JRC Jonathan Roberts Consulting

Lewisham Council
Sustainable Development
Select Committee

14 September 2010

Integrated Transport-
Bakerloo Line Extension

Appendix B – JRC report

Potential options for Bakerloo Line extension towards SE London

September 2010

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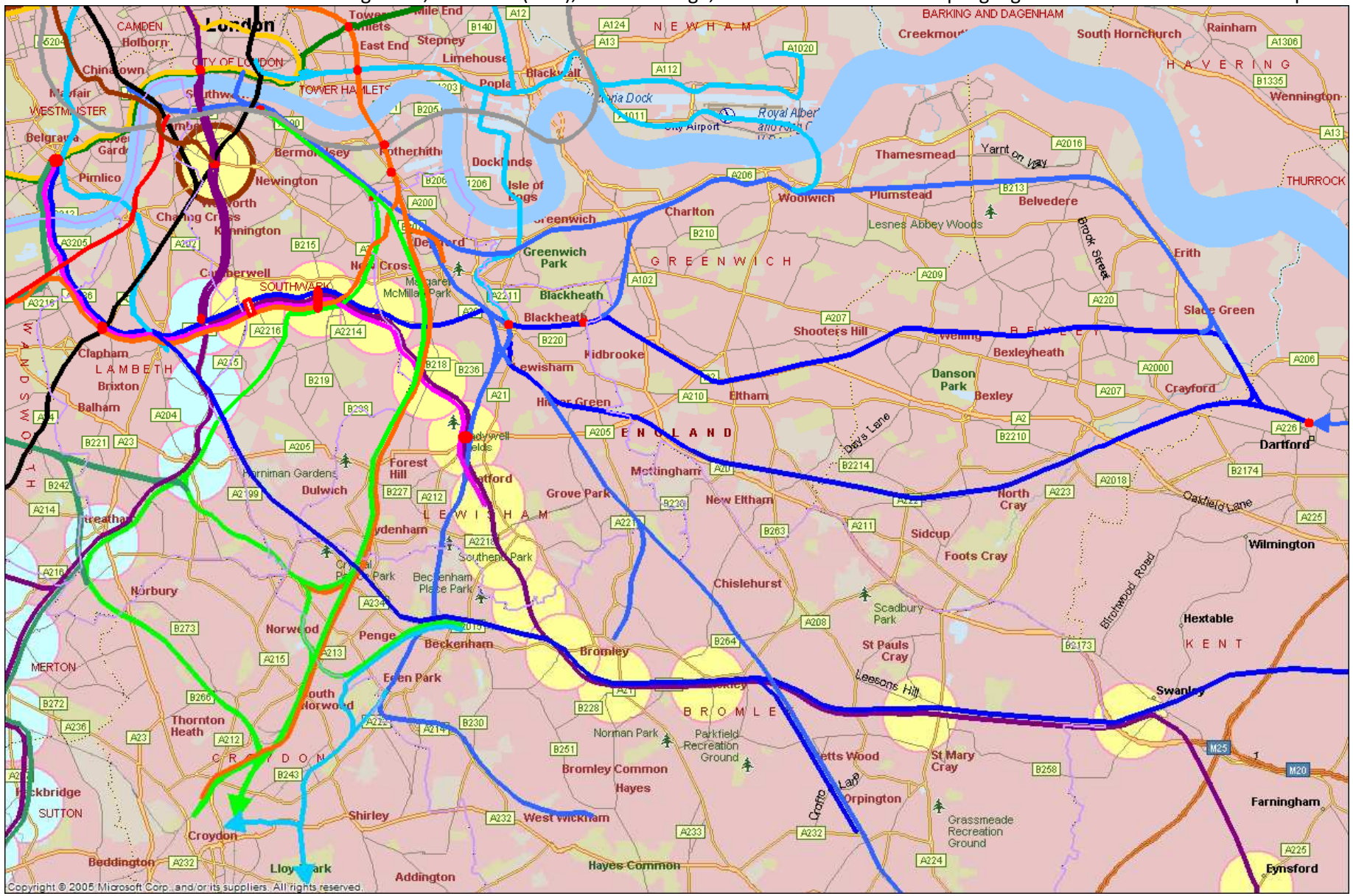
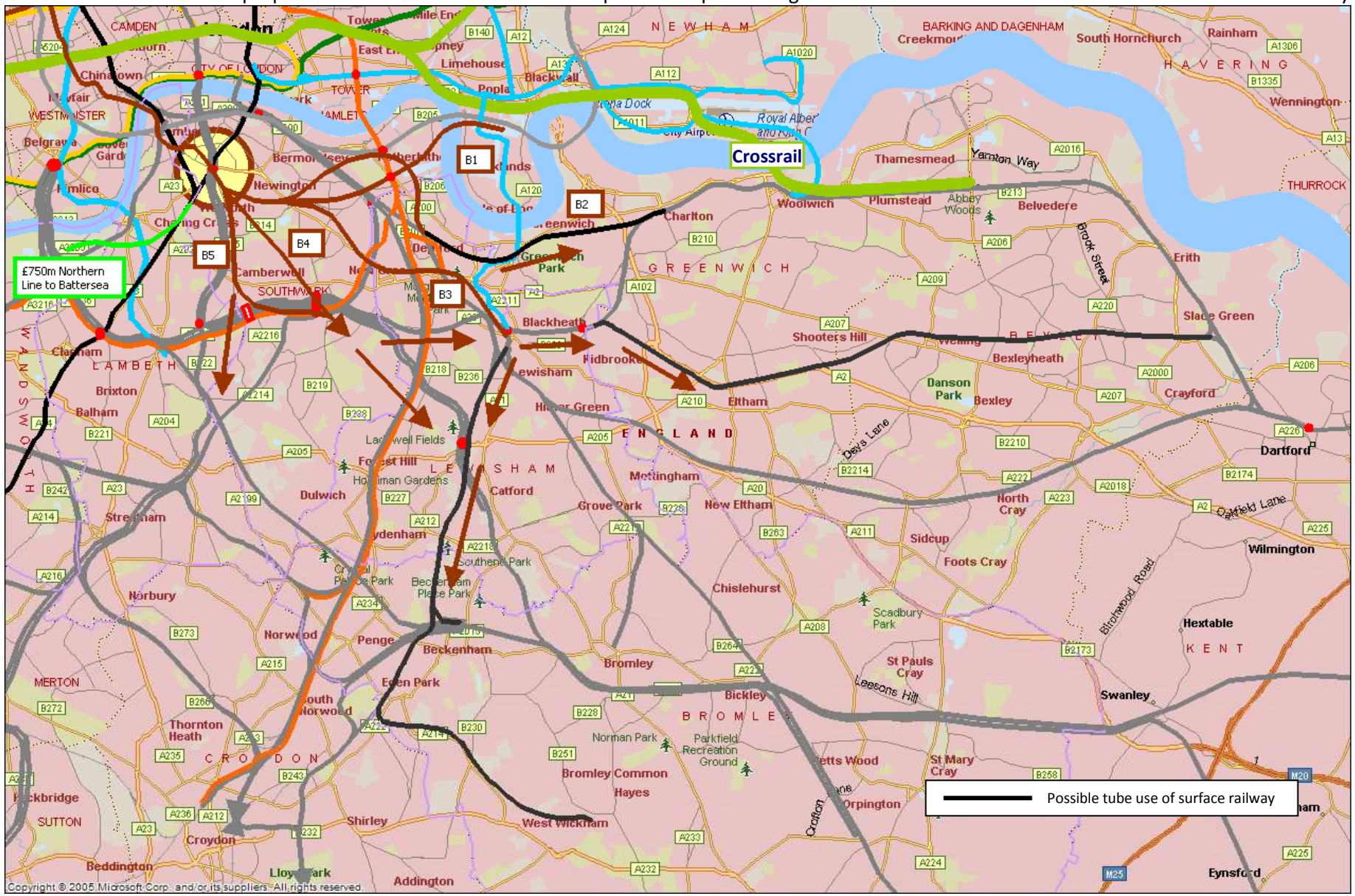
Map: SE London rail network in 2012 (incl notional service Victoria to Bellingham – options for SLL replacement are under review)

Most stations are accessible from Charing Cross, Waterloo (East), London Bridge, Blackfriars or Victoria. Map highlights stations accessible from Elephant & Castle.



Map: Potential Bakerloo Extension options

Schemes based on historic proposals and some current known transport stress points. Alignments are notional. Crossrail and Thameslink are intended by 2018.



Headline comments on potential Bakerloo Extension options

General comments

The summary notes below are arranged by geography:

- inner London
- the middle and outer suburbs.

This is because any extension of the Bakerloo Line beyond Elephant & Castle would be in tube tunnel within inner London for at least 2-4 miles, and have similar characteristics and costs per mile for this sector.

Any railway is costly, a railway in tube tunnel is very costly. As a former MD of London Underground (Lord Tunnicliffe) has commented in public evidence, no-one rationally would want to spend this sort of money if there are surface options available.

The sooner a tube can surface and use an overground alignment, the better, but this is rarely the case in inner London. One of the main reasons why the East London Line Extensions were authorised and are now happening, is because they make the fullest use of existing railway infrastructure, and any new alignment is on the surface or on viaduct. There are also different environmental benefits and costs with tube or surface railway, which will need to be assessed and managed.

A business case for any core tube tunnel extension in inner London can therefore be compared against other options, and the least worthwhile options eliminated, before consideration is given to any further extension to the middle and outer suburbs.

A previous historic option of surfacing the line and using a pair of tracks along the four-track Elephant-Walworth-Camberwell-Loughborough Junction railway viaduct is not feasible, because of the approved Thameslink project which makes more intensive use of this railway.

Similarly, use of the former Bricklayers Arms goods railway near the Old Kent Road is no longer possible – the railway lands have been built on, while the junctions in the Bermondsey area are now being redesigned for use by Thameslink services.

Having observed the cost factor, it is also generally true that tube railways are highly generative for passenger traffic, and have similarly high social benefits assisting regeneration and economic development because of the advantages with accessibility.

However that does not mean that any tube line is worth doing. The infrequency of tube schemes being funded and authorised, shows that there is an affordability barrier. Also there are often other options available, such as improving the existing modes of transport, whether those are main line railways or improving bus services and bus/rail interchanges. Recent schemes have been driven by overriding capacity and access pressures:

- (1970s) splitting the Bakerloo Line into two railways, the new railway being authorised as the Fleet Line and opened as the Jubilee Line

- (1990s) the Jubilee Line Extension into Isle of Dogs, Lower Lee Valley and Stratford, primarily for local regeneration and new transport access to the Canary Wharf business zone. [Since its authorisation, the Millennium Dome and the Olympic Games at Stratford have piggybacked on this new railway.]

The schemes now authorised and under construction, such as the East London Line and Thameslink, were also approved on the expectation that they would have a 'clear run' of delivering benefits before another scheme came into their catchments. So it is less likely that tube schemes will prove technically worthwhile or pass political 'sensibility tests' on outcome and affordability, unless they can show a clear Value for Money case benefiting catchments which mostly are not part of other recent schemes.

It is not the purpose of these notes to assess in detail a Benefit Cost Ratio or other similar measures. Instead some simple points will flag up:
- the potential purposes of specific Bakerloo Line extensions
- a possible route and service specification for each extension (there will be other options also to consider)
- a feel for costs and, if relevant, some other factors.

JRC has adopted some standardised assumptions on costs. These are indicative and mainly give a feel for magnitude. They have been influenced by the costs of the Jubilee Line Extension from Green Park to Stratford, and by current proposals to extend the Northern Line Charing Cross branch from Kennington to Battersea.

Stations: new station in tube £100m, each extra interchange £50m, alteration to existing station where adapted main line £30m.
Tube tunnels: overall £180m per mile of new twin-tunnel railway. **Adaptation costs for existing main line**, per double-track mile, if used for tube trains: £40m.
Trains (assumes 7-car trains): £9m (rounded up, ie 1 train = £10m). **Land acquisition**, depot changes, other related infrastructure, environmental mitigation, engineering, design and project management costs, risk contingency: taken as £130m per double-track mile for tunnel section, £30m per mile for surface section.

The timescale for any extension could be lengthy. The Fleet Line scheme (at one point planned to take over the Hayes Line in SE London) was conceived by 1965 and subsequently become the Jubilee Line, but was only affordable initially between Stanmore and Central London (open 1979). Plans to extend to SE London were replaced by the River Line scheme in the late 1970s, and then by the Jubilee Line Extension project, which ran as a scheme from first planning ideas in 1988 (including a separate Waterloo and Greenwich railway) and to full opening in 1999. There are still works underway to increase the line's capacity.

The current plans to extend the Northern Line from Kennington to Battersea originated in about 2007-08, and might see powers being sought in 2011 (subject to affordability – about $^{2}/_{3}$ of the extension costs of £750m for 1¾ miles might be paid for by developers). Opening might be in the mid-2010s. As with Canary Wharf, improved accessibility to a large-scale development is a major driving force behind the project.

The Bakerloo Line is near the bottom of the sequence for line upgrading as part of the tube investment projects, which have been subject to cost and investment delays as the PPP funding and delivery process has foundered. Work on the Bakerloo Line is unlikely to proceed until the late 2010s. This has the advantage that the planning and design of upgrading works in Central and NW London can make provision for an extension to SE London, so incorporating some possible costs within the upgrade rather than the extension.

Potential extensions in Inner London

B1 Elephant – Old Kent Road – Surrey Quays – Canary Wharf

Purposes:

- new public transport capacity in inner SE London and cross-river
- serve Old Kent Road (regeneration)
- Surrey Quays (orbital and Croydon Line interchange)
- additional cross-river capacity to Canary Wharf
- relieve overloaded Jubilee Line and allow Overground-Isle of Dogs passengers to avoid Canada Water
- new orbital link from Elephant to Stratford changing at Canary Wharf.

Specification:

- standard tube railway characteristics
- distance approx 3.6 miles, so might need only limited depot expansion in NW London (approx 8 trains if 2½ minute service)
- some risk of overloading Central London Bakerloo section, but Bakerloo frequency can be raised (= need for additional trains)
- assumes 3 stations (Old Kent Road, Surrey Quays, Isle of Dogs), all underground
- no interference with main line railway tracks.

Costs and other factors:

- notional capital cost ca. £1.6bn: £80m trains, £400m for stations including interchanges, £1.1bn for tunnels, tracks and other works
- serves growing demand to a major London Region economic growth destination.

B2 Elephant – Old Kent Road – Canada Water – Deptford – Greenwich – Maze Hill – Westcombe Park – Charlton

Purposes:

- new public transport capacity in inner SE London
- serves Old Kent Road (regeneration)
- Canada Water (Jubilee Line, orbital and Croydon Line interchange, and transfer London Bridge – Greenwich line passengers between routes)
- takes over Greenwich Line branch of main line network
- relieves inner London overloading on North Kent Line
- frees up capacity on main line network (benefits some train slots into London Bridge)
- relieves Jubilee Line by attracting SE London tube passengers away from North Greenwich railhead
- connects Greenwich branch into Overground and orbital network
- serves housing expansion area in SE London.

Specification:

- standard tube railway characteristics
- distance approx 3.7 miles including ramp to viaduct, then 3.1 miles overground
- approx 14-15 trains, assuming 2½ minute frequency with half of service reversing at Maze Hill
- significant depot expansion needed, scope for sidings in Angerstein area
- medium risk of overloading Central London Bakerloo section, but Bakerloo frequency can be raised (= need for additional trains)
- assumes 2 new tube stations (Old Kent Road, Canada Water) then takeover and adapt existing 5 main line stations (Deptford, Greenwich, Maze Hill, Westcombe Park, Charlton incl interchange with North Kent Line)
- takes over part of existing main line network.

Costs and other factors:

- notional capital cost ca. £1.95bn: £140m trains, £450m for stations including upgrading existing premises, £1.35bn for tunnels, tracks, adaptation of existing main line and other works
- relief of Jubilee Line via North Greenwich could be counterbalanced by increased loadings via Canada Water interchange
- operating benefits for the main line network are limited because of increased train slot need at Lewisham Junction from the North Kent Line
- potentially only operable if there is other investment to increase capacity at Lewisham Junction
- alignment assumes routeing via Canada Water to achieve interchange for London Bridge – Greenwich line passengers
- another option is to follow B3 to New Cross, thence to Deptford Bridge and Greenwich, however this would be in tube until Greenwich Park (4½ miles), with only $1^{2}/_{3}$ miles of adapted surface railway. There would be significantly greater capital cost, notionally ca. £2.35bn overall.

B3 Elephant – Old Kent Road – New Cross – Lewisham

Purposes:

- new public transport capacity in inner SE London
- serves Old Kent Road (regeneration) – might be one or two stations on Old Kent Road
- direct tube between Lewisham, New Cross area and West End
- connects to strategic inner SE London centre and interchange at Lewisham.

Specification:

- standard tube railway characteristics
- tube line approx 4.5 miles to Lewisham
- some risk of overloading Central London Bakerloo section, but Bakerloo frequency can be raised (= need for additional trains)
- assumes 4 stations (2 in Old Kent Road, New Cross/Gate, Lewisham), all underground
- approx 9 trains assuming a 2½ minute frequency
- no interference with main line railway tracks.

Costs and other factors:

- notional capital cost ca. £2.05bn: £90m trains, £550m for stations incl New Cross tube station linking to both New Cross and New Cross Gate, £1.4bn for tunnels, tracks and other works
- cost similar to B2, strengthens role of Lewisham as gateway centre for SE London, benefits communities along the route
- this option has the capability to extend further into SE London.

B4 Elephant – Aylesbury Estate – Peckham Rye

Purposes:

- new public transport capacity in inner SE London
- serves Aylesbury Estate and Peckham (regeneration)
- direct tube between Peckham and West End
- connects to strategic inner SE London centre and interchange at Peckham.

Specification:

- standard tube railway characteristics
- tube line approx 2.1 miles to Peckham Rye
- some risk of overloading Central London Bakerloo section, but Bakerloo frequency can be raised (= need for additional trains)
- assumes 2 stations (Aylesbury Estate, Peckham Rye), both underground
- approx 5 trains assuming a 2½ minute frequency (no additional spare trains assumed with this option)
- no interference with main line railway tracks.

Costs and other factors:

- notional capital cost ca. £0.95bn: £50m trains, £250m stations, £650m for tunnels, tracks and other works
- this is a lower capital cost option, with capability to extend further into SE London.

B5 Elephant – Camberwell – Peckham Rye

Purposes:

- new public transport capacity in inner SE London
- serves Camberwell (inner London centre lacking rail service)
- serves Peckham (regeneration)
- a 'double-ended' station at Camberwell could offer direct access to hospitals at Denmark Hill
- direct tube between Peckham, Camberwell and West End
- connects to strategic inner SE London centre and interchange at Peckham.

Specification:

- standard tube railway characteristics
- tube line approx 2.7 miles to Peckham Rye
- some risk of overloading Central London Bakerloo section, but Bakerloo frequency can be raised (= need for additional trains)
- assumes 2 stations (Camberwell, Peckham Rye), both underground
- approx 6 trains assuming a 2½ minute frequency (no additional spare trains assumed with this option)
- historic alignment for Bakerloo Line extension into SE London – extensive planning has been undertaken several times for this route
- no interference with main line railway tracks.

Costs and other factors:

- notional capital cost ca. £1.2bn: £60m trains, £300m stations (assuming Denmark Hill link), £840m for tunnels, tracks and other works
- this costs more than B4, and serves Camberwell/Denmark Hill rather than Aylesbury Estate
- it has the capability to extend further into SE London
- an option to run via Camberwell to Herne Hill is noted here but not considered further
- a Herne Hill option has been reviewed before by railway planners – it would conflict with a Victoria Line extension from Brixton whose alignment already points towards Herne Hill and could be under 1 mile long, compared to 3 miles from Elephant & Castle.

Potential extensions to the SE London middle and outer suburbs

Reasons for extensions

Historically, suburban extensions of tube lines were authorised because of a combination of factors:

- overcrowding on other lines which a new railway would relieve
- opportunity to serve expanding populations or new centres of employment
- new links and connections which were strategically important
- where possible, use was made of existing suburban railways where this made economic sense, either by adopting the existing tracks, or by building additional tracks alongside where the alignment permitted this.

The last major extension largely *in tube* beyond inner London was the Victoria Line to Walthamstow, in the 1960s. The route was justified by relieving overcrowding on the commuter lines into Liverpool Street, and by offering a direct West End tube service while the main line focused on the City of London. The tube was authorised in 1955 but not funded until 1963.

The River Line scheme to Thamesmead – an extension of the Fleet Line – was authorised in the late 1970s to serve Docklands redevelopment but was never funded. In inner London, it was replaced by the DLR project, which has since expanded to Lewisham, the Royals and Woolwich. Later, the Jubilee Line Extension was authorised on a different alignment, in tube to Canary Wharf and North Greenwich, and on the surface through the Lower Lea Valley and to Stratford, again for jobs and regeneration objectives. Crossrail to SE London is also authorised because of capacity and accessibility to the Isle of Dogs employment area, and for its regeneration and interchange capability in the Royals, Woolwich and Abbey Wood.

How and why would another tube extension be justified in the SE suburbs?

The same historic justifications remain relevant. So, for these criteria, the area served would need to show a cogent case for investment which could amount to another £0.3-1.3bn capital costs on top of an extension through inner London (this is how Crossrail's extension via Stratford to Shenfield has been justified). For a Bakerloo Line extension, participating boroughs such as Bexley, Bromley, Greenwich, Lewisham and Southwark would need to demonstrate clear spatial and economic development reasons for a tube extension.

New reasons emerging in the 21st Century are:

- increased public transport capacity and modal share, required to reduce carbon consumption in the suburbs (principally, substitution of car travel)
- extra commuting pressures on the conventional main line railways, linked to the growing importance of London jobs as a destination from a large catchment in the Home Counties and beyond
- these pressures put a premium on allocation of train slots (and their worth), with a new tube being a valid alternative if it can take over a suburban branch and free up capacity on the main line for other services.

B1 Beyond Canary Wharf / Isle of Dogs

It is difficult to see how an extension beyond the Isle of Dogs towards SE London would be justified in the foreseeable future, with the DLR extension to Woolwich and Crossrail's authorisation. This option is not considered further in this note.

B2 Beyond Charlton

No further extension is assumed beyond Charlton, as the next logical destination would be Woolwich, which is to be served by Crossrail.

B3 Beyond Lewisham

Historically, two lines have been the usual candidates for proposed tube extensions beyond Lewisham:

- to Blackheath, then taking over the Bexleyheath Line
- to Catford, then taking over the Hayes Line.

This is because they are capable of separation from the rest of the main line network and becoming self-contained tube lines.

A further option might be to Central Bromley via Hither Green and Grove Park, taking over the Grove Park-Bromley North line. However this railway does not offer much SE main line relief, as it is a self-contained shuttle service. Journey times by fast train from Bromley South make a tube journey relatively unattractive. Further consideration of this option would depend on a strong development case linked to proposals for Central Bromley. The rest of this option focuses on the Bexleyheath and Hayes Lines. Extension of B3 beyond Lewisham is possible in either direction.

Towards Blackheath and Bexleyheath

Purposes:

- primarily a suburban commuter railway
- extra train slot capacity on the main line network at Lewisham Junction and towards London Bridge, Cannon Street and Charing Cross
- scope for extension to Bluewater, to providing a traffic attraction at the further end of the line

Specification:

- tube railway takeover of suburban main line east of Blackheath (main line retained for North Kent services between Lewisham and Blackheath)
- use part of existing depot capacity at Slade Green, to reduce extension costs and provide sidings in SE London (with adaptation costs)
- further 0.8 miles from end of Lewisham tube to Blackheath (mix of ramp / surface), assumed parallel to existing line as far as Blackheath Junction, then 8.5 miles to Slade Green depot via Bexleyheath

- approx 12 trains needed to extend Lewisham service to Slade Green at assumed 5 minute headway
- high risk of overloading the existing service on the Central London Bakerloo section, requiring an increase in service towards 2 minute headways between Lewisham or Elephant and Paddington (possibly a further 6 trains in use if Elephant-Paddington).

Costs and other factors:
- additional capital cost Lewisham-Slade Green ca. £1.3bn: £170m trains (incl Central London), £340m stations, £770m route and other works
- overall cost Elephant & Castle to Slade Green ca. £3.35bn
- the existing Bexleyheath Line has a mix of City and Waterloo/Charing Cross services, and Victoria trains (not an all day service)
- a future tube line would be more frequent but only serve Waterloo/Charing Cross/West End directly.

Towards Catford and Hayes

Purposes:
- primarily a suburban commuter railway
- extra train slot capacity on the main line network at Lewisham Junction and towards London Bridge, Cannon Street and Charing Cross
- assists economic development at Central Catford
- scope for additional short distance services to Beckenham Junction, connecting with SE main line via Bromley South
- Tramlink via Elmers End and Beckenham Junction, to Croydon, to providing balancing traffic in outer London and attract car users to public transport.

Specification:
- tube railway takeover of suburban main line south of Lewisham
- additional sidings required to support increased train service frequency in SE London (increases the specific scheme cost)
- 1.25 miles to Catford Bridge from end of Lewisham tube (mix of ramp/surface), then 7 miles to Hayes and 0.5 mile to Beckenham Junction
- approx 10 trains needed to extend Lewisham service to Beckenham Junction / Hayes, each at 8 minute headway
- high risk of overloading the existing service on the Central London Bakerloo section, requiring an increase in service towards 2 minute headways between Lewisham or Elephant and Paddington (possibly a further 6 trains in use if Elephant-Paddington).

Costs and other factors:
- additional capital cost Lewisham-Hayes ca. £1.3bn: £150m trains (incl Central London), £400m stations, £730m route and other works
- overall cost Elephant & Castle to Hayes ca. £3.35bn
- the existing Bexleyheath Line has a mix of City and Waterloo/Charing Cross services
- a future tube line would be more frequent but only serve Waterloo/Charing Cross/West End directly.

B4+B5 Beyond Peckham

Towards Lewisham

Purposes:

- alternative extension to Lewisham (and beyond) if route via Peckham favoured over route via Old Kent Road
- connects to strategic inner SE London centre and interchange at Lewisham, serving 2 or 3 town centres on the same railway (Camberwell / Peckham / Lewisham
- potential for further extension to Blackheath and beyond to the Bexleyheath Line (not to Catford as this would be a roundabout route)
- the latter would achieve extra train slot capacity on the main line network at Lewisham Junction and towards London Bridge, Cannon Street and Charing Cross, as discussed above under option B3.

Specification:

- standard tube railway characteristics as far as Lewisham (surface alignment unlikely to be achievable)
- tube line approx 2.5 miles between Peckham Rye and Lewisham
- if extended beyond Lewisham, see characteristics identified above for Slade Green service under option B3.
- distance in tube between Elephant and Lewisham via Aylesbury Estate and Peckham is similar to Old Kent Road option B3 (above), and with similar costs (assumes new intermediate station at Brockley)
- approx 9 trains needed for Elephant- Lewisham service and another 12 beyond, based on previous specifications, via option B4, one further train required with option B5 via Camberwell
- significant risk of overloading the existing service on the Central London Bakerloo section, requiring an increase in service towards 2 minute headways between Lewisham or Elephant and Paddington. However in short term new trains might be resourced from other fleet cascades.

Costs and other factors:

- total capital cost Elephant-Peckham-Lewisham ca. £2.15-2.4bn (B4 or B5 options): £90-100m trains (excl Central London), £650-700m stations, £1.4-1.6bn tunnels, tracks and other works
- overall cost Elephant & Castle to Slade Green ca. £3.45-3.7bn (B4 or B5 options)
- the existing Bexleyheath Line has a mix of City and Waterloo/Charing Cross services, and Victoria trains (not an all day service)
- a future tube line would be more frequent but only serve Waterloo/Charing Cross/West End directly.

Towards Catford

Purposes:

- alternative extension to Catford (and beyond) if route via Peckham favoured over route via Lewisham
- assists economic development at Central Catford, serving 2 or 3 town centres on the same railway (Camberwell / Peckham / Catford)
- potential for further extension onto Hayes Line, but arrangements for the Lewisham-Ladywell-Catford Bridge section would need to be defined
- unless the Hayes Line service were wholly replaced, there would be only limited additional train slot capacity on the main line network at Lewisham Junction and towards London Bridge, Cannon Street and Charing Cross.

Specification:

- standard tube railway characteristics as far as Catford, whether in tube or on the surface
- any joint operation of tube (West End) and main line (City) trains south of Catford Bridge is unlikely unless platform heights (and automatic train protection) were resolved – disability legislation requires level access between platform and train, but tube and main line trains have separate platform heights, so the present compromise arrangements on some lines would not be allowed again
- until a workable scheme were developed south of Catford (see issues above), it is not assumed that a Bakerloo Line via Peckham could be extended towards Hayes or Beckenham Junction
- it might be possible to widen the Catford Loop line to accommodate parallel Bakerloo Line tracks at surface level from east of Nunhead Junction to Catford, though this would incur disruption and environmental impact
- surface route 2.6 miles, via Nunhead and Crofton Park, terminating at the present Catford station area
- the alternative is an extension in tube, possibly non-stop to achieve the fastest West End journey times from southern Lewisham via Catford Interchange, or with an intermediate station near Honor Oak Park for the Croydon line
- tube route approx 2.6 miles between Peckham Rye and Catford via Honor Oak Park
- this assumes the optimum location for new Catford tube platforms to support economic development at Central Catford, would be to locate these on an E-W alignment between the existing Catford stations and Central Catford
- approx 9 trains needed for Elephant-Catford service, via Option B4
- significant risk of overloading the existing service on the Central London Bakerloo section, requiring an increase in service towards 2 minute headways between Catford or Elephant and Paddington. However in short term new trains might be resourced from other fleet cascades.

Costs and other factors:

- total capital cost Elephant-Peckham-Catford tube route ca. £2.15-2.4bn (B4 or B5 options): £90-100m trains (excl Central London), £600-650m stations (beoynd Peckham, at Honor Oak Park, and Catford Interchange/Central Catford), £1.45-1.65bn tunnels, tracks and other works
- a Bakerloo Line to Catford could be similar to the Victoria Line at Seven Sisters/Tottenham, offering a faster direct West End service than existing main line trains (whose typical journey is 20 minutes), and complementing the bulk of main line services at Catford/Catford Bridge which serve the City.

Notional scheme costings

Bakerloo extension schemes	TOTAL	extra trains	trains	tube stns	extra i/cs	adapted stns	stations	tube miles	surface miles	track+infra	additional
	£bn	no.	£m	@ £100m	@ £50m	@ £30m	£m	@ £180m	@ £40m	£m	costs £m
INNER LONDON											
B1 Canary Wharf	**1.6**	8.2	**80**	3	2	0	**400**	3.6	0	**648**	**468**
B2 Charlton via Canada Water	**1.95**	15	**140**	2	2	5	**450**	3.7	3.1	**790**	**574**
B2 Charlton via New Cross	**2.35**	15	**140**	4	4	3	**690**	4.5	1.7	**878**	**636**
B3 Lewisham via Old Kent Road	**2.05**	9	**90**	4	3	0	**550**	4.5	0	**810**	**585**
B4 Peckham via Aylesbury Estate	**0.95**	4.8	**50**	2	1	0	**250**	2.1	0	**378**	**273**
B5 Peckham via Camberwell	**1.2**	6.2	**60**	2	2	0	**300**	2.7	0	**486**	**351**
MIDDLE SUBURBS											
B3 Lewisham-Blackheath *+	**0.3**	3	**30**	0	1	1	**80**	0.5	0.3	**102**	**74**
B3 Lewisham-Catford *+	**0.4**	4	**40**	0	2	2	**160**	0.5	0.75	**120**	**87**
B4/B5 Peckham-Lewisham (tube) +	**1.2**	4	**40**	3	2	0	**400**	2.5	0	**450**	**325**
B4/B5 Peckham-Catford (tube) +	**1.2**	4	**40**	2	3	0	**350**	2.6	0	**468**	**338**
OUTER SUBURBS											
B3 Lewisham-Blackheath-Slade Grn +	**1.3**	18	**170**	0	2	8	**340**	0.5	8.8	**442**	**329**
B3 Lewisham-Catford-Hayes +	**1.3**	16	**150**	0	2	10	**400**	0.5	8.25	**420**	**312**

* mix of tunnel ramp and surface

+ assumes no extra Central London train costs until tube service extended to outer suburbs. In short term new trains might be resourced from other fleet cascades.

Costings derived from recent schemes including 2009 costs reported for Northern Line project to Battersea

Stations: new station in tube £100m, each extra interchange £50m, alteration to existing station where adapted main line £30m.

Tube tunnels: overall £180m per mile of new twin-tunnel railway.

Notional adaptation costs for existing main line, per double-track mile, if used for tube trains: £40m.

Trains (assumes 7-car trains): £9m (rounded up, ie 1 train = £10m).

Land acquisition, depot changes, other related infrastructure, environmental mitigation, engineering, design and project management costs, risk contingency: taken as £130m per double-track mile for tunnel section, £30m per mile for surface section.