessibility. However, the additional public transport demand does result in some additional crowding impacts on the public transport network.

E1.29 At a local level, as demonstrated in the Environmental Statement changes in crowding levels on specific links and lines are limited, with some sections such as the Victoria line north of Vauxhall and the Northern line south of Kennington experiencing marginally reduced levels of crowding and some sections such as both branches of the Northern line north of Kennington experiencing slight increases in crowding levels.

E1.30 Additional patronage on the London Underground and wider public transport network also provides additional public transport revenues over the network that accrues to TfL.

E1.31 The redistribution of activity from Outer London results in a reduction in highway demand that, in turn, leads to decongestion benefits for remaining users across the wider network.

E1.32 The patterns of benefit described above are reflected in the benefits presented in more detail below.

Public Transport Benefits

E1.33 The total public transport benefits for each time period have been estimated using Railplan. The benefits represent the change in generalised travel cost between the Without NLE scenario and the With NLE scenario. The benefits are presented by the following categories:

- Benefits to VNEB, Wandsworth and Lambeth – these benefits largely represent benefits to users of the NLE.
- Benefits (or disbenefits) to other users – these largely reflect the crowding impacts that result from the change in overall public transport demand levels.
- Benefits to 'new' users – these are benefits to new public transport users (most of whom, but not all account for the additional trips associated with the higher level of development in the VNEB area). These benefits to these users have been estimated based on the 'Rule of a Half' appraisal convention.

E1.34 The breakdown in modelled benefits by scenario for 2031 morning and inter-peak periods respectively are set out in Table E.7 and Table E.8. It should be noted that a negative value indicates a reduction in generalised travel time, i.e. a benefit. Overall there are much more transport user benefits than disbenefits.

Appendix Table E.7 Public Transport Benefits in Generalised Hours – AM Peak Period (0700-1000), 2031

	Change in Generalised Journey Time (hours in 3 hour peak period)
Benefits to existing users - VNEB, Lambeth & Wandsworth	-880
Benefits to existing users - Other	1,040
Benefits to New Users	-410
Total Public Transport Benefits (Hours)	***-250***

Appendix Table E.8 Public Transport Benefits in Generalised minutes – Inter-Peak Period (1000-1600), 2031

	Change in Generalised Journey Time (hours in 6 hour inter-peak period)
Benefits to existing users - VNEB, Lambeth & Wandsworth	-870
Benefits to existing users - Other	-140
Benefits to New Users	-330
Total Public Transport Benefits	***-1,340***

E1.35 The benefits to VNEB users are around 900 hours in the morning peak 3 hours. However, the increased VNEB demand to and from Central London imposes crowding on remaining users of the network which results in a dis-benefit of 1,000 hours. The 'benefits to new users' represent benefits to the additional demand (mostly additional trips in VNEB with the NLE), which totals 400 hours.

E1.36 In the inter-peak the lower levels of network crowding means that additional demand does not result in the same level or pattern of dis-benefit. As a result the benefits to VNEB users is around 900 hours and this is added to the benefits to the wider network (150 hours). The 'benefits to new users' totals 300 hours.

Other Public Transport Benefits

E1.37 The proposed new stations at Battersea and Nine Elms will be designed to be fully accessible. TfL has undertaken a initial analysis which demonstrates that there will be additional accessibility benefits as a result of the NLE.

E1.38 TfL has also undertaken analysis of passenger movements at Kennington and concluded that there will be some net benefit for those interchanging at Kennington when the With NLE Scenario is compared against the Without NLE Scenario as a result of the additional passages between platforms.

E1.39 These accessibility and station movement benefits are additional to those currently captured in the economic appraisal.

Public Transport Revenues

TfL and National Rail Passenger Revenue

E1.40 The Railplan model does not directly forecast changes in revenues by public transport mode. It is therefore necessary to estimate changes in revenues based on ridership statistics directly produced by Railplan.

E1.41 It is considered that the most robust approach to estimating revenues is by employing an average fare per passenger-kilometre to the Railplan modelled changes in passenger kilometres. Table E.9 sets out the fare assumptions provided by TfL. The average fare is assumed to increase by 1% per annum in real terms over the appraisal period.

Appendix Table E.9 Average Fare Per Passenger Kilometre (Source: TfL)

Mode	Average Fare (£/pax km in 2010 prices)	Notes
London Underground	0.25	Based on LU zone 1,2,3 average in 2012
Bus/DLR/Croydon Tramlink	0.17	Based on London bus including free child travel in 2012
National Rail	0.14	Based on Rail Industry Monitor statistics for six major TOCs operating in London and the South East

Congestion Charge Revenues

E1.42 The change in development patterns associated with the NLE is expected to impact the revenues TfL receive from the London Congestion Charge scheme. The change in highway trips entering the London Congestion Charge zone in the morning and inter-peak periods was estimated using the CLoHAM model. It is assumed that the average payment is £8 in 2007 prices (as stated in the BCDM). The Congestion Charge revenues were annualised as follows:

- AM peak hour to annual peak – 750, assuming a 3-hour AM peak period over 250 weekdays a year and that those who travel in the PM peak have already paid in the AM or inter-peak period;
- Inter peak hour to annual off-peak – 750, assuming a 6-hour inter peak period over 250 weekdays a year and that 50% of the one-way trips enter the Congestion Charge zone for the first time (some are repeat users from the AM peak period, while others make repeat trips within the inter-peak period).

Commercial Revenues

E1.43 New stations at Battersea and Nine Elms present TfL with an opportunity for additional commercial revenue through retail units, advertising and ATMs. TfL has estimated the potential for commercial revenues at these two new stations.

E1.44 The commercial revenues included in the business case are summarised in Table E.10. These commercial revenues are assumed to be constant in real terms throughout the appraisal period.

Appendix Table E.10 Commercial Revenues (£ in 2010 Prices)

Commercial Revenue Item	**£ per annum**
Retail - Nine Elms	104,600
Retail - Battersea	66,600
Advertising	193,000
Metro	19,800
ATM	98,000
Wifi	68,000
Total	***550,000***

E1.45 The overall revenues impacts of the NLE are summarised in Table E.11. The net TfL revenue of £20m per annum compares against a net annual operating and maintenance cost of £10m in 2010 real prices, indicating a £10m per annum operating surplus.

Appendix Table E11 Summary of Annual Incremental Revenue Forecasts in 2031 (£m, 2010 real prices)

	With NLE
London Underground	25.2
Bus/DLR/Croydon Tramlink	-4.1
National Rail	4.7
Congestion Charge	-1.3
Commercial Revenues	0.6
Net TfL Revenue	***20.4***

Note: National Rail revenues includes London Overground services. The “Net TfL Revenue” in this table excludes impacts on National Rail revenues. However, in the economic appraisal it

has been assumed that a grant or subsidy to Central Government will reflect any change in National Rail revenues.

Highway Impacts

E1.46 As described earlier in this Appendix, the planning assumptions underpinning the business case scenarios deliver varying levels of highway trips. This is because of the opposing effects of:

- Increase in highway trips as a result of the development enabled through the delivery of NLE; and
- Change in highway trips based on the assumption that a majority of the VNEB development (jobs and population) is redistributed from Outer London. As Outer London is an area less accessible by public transport) to VNEB, then this results in an overall reduction in traffic.

E1.47 Highway impacts in central London have been modelled through CLoHAM for the 2031 AM and inter-peak periods. CLoHAM has full junction and link simulation for the central London area

E1.48 CLoHAM was used to model highway delays for the AM and inter-peak hours and TUBA was used to derive the highway impacts within the central London area.

E1.49 Outside central London, junctions are not simulated in CLoHAM. The highway impacts were estimated based on the change in highway kilometres for trips within this area and appropriate WebTAG unit rate congestion values[18] were applied. The central London and Outer London highway impacts were then combined.

E1.50 Congestion is likely to occur during the peak and inter-peak periods where traffic volumes are close to the theoretical capacity of the highway network. During the evenings and weekends, the highway network is less busy and therefore the level of congestion is likely to be lower. This is accounted for through a separate annualisation factor for demand and benefits.

E1.51 In summary, highway demand and benefits have been annualised as follows:

- Modelled AM peak 1-hour to annual peak period: 1,350 (demand and benefits); and
- Modelled inter-peak 1-hour to annual non-peak period: 5,289 (demand) and 4,380 (decongestion benefits only)

[18] Congestion categories: Other Urban A Road congestion level 4 (AM peak) and Level 3 (Inter peak)

E1.52 Further information on the annualisation of highway demand and benefits can be found in Appendix F. The modelled highway impacts are summarised in Table E.12.

Appendix Table E.12 Highway Benefits in 2031

	With NLE
Change in million PCU kilometres per annum	-27
Benefits (£m per annum)	2.6

Highway Impacts During Construction

E1.53 The construction of the NLE is expected to create approximately 17,400 truck one-way movements over four years during the construction period. For the purpose of estimating the highway impacts of these trips, it has been assumed that the average trip length is 30km and, using a private car unit (PCU) factor of 2, the total increase in PCU kilometres is 1.05m pcu-km per annum between 2015 and 2018. The corresponding disbenefits have been included in the appraisal.

Accidents and Emissions

E1.54 The accident and emission benefits have been estimated in accordance with TfL and WebTAG guidance. These benefits relate to the reduction in 27 million highway vehicle kilometres per year as a result of the scheme. These are set out in Table E.13.

Appendix Table E.12 Accident and Emission Benefits in 2031

Benefit	**£m per Annum in 2010 Real Prices**
Accidents avoided	1.7
Greenhouse Gas Emissions	0.2
Air Quality	0.3

APPENDIX

F

ANNUALISATION FACTORS

F1 ANNUALISATION FACTORS

F1.1 This Appendix summarises the annualisation factors employed in the business case for the Northern Line Extension.

Introduction

F1.2 The NLE business case has been developed using TfL's Railplan model which produces 3-hour AM peak and 6-hour Inter-peak period forecasts. It is therefore necessary to develop AM peak and inter-peak period annualisation factors to estimate annual NLE ridership, revenues and benefits from the modelled periods. Annualisation factors are therefore an important part of the forecasting process.

F1.3 CLoHAM was used to estimate highway impacts in central London and to provide the change in number of vehicles entering the congestion charge zone. CLoHAM adopts a 1-hour AM peak and 1-hour average inter-peak as its modelled time period. However, due to the one-off nature of the charge, specific annualisation assumptions have been developed.

F1.4 In addition, the LTS model has been used to inform the potential highway impacts outside central London. The model produces 3-hour AM peak (0700-1000) and 6-hour inter-peak impacts and annualisation factors are also needed to assess highway impacts in the business case.

F1.5 The derivation of public transport, highway and congestion charge annualisation factors are set out in the following sections.

Public Transport Annualisation Factors

Derivation of LU Annualisation Factors

F1.6 The proposed AM and inter-peak annualisation factors for Nine Elms and Battersea stations are based on averaged observed passenger usage in 2012 at a number of LU stations in the area on both the Northern and Victoria lines, including the following stations:

- Vauxhall;
- Kennington;
- Oval;
- Stockwell;
- Clapham North; and
- Clapham Common.

F1.7 These stations were selected because they are in the vicinity of the NLE and therefore are likely to exhibit similar demographics and propensity to travel as would be seen at the future NLE stations. The combination of these stations is also expected to reflect the varied land use around Nine Elms and Battersea stations.

F1.8 The 2012 AM and Inter-peak annualisation factors are summarised in Table F.1. Based on the averages of the selected LU stations, the annualisation factors to be used for NLE forecasts are as follows:

- Modelled AM peak period (3 hours) to peak annualisation = 481
- Modelled Inter-peak period (6 hours) to non-peak annualisation = 920

F1.9 Clapham North and Clapham Common stations have higher inter-peak annualisation factors than the other stations. This is because Clapham (with its local retail offer, restaurants and bars) is a key local destination for leisure trips, so the evening and weekend counts are relatively higher. In contrast, Kennington, Oval, Stockwell and Vauxhall to a lesser extent are primarily residential areas, with lower levels of travel outside peak periods.

F1.10 Given the mixed use nature of the development in VNEB, one would expect significant trips to be made during the evenings and weekends, particularly to and from Battersea station. Furthermore, the potential for the Power Station as a tourist attraction should not be underestimated. Nine Elms station is likely to exhibit travel patterns similar to other surrounding residential areas.

F1.11 Overall, the average of these six LU stations was considered an appropriate representation of NLE's demand profile. Table F.1 sets out how the annualisation factors were derived.

Appendix Table F.1 Derivation of NLE Public Transport Annualisation Factors Based on 2012 LU Counts

	AM Peak Period to Weekday Peak Period (a)	**Inter Peak Period to Weekday Non-Peak Period** (b)	**Inter Peak Period to Weekend** (c)	**AM Peak Annualisation Factor** (a*250)	**Inter Peak Annualisation Factor** ($b*250^{19}$+c*52)
Clapham Common	2.0	2.5	7.4	498	1,016
Clapham North	2.1	3.0	8.7	535	1,193
Kennington	1.9	2.2	6.2	464	865
Oval	2.0	2.1	5.3	497	807
Stockwell	1.7	2.2	6.1	415	873
Vauxhall	1.9	1.9	5.4	478	766
Average				**481**	**920**

Highway Annualisation Factors

F1.12 The proposed NLE is expected to have an impact on the highway network. This is driven by the following factors:

- The net additional jobs assumed for the VNEB area would result in increased traffic flows within the vicinity of the VNEB area;
- The jobs in VNEB that would otherwise occur in Outer London which has a lower public transport mode share. Therefore when jobs are relocated to VNEB, more people will commute by public transport and there will be an overall reduction in highway trips;
- The implementation of NLE is also expected to deliver modal shift as drivers switch to use NLE.

F1.13 CLoHAM forecasts future highway and public transport trip distributions in the future given the assumed land use changes. It produces changes in highway kilometres for the AM peak (1-hour) and Inter-peak (1-hour) hours. Highway impacts are estimated using a combination of CLoHAM (for central London) and DfT's externality unit rates for congestion (for Outer London), safety and emissions. These are annualised for the inclusion into the NLE business case.

[19] The number of weekdays in a year is assumed to be 250.

Observed Locations

F1.14 Traffic counts for a total of five sites around the VNEB area were used to analyse the traffic flow profiles. These include the following locations in both directions of travel:

- Queenstown Road (4 weekdays, 0600-1900);
- Wandsworth Road Site A (1 weekday, 0600-1900);
- Wandsworth Road Site B (1 month, 24 hours);
- Larkhall Rise (1 weekday, 0600-1900); and
- Vauxhall Bridge (1 month, 24 hours).

F1.15 These sites contained a wide range of traffic flow spreads and northbound/ southbound data was combined at each site. Data from all five sites were used to derive the AM peak hour to peak period annualisation factor; Wandsworth Road Site B and Vauxhall Bridge, where all day and weekend counts were available, was used to derive the inter-peak annualisation factor.

Volume vs. Congestion

F1.16 It is important to note that the congestion externality unit rates used to forecast delays due to congestion is unlikely to be the same across a typical day or week. Delays generally occur when traffic flows are high (as conventionally illustrated through a speed/flow curve). To use annualisation factors simply based on traffic flow data would result in an overestimation in delays.

F1.17 The data used to derive annualisation factors for highway impacts therefore exclude counts projected to be less than 60% of the average Inter-peak hour. Any counts below 60% of the average Inter-peak hour for the site were omitted, meaning that traffic counts from an average of 7 hours on weekdays and weekends were screened out.

F1.18 Table F.2 summarises the traffic data in the area and the corresponding annualisation factors for congestion impacts. The highway impacts are assumed to be annualised as follows:

- Modelled highway AM peak (1-hour) to peak annualisation = 1,350.
- Modelled highway Inter-peak (1-hour) to non-peak annualisation (congestion impacts) = 4,380.

F1.19 Other environmental impacts such as greenhouse gas (GHG) and safety benefits are annualised in the conventional way (i.e. without the low-flow screening). The annualisation factor is as follows:

- Modelled highway Inter-peak (1-hour) to non-peak annualisation (environmental impacts) = 5,289.

Congestion Charge Annualisation

F1.20 CLoHAM forecasts the number of drivers entering the Congestion Charge zone in the AM peak hour and the average inter peak hour.

F1.21 In order to estimate the impact of NLE on the Congestion Charge revenues to TfL, these forecasts are annualised in a different way to highway traffic because:

- The charge is a one-off daily charge and many users make multiple trips within the charging period;
- The charge period is between 07:00 and 18:00, Monday to Friday only.

AM Peak Annualisation

F1.22 During the AM peak period, the vast majority of trips will be unique inbound trips. Assuming a uniform 3-hour AM peak period over 250 weekdays, the AM peak annualisation is therefore 750. This assumes that those who travel in the PM peak have already paid in the AM or inter-peak period.

Inter Peak Annualisation

F1.23 During the inter peak, some users will be repeat users for those who already entered the zone in the AM peak. Many others are expected to make their return trip within the inter peak period.

Assuming a 6-hour inter peak period over 250 weekdays a year and that 50% of the one-way trips enter the Congestion Charge zone for the first time, the inter peak annualisation factor is therefore 750.

Appendix Table F.2 Derivation of NLE Highway Annualisation Factors Based on 2012 Survey

AM Peak Annualisation	**Larkhall Rise**	**Vauxhall Bridge**	**Wandsworth Road Site A**	**Wandsworth Road Site B**	**Queenstown Road (4 day average)**	**Average**
AM peak 1-hour (0800-0900)	401	686	1,448	557	1,736	
AM+PM Peak 1-periods (0700-1000, 1600-1900)	1,586	3,923	8,178	3,524	9,270	
AM peak hour to AM+Peak period factor	4.0	5.7	5.6	6.3	5.3	**5.4**
Peak Hour Annualisation (250 weekdays/year)	989	1,430	1,412	1,583	1,335	**1,350**

Inter-peak Annualisation	**Vauxhall Bridge NB**	**Vauxhall Bridge SB**	**Wandsworth Road NE**	**Wandsworth Road SW**	**Average**
Weekday inter-peak 6-hours (1000-1600)	3,787	2,655	2,991	3,588	
Weekday off-peak *(with low-flow screening)*	2,646	2,185	2,006	2,474	
Weekday non-peak *(with low-flow screening)*	6,433	4,840	4,997	6,062	
Weekend day *(with low-flow screening)*	11,533	8,080	6,141	8,213	
Inter-peak period to weekday non-peak factor	1.70	1.82	1.67	1.69	**1.72**
Inter-peak period to weekend day uplift factor	3.05	3.04	2.05	2.29	**2.61**
Inter-peak Hour Annualisation (6-hours per inter-peak period, 250 weekdays and 115 weekends/holidays)	4,649	4,834	3,923	4,114	**4,380**

APPENDIX

G

SUMMARY OF CHANGES SINCE THE 2012 ECONOMIC CASE FOR THE NLE

G1 SUMMARY OF CHANGES SINCE THE 2012 ECONOMIC CASE FOR THE NLE

G1.1 This appendix outlines the differences in the Northern Line Extension (NLE) Economic and Business Case (August 2013) and the preliminary assessment of the NLE that was detailed in the report by Volterra Partners, *The Wider Economic Benefits of the Northern Line Extension in the Vauxhall, Nine Elms, Battersea Opportunity Area*, published in January 2012.

G1.2 Models and DataThere has been considerable work since early 2012 to fully review the models and data underpinning the assessment, to ensure these are up-to-date and fit for purpose.

G1.3 In particular, the following elements have been fully reviewed:

- **Planning Data in VNEB.** A detailed review of planning applications has been undertaken to inform the definition of the scale of development in the Without NLE and With NLE scenarios. This 'bottom-up' assessment is based on up-to-date actual planning applications, and supersedes the previous analysis that was based on VNEB-wide target numbers for jobs and employment. As such, the current assessment is more detailed and robust in terms of both the scale, and distribution of developments assumed in the VNEB area.
- **Transport Model Development.** TfL regularly enhances and updates its transport models. The models that underpin the transport analysis (LTS, Railplan and CLoHAM – see Appendix C for details) have all been updated since the 2012 work was undertaken. Furthermore, detailed work has been undertaken to ensure that the modelling in the VNEB area represents the current travel patterns (through the validation of the base year transport model) and the future scenarios through the more detailed coding of developments and transport network in the VNEB area with the future developments. Again, these are summarised in Appendix C.
- **Transport Models Used.** The 2012 transport analysis was based only on Railplan (public transport) forecasts for a single year (2031) and a single time period (AM peak). The current modelling is based on TfL's model framework, employing LTS to represent the planning data, Railplan for the public transport forecast and CLOHAM to represent highway impacts. The forecast have been prepared for

two forecast years (2020 and 2031) and two time periods (AM and inter-peak).

G1.4 The combination of the above mean that the data and models underpinning the current Economic and Business Case analysis are significantly more robust and comprehensive than those employed in the 2012 work.

Key Assumptions

G1.5 There are several economic assumptions that underpin the current Economic and Business Case that represent a refinement of the approach adopted in the 2012 work.

G1.6 First, within the central case in the Economic and Business Case an assumption has been made that 13% of the jobs enabled by the NLE in the VNEB area would be net additional. This was previously employed as a sensitivity. The rationale for the 13% is set out in the main report and Appendix D, and sensitivity tests have been presented around this assumptions, including a 0% additionality test.

G1.7 Second, the displacement assumption within the current central case has been refined to better reflect the likely long-term impact of the NLE on the location of economic activity, and specifically its role in facilitating the expansion of the CAZ. The current assumption is that future jobs growth would take place in VNEB rather than Outer London. The justification for this assumption is explained in the main report and Appendix D.

G1.8 Third, a more suitable employment productivity index has been employed to value the productivity benefits associated with the move towards more productive jobs (M2MPJ), again reflecting the role of VNEB as part of the CAZ. Sensitivity tests have also been applied to test the impact of this assumption on the WEIs outputs.

G1.9 There are other detailed appraisal assumptions that have been updated, such as the build-up profile of benefits based on the latest view of how development is expected to come forward, and the application of appraisal parameters based on the latest version of BCDM, published in September 2012.

Interface Between Economic and Transport Analysis

G1.10 The assumptions underpinning the benefits within the Economic and Business Case are fully internally consistent between the economic benefits (M2MPJ) and the transport benefits.

G1.11 Specifically, the assumed changes in the scale and location of economic activity is fully represented in the transport modelling, whereby the planning inputs that reflect the economic assumptions are modelled through the strategic LTS model (detail in Appendix C) . This means that the crowding costs imposed by the additional jobs (and hence trips) enable by the NLE is fully represented in the benefits.

G1.12 The 2012 analysis did not include the full integration of the economic and transport benefits and impacts within the modelling and analysis. The current Economic and Business Case therefore produces a more robust and internally consistent set of benefits and impacts.

Summary

G1.13 The 2012 analysis represented a best view of the economic impacts of the NLE based on available data and a set of reasonable assumptions.

G1.14 As part of the work to prepare the current Economic and Business Case a significant amount of work has been undertaken to increase the robustness and accuracy of the forecasts, and to fully integrate the planning, economic and transport strands of the analysis. As part of this work all assumptions have been reviewed and, where appropriate, refined to reflect the likely impacts of the scheme.

G1.15 There can therefore be greater confidence in the work undertaken in 2013. While the inputs and assumptions have changed, the central conclusions of the analysis from 2012 and 2013 are the same, in each case demonstrating that the NLE would deliver significant economic benefits and a very strong benefit-cost ratio.

G1.16 The changes are summarised in Table G.1.

Appendix Table G.1 Key Differences in the Economic and Business Case Analysis

Input / Assumption	January 2012	August 2013 (Current)	Comment
Planning data	Based on OAPF framework revised option 5	Based on Quod assessment of current planning applications	More accurate representation of development scenarios
Transport Models	Used TfL Railplan model only, for single year and time period.	Integrated suite of TfL transport models used, including better representation of both base and future years. Two forecast years and two time periods employed	Greater confidence in forecasts
Net additionality	0% (13% additionality applied as a sensitivity)	13% (0% additionality applied as a sensitivity)	More realistic assumption in current work – reflect CAZ role of VNEB and impact of NLE
Displacement	60% redistributed from London/40% from South East	100% from Outer London	More realistic assumption in current work – reflect CAZ role of VNEB and impact of NLE
Productivity	DfT standard guidance	Productivity Index and GDP per worker adjusted for Inner London average	More realistic assumption in current work – reflect CAZ role of VNEB and impact of NLE
Interface between economic and transport analysis	Calculated based on separate analysis	Fully integrated and internally consistent	Increased accuracy and robustness of results.

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Appendix 5

Finance and Policy Committee

Date: 21 January 2016

Item: Northern Line Extension

This paper will be considered in public

1 Summary and background

1.1 On 4 November 2015, the Board delegated authority to the Committee to approve any decisions that are reserved to the Board for determination in relation to the Northern Line Extension (NLE) project in order to enable matters that may require consideration and decision at short notice to be taken at short notice.

1.2 At its meeting on 6 November 2013, the Board approved Project Authority of £1,044m to deliver the NLE subject to the Transport and Works Act Order (TWAO) being granted.

1.3 On 20 August 2014, acting under authority delegated by the Board, the Committee approved award of contract and Procurement Authority for the NLE main works design and build contract. The contract with Ferrovial Agroman Lang O' Rourke (FLO) was awarded on the 1 September 2014.

1.4 Since then, good progress has been made at three of the four key worksites (Kennington Park, Kennington Green, Nine Elms). However, there have been significant changes to the proposed over station development (OSD) at Battersea Power Station. These have resulted in a requirement for significant additional design work to develop a revised integrated station design which is capable of supporting the very different OSD to that originally intended and contracted.

1.5 In order to accommodate the consequences of the additional design work and resultant revised design, this paper asks the Committee to approve revised authorities for the NLE programme. The details are outlined in the related paper on Part 2 of the agenda.

1.6 A paper is included on Part 2 of the agenda, which contains exempt supplementary information. The information is exempt by virtue of paragraph 3 of Schedule 12A of the Local Government Act 1972 in that it contains information relating to the business affairs of TfL. Any discussion of that exempt information must take place after the press and public have been excluded from the meeting.

2 Recommendations

2.1 Under the authority delegated by the Board on 4 November 2015, the Committee is asked to note the paper and the supplemental information in the paper on part 2 of the agenda and to grant the revised authorities for the sums set out in the paper on Part 2 of the agenda in relation to the Northern Line Extension project.

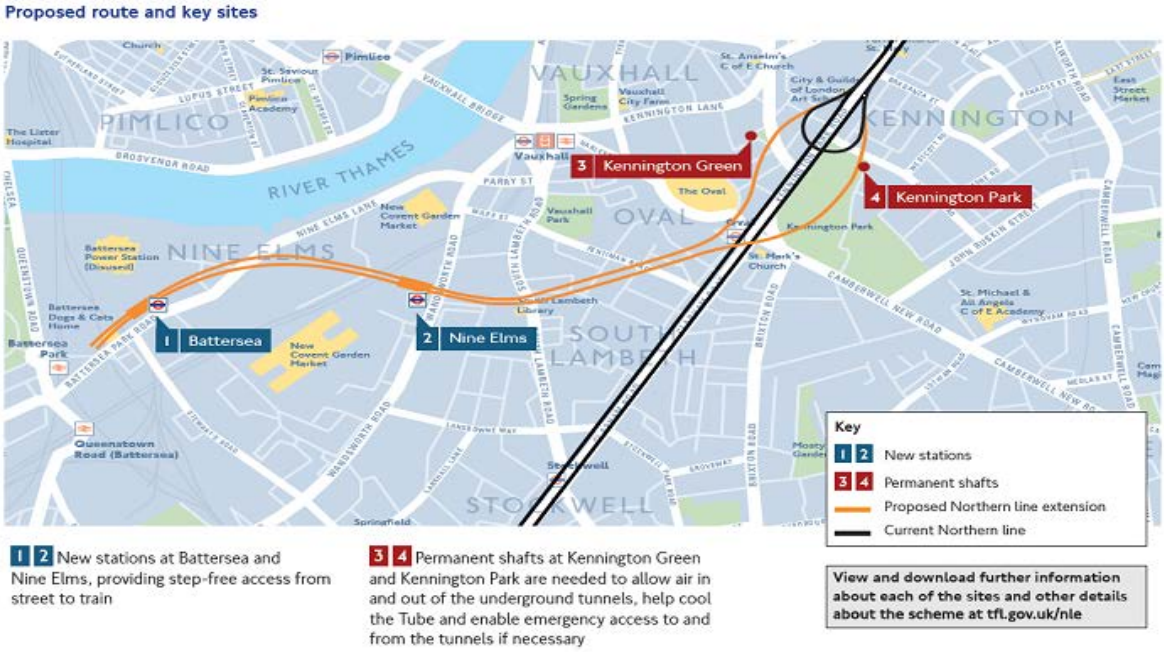
3 Project Scope

3.1 The NLE provides a twin tunnelled extension from Kennington to a terminus station at Battersea, via an intermediate station at Nine Elms (see Figure 1 below).

3.2 There are OSDs at both Battersea and Nine Elms stations; the Battersea OSD is developed by the Battersea Power Station Development Company (BPSDC) and at Nine Elms by TfL. The Battersea construction site is thus shared with the BPSDC and its scheduled delivery is critically linked to the timely construction of the Battersea station box.

3.3 The draft TWAO application was submitted on 30 April 2013 and a public inquiry took place during November and December 2013 to consider the proposals. The Secretary of State for Transport's decision to grant the Order was made in November 2014.

Figure 1: NLE Route



Project Funding

3.4 The current Project Authority is £1044m. NLE project costs up to £1bn will be financed by the Greater London Authority. This borrowing is to be repaid through a combination of:

(a) developer contributions in the form of s106 and Community Infrastructure Levy (CIL) payments from developers in the Vauxhall Battersea Nine Elms Opportunity Area; and

(b) incremental business rates from a new Enterprise Zone in Battersea, which commences in April 2016, for a period of 25 years.

Battersea Design Changes

3.5 BPSDC has significantly changed its OSD design from the Vinoly design baselined at the time the Land and Works Agreement (LWA) between TfL and BPSDC was

executed in April 2014. Accommodating these OSD design changes has required significant change to the designs for Battersea as contracted with FLO.

4 Costs and Programme

4.1 The implications for the project's estimated final cost and schedule as a consequence of the changes to the OSD are outlined in the supplementary paper on Part 2 of the agenda.

List of appendices:

None

List of background papers:

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Appendix 6 and Appendix 7

March 2016 Budget and Business Plan Restated Capital Renewals and Enhancements

	March 2016 Business Plan 4 Years (£m)				March 2016 Business Plan 4 Years (£m) RENEWALS				March 2016 Business Plan 4 Years (£m) ENHANCEMENT			
	2017/18	2018/19	2019/20	2020/21	2017/18	2018/19	2019/20	2020/21	2017/18	2018/19	2019/20	2020/21
Modernisation of Circle, District, Hammersmith and City and Metropolitan lines	390	307	204	249	188	154	102	124	202	152	102	124
Deep Tube Upgrade Programme	133	210	257	523	64	106	129	261	69	104	129	261
Jubilee and Northern line capacity enhancement	120	213	193	145	58	107	96	73	62	106	96	73
Northern Line Extension	225	222	135	178	108	112	67	89	116	110	67	89
Major Station Upgrades (incl. Victoria, Tottenham Court Road, Bond St, Bank)	228	144	165	118	110	73	83	59	118	72	83	59
London Underground fleet and signalling renewals	120	126	104	109	58	63	52	54	62	62	52	54
London Underground Station Step Free Access	(3)	7	14	63	(2)	4	7	31	(2)	3	7	31
Energy/Carbon Reduction schemes	5	7	3	1	2	3	2	1	2	3	2	1
Final elements of JLU1 and NLU1 capacity upgrades	(1)	5	6	5	(0)	3	3	2	(0)	3	3	2
Future Major Stations (inc. Camden Town and Holborn)	42	38	84	112	20	19	42	56	22	19	42	56
Victoria Line Capacity	13	5	-	-	6	2	-	-	7	2	-	-
Other Capital Renewals	309	299	248	253	149	151	124	127	160	148	124	127
Contingency & Overprogramming	(474)	(355)	(274)	(321)	(229)	(179)	(137)	(160)	(245)	(177)	(137)	(160)
Total London Underground	**1,106**	**1,228**	**1,139**	**1,434**	**534**	**618**	**569**	**717**	**572**	**610**	**569**	**717**
Commercial Development	241	179	163	65	116	90	82	32	125	89	82	32
Planning Projects	2	37	20	21	1	19	10	10	1	18	10	10
River Crossing	-	15	17	62	-	8	8	31	-	8	8	31
Customer Experience	34	16	12	13	16	8	6	7	17	8	6	7
Information Management	21	39	30	24	10	19	15	12	11	19	15	12
Other Corporate (incl. Third party)	95	36	34	241	46	18	17	120	49	18	17	120
Total Planning and Commercial	**392**	**322**	**276**	**426**	**189**	**162**	**138**	**213**	**203**	**160**	**138**	**213**
Healthy Streets (including Air Quality)	274	200	215	237	100	73	81	30	175	128	134	207
DLR enhancements	47	70	60	57	17	25	23	7	30	44	37	50
Crossrail (Trains and enabling work)	358	322	110	69	130	117	42	9	228	205	69	60
Surface - Public Transport infrastructure	52	-	-	-	19	-	-	-	33	-	-	-
Overground enhancements	37	7	12	7	13	2	5	1	24	4	7	6
Barking Riverside extension	(4)	28	25	19	(2)	10	10	2	(3)	18	16	17
Silvertown crossing	13	15	16	9	5	6	6	1	8	10	10	8
Rail Devolution	-	-	-	-	-	-	-	-	-	-	-	-
Tram enhancements	8	5	1	-	3	2	0	-	5	3	1	-
Other Capital Renewals	172	159	204	257	63	58	77	32	110	101	127	225
Contingency, Overprogramming & Other	(136)	(36)	(52)	(123)	(49)	(13)	(20)	(15)	(86)	(23)	(33)	(108)
Surface - Total	821	770	591	533	298	279	223	67	523	491	368	466
Centrally-held (P50-P80) Risk												
Total per Business Plan	**2,319**	**2,319**	**2,006**	**2,393**	**1,021**	**1,059**	**930**	**996**	**1,298**	**1,261**	**1,076**	**1,396**

December 2016 Budget and Business Plan Capital Renewals and Enhancements

	December 2016 Business Plan 5 Years (£m)				December 2016 Business Plan 5 Years (£m) RENEWALS				:cember 2016 Business Plan 5 Years (£m) ENHANCEMEN			
	2017/18	2018/19	2019/20	2020/21	2017/18	2018/19	2019/20	2020/21	2017/18	2018/19	2019/20	2020/21
Modernisation of Circle, District, Hammersmith and City and Metropolitan lines	392	322	201	222	247	177	141	155	145	145	60	66
Deep Tube Upgrade Programme	88	108	151	367	-	-	-	-	88	108	151	367
Jubilee and Northern line capacity enhancement	75	128	97	168	19	32	24	42	57	96	73	126
Northern Line Extension	191	201	137	69	-	-	-	-	191	201	137	69
Major Station Upgrades (incl. Victoria, Tottenham Court Road, Bond St, Bank)	189	106	72	98	-	-	-	-	189	106	72	98
London Underground fleet and signalling renewals	62	82	73	83	19	36	33	26	44	46	40	57
London Underground Station Step Free Access	4	20	40	60	-	-	-	-	4	20	40	60
Energy/Carbon Reduction schemes	1	4	2	7	0	1	0	2	1	4	2	6
Final elements of JLUI and NLUI capacity upgrades	1	(5)	(1)	(0)	0	(1)	(0)	(0)	0	(4)	(1)	(0)
Future Major Stations (inc. Camden Town and Holborn)	31	11	28	64	-	-	-	-	31	11	28	64
Victoria Line Capacity	2	-	-	-	1	-	-	-	2	-	-	-
Other Capital Renewals	171	156	236	203	171	117	210	203	-	39	26	-
Contingency & Overprogramming	(149)	(70)	(39)	(52)	(139)	(43)	(29)	(28)	(10)	(27)	(10)	(24)
Total London Underground	**1,059**	**1,064**	**998**	**1,289**	**318**	**319**	**379**	**400**	**741**	**745**	**619**	**889**
Commercial Development	85	114	80	85	31	50	17	14	55	64	63	71
Planning Projects	8	34	89	82	-	-	-	-	8	34	89	82
River Crossing	5	5	20	45	-	-	-	-	5	5	20	45
Customer Experience	33	17	20	14	18	13	12	10	15	3	9	4
Information Management	20	31	32	26	11	25	18	18	9	6	14	8
Other Corporate (incl. Third party)	17	(1)	(15)	10	-	-	-	-	17	(1)	(15)	10
Total Planning and Commercial	**168**	**200**	**227**	**261**	**60**	**89**	**47**	**42**	**109**	**112**	**180**	**220**
Healthy Streets (including Air Quality)	183	204	355	354	18	57	71	53	164	147	284	301
DLR enhancements	37	51	82	78	28	28	45	43	9	23	37	35
Crossrail (Trains and enabling work)	348	350	114	69	104	105	34	21	244	245	80	48
Surface - Public Transport infrastructure	26	17	13	7	4	2	2	1	22	14	11	6
Overground enhancements	41	2	6	0	31	0	1	0	10	2	5	0
Barking Riverside extension	7	29	28	18	-	-	-	-	7	29	28	18
Silvertown crossing	17	6	42	14	-	-	-	-	17	6	42	14
Rail Devolution	-	10	10	-	-	-	-	-	-	10	10	-
Tram enhancements	4	2	3	2	3	0	0	0	1	2	3	2
Other Capital Renewals	123	138	145	199	123	138	145	199	-	-	-	-
Contingency, Overprogramming & Other	(44)	(2)	(37)	10	(30)	(1)	(7)	8	(14)	(1)	(30)	2
Surface - Total	**741**	**806**	**762**	**751**	**282**	**330**	**292**	**324**	**459**	**476**	**470**	**427**
Centrally-held (P50-P80) Risk	**14**	**12**	**25**	**50**			**10**	**1**	**14**	**12**	**15**	**49**
Total per Business Plan	**1,982**	**2,082**	**2,012**	**2,351**	**659**	**737**	**728**	**767**	**1,323**	**1,344**	**1,284**	**1,584**

Appendix 8

Growth Fund Schemes - Third Party Contributions

18 April 2017

Growth Fund Projects	Current Estimated Financial Cost (EFC)	Growth Fund contribution	Funding Secured from Third Party	Third Party Funding Source	Funding being negotiated with third party	Is third party funding needed for these projects to proceed
Barking Riverside Extension	£263m	£30m	£172m	Barking Riverside Ltd (BRL) - JV between GLA and dev. partner	-	Yes
Tottenham Hale	£31.2m	£28.1m	£3.1m	GLA	-	Yes
E&C Northern Line Ticket Hall		£70m	£58m	GLA / LB Southwark	TBC	Yes
E&C Northern Roundabout	£24.4m	£14.4m	£10m	GLA / LB Southwark	-	Yes
Bromley-by-Bow	£21.9m	£11.3m	£0.5m	London Legacy Dev Corp (LLDC)	10m	Yes
Fiveways	£63.3m	£43.3m	£20m	LB Croydon	-	Yes
Wandsworth Ram Brewery	£67m	£33m	£2.2m	LB Wandsworth	£25.3m	Yes
Vauxhall Cross	£53.7m	£38m	-	LB Lambeth	£11.5m	Yes
White Hart Lane	£25.8m	£21.6m	£4.2m	GLA	-	Yes
Metropolitan Line Extension	£335m	£16m	£235.17m	DfT, Hertfordshire CC, Watford BC and Hertfordshire LEP	£50m	Yes
Old Oak Overground stations - feasibility study	£5.1m	£3.2m	£2.9m	European Commission Connecting Europe Facility	-	Yes
Woolwich station (Crossrail scheme)	£79m	£24m	£25m	Crossrail Ltd	-	Yes
Beam Park (Network Rail scheme)	£18m	£9m	N/A	N/A	N/A	N/A
STAR (North) (Network Rail scheme)	£52.4m	£10m	N/A	N/A	N/A	N/A