CROSSRAIL: STUDIES OF COST-EFFECTIVENESS BY LUL/BR AND BY DOT CONSULTANTS

A. Introduction

1. In May 1993, the Prime Minister decided that the CrossRail Bill should proceed to its Commons Second Reading on condition that the scope for cost savings should continue to be investigated urgently but thoroughly. Following consideration by DOT, Treasury, LT/LUL and BR on how best to undertake the investigation, LUL/BR embarked on a study involving a detailed evaluation of each key element of the CrossRail project as defined in the Bill. The aims of that study have been to recommend the final form of the project including any additional project elements and to indicate which elements might be financed privately and which publicly.

2. Some two months into the LUL/BR study period, consultants were appointed by DOT to build on the work so far done by LUL/BR by doing their own evaluations of key elements of the project as defined in the Bill and by looking as well at any alternatives which seemed to them likely to compare favourably with the project as defined in the Bill.

B. Costs

3. The project as defined in the Bill is estimated by LUL/BR to cost some £1.7bn at March 1990 prices. DOT's consultants point out that that estimate would rise to some £2.7bn in November 1993 prices if full account were taken of inflation, rolling stock costs and contingencies.

4. DOT's consultants also point out that, of the £1.7bn total cost, nearly half is attributable to five central area stations -

- Tottenham Court Road (£250m), Bond Street, Farringdon and Liverpool Street (£150m each) and Paddington (£100m).

5. Of the five central area stations, Bond Street and Liverpool Street have the strongest economic/financial case, followed by Tottenham Court Road. Neither Farringdon nor Paddington could be justified on purely economic or financial terms.

6. There could be scope for achieving further cost reductions by:

i. reducing station sizes by changing from 2 ticket halls to 1;

ii. reducing tunnel diameter;

iii. standardising escalators; and

iv. deleting provision for expansion, eg reducing platform and train lengths.

7. The £1.7bn cost of the full scheme could be reduced to:

i. £1.5bn by changing from 5 double-ended, to 5 single-ended, central area stations;

ii. £1.4bn by changing from 5 double-ended, to 3 single-ended, central area stations and by reducing train frequencies from 24 to 22 trains per hour; or

iii. £1.3bn by changing from 5 double-ended, to 2 single-ended, central area stations and by reducing train frequencies from 24 to 14 eastbound and 16 westbound trains per hour.

C. Benefits

8. LUL/BR have identified several factors which have resulted in an improvement in the economic performance of the scheme. Among these is an increase in the benefits by some 15% because the proposed train service now better reflects forecast demand by, for example, the provision of limited stop services to shorten journey times and because of improvements in the design of stations to facilitate access to trains. Other changes to the economic appraisal include a measure of the benefit of safety related expenditure and the revaluation of costs and benefits to a 1993 base: since the previous estimates were made, the real project costs have risen less than the forecast value of the benefits.

9. LUL/BR estimate that with these revisions the full Crossrail scheme would have a benefit:cost ratio of between 1.4:1 and 1.7:1 depending on the forecasts of the growth in Central London employment (see Section 4 below). DoT's consultants have not had the opportunity to make corresponding revisions to their appraisal but estimate that the full scheme could have a benefit:cost ratio 1.2:1 even on relatively modest forecasts of growth in demand. In addition the consultants have estimated that the three lower cost options (see paragraph 7 above) could have benefit:cost ratios ranging from 1.0:1 to 1.4:1. The consultants and LUL/BR are broadly agreed that the most cost-effective option would be to have two central area stations at Bond Street and Liverpool Street plus a third central area station at either Tottenham Court Road or Holborn. Extra central area stations could be added at Paddington or Farringdon only by allowing a cost increase greater than any benefit increase that could be achieved by their addition.

D. Forecasts of Employment in Central London

10. The 1989/BR/LT Central London Rail Study (CLRS) report showed that, with the rate of growth then pertaining in commuting to Central London, Crossrail would be required by 2001. The Crossrail team's 1.4:1 ratio quoted by DOT's consultants for the full Crossrail scheme was based on the growth forecast assumed in the CLRS report and on an assumption that the project would be taken forward as a public sector project attracting major

social benefits and, to a lesser extent, increasing the rail operators' revenues.

11. Central London employment has fallen by about 20% since 1989. The estimates used by DoT's consultants assume a growth in Central London employment of around 15% on the present depressed levels by 2001 and this would produce a benefit cost ratio for a publicly funded reduced scheme of around 1.4:1. There is inevitable uncertainty about the future of employment in and commuting to Central London. The pattern has been one of long term decline over the 1960s and 70s which was arrested in the 1980s, partly because the proportion of manufacturing employment, which had largely accounted for the decline, had become relatively insignificant in the total.

E. Scope for Private Finance

12. Both studies suggest that the project might be attractive to the private sector as a joint venture although the conclusions of Bovis Gibb are more uncertain. Our analysis of both sets of figures shows that if the public sector accepts an 8% return in terms of social benefits on its share of the project costs, the nominal return to the public sector from the reduced scheme is of the order of 20%, even on the operators' low demand forecasts given their specification of the scheme. Our consultants and those working for the operators view this as an investment project which is within, albeit towards the lower end of, the range for a privately financable project.

Public Transport London Division

Department of Transport

7 January 1994

OPERATORS' REPORT: SUMMARY

The operators (British Rail and London Underground) looked at the Crossrail scheme as at present envisaged and at the alternative northerly alignment via King's Cross. They did not look at other alternatives, but as noted below they have commented on the possibilities identified by Bovis-Gibb.

2. The operators have identified three versions of the Crossrail scheme, each of which they conclude is worthwhile. These three schemes are:

- the full project, as originally planned, with stations at Paddington, Bond Street, Tottenham Court Road, Farringdon and Moorgate, and with a range of through services;

- 'a reduced scheme', with three stations, probably at Bond Street, Tottenham Court Road and Moorgate (though there might also be a case for Farringdon). Services would be between Shenfield in the east and Reading and Aylesbury in the west, with a peak frequency of 22 trains per hour;

- a further reduced 'core scheme', with stations only at Moorgate and Tottenham Court Road. Services would be between Shenfield and Slough, with a peak frequency of around 16 trains per hour.

3. The reduced scheme is costed at 86% of the cost of the full scheme. The core scheme is costed at 70% of the cost of the full scheme.

4. On the balance between costs and benefits, the operators conclude that all three schemes produce positive benefit-cost ratios (which they put at between 1.4 and 1.7). But in addition the operators have carried out further transport modelling which indicates that the benefits of the scheme are some 25% larger than previously calculated; these extra benefits take the form of reduced journey times and crowding relief. The operators calculate that this increases the benefit-cost ratio of the full scheme from 1.4 to 1.7.

5. The operators have also tested the full scheme against two lower demand scenarios, one assuming little future growth in central London employment, and the other (the "central forecast") assuming some growth, but at a lower level than the 1989 Central London Rail Study. The operators calculate that both scenarios produce positive benefit-cost ratios for the full scheme, at 1.37 for the lowest growth scenario, and 1.52 for the central forecast.

6. On finance, NatWest Markets, who are advising the operators, conclude that the full scheme, and the reduced and core versions, could produce a positive return for the public and private sectors as a joint venture (assuming that the private sector bears about half the capital costs and all the operating costs). The public sector returns would be in the form of social benefits

(such as time savings) gained by passengers and road users. NatWest Markets see the reduced scheme (that is, with medium cost reductions) as being the preferable option for financing.

7. The operators do not see merit in an alternative route via King's Cross. It would be more expensive to build, and would have lower benefits, reflecting the fact that passengers would not be taken so close to their destinations. It would also pose operating difficulties.

8. Overall, the operators conclude that it is possible to develop Crossrail as an operationally and financially viable scheme, either at the level originally proposed or at lower levels, even though these lower levels would not capture all the benefits of the full scheme. (Provision could be made for future expansion.) The operators argue that sufficient finance could be raised through debt and equity for 51% of the gross project cost. They recommend that the Bill should proceed through the Parliamentary process, so that further development and business planning can be undertaken to determine the optimum scheme.

9. As a separate exercise, London Underground have conducted a preliminary assessment of the various alternative options involving modifications to the existing London rail network put forward by Bovis-Gibb. None of the schemes is wholly ruled out, but London Underground are doubtful about the benefits in relation to the costs, especially in comparison with Crossrail. They see operational difficulties in some of the proposals, particularly the running of Heathrow Express services to the City via the northern part of the Circle Line.

BOVIS-GIBB REPORT: SUMMARY

Bovis-Gibb conclude that Crossrail as at present conceived is a well engineered and operationally efficient scheme; the cost estimate appears robust. Of the central London stations, they conclude that there should be stations, with one entrance only, at Moorgate and Bond Street plus either Tottenham Court Road or Holborn. The cases for Paddington and Farringdon are doubtful; further work needs to be done. More work also needs to be done on various possible cost reductions in the basic scheme, particularly omitting the scope for future expansion of the stations (the promoters envisage providing for potential expansion to handle 12-car trains instead of 8-car, and to have two ticket halls rather than one); in fact Bovis-Gibb suggest that the possibility of 6-car trains should be looked at.

2. Bovis-Gibb see no advantage in an alternative route for Crossrail via King's Cross.

3. Bovis-Gibb look at likely future demand and the implications for Crossrail as a joint venture with the private sector. They point to the fact that employment in central London has not followed the growth forecast of the 1989 Central London Rail Study (CLRS - a DOT/BR/LT review); in fact central London employment has fallen by some 20% since 1989, and there had been a longer-term decline before the growth of the 1980s. Bovis-Gibb have therefore taken only 85% of the demand figures for 2001 used by LT in planning the scheme. (This is very close to the assumptions now being adopted by DoT for the appraisal of

projects and policies in London).

4. On this basis (and before taking account of the further scheme development work by the Operators, which produced higher benefits), Bovis-Gibb looked at nine variants of the scheme. All have benefit: cost ratios of 1:0:1 or below, with three put at 1.3:1 or 1.4:1.

5. Bovis-Gibb examine the financing of the project (noting that 'the assumption that there will be some growth in overall demand would seem to be reasonable'). They assume that a range of different sources of finance (including debt, equity, fare revenue and an element of public finance) will be available. However they express some doubts about timing of the project, depending on the level of demand, with a view to obtaining a positive return for the public sector share of the project cost.)They note that 'as a public sector project, the scheme could be brought to fruition in a shorter timescale than as a public/private sector joint venture'.) However they comment that this 'would not necessarily require a delay in the Bill process'. Implementation could depend on subsequent analysis of changes in employment and commuting.

6. Bovis-Gibb have also looked at alternative smaller-scale schemes, which aim to achieve some of the benefits of Crossrail. These schemes would involve additions to the existing London rail networks, and any or all could be pursued on a shorter timescale than Crossrail, without ruling out any longer term Crossrail scheme. Bovis-Gibb believe that private finance could be

attracted to these projects.

7. The smaller schemes include running the Heathrow Express to the City along an upgraded north side of the Circle Line; linking the eastern end of the Jubilee Line to the Central Line, to relieve the congested Central Line by providing an alternative route from the eastern suburbs to the West End; running through services between Slough and Barking, also via the north side of the Circle Line; and creating spare capacity on the northern Circle Line by diverting the Hammersmith and City Line to the West End via the Bakerloo Line and diverting the Wimbledon branch of the District Line into the Central Line at Holland Park, rather than running to Edgware Road. More work would need to be done on all such options.

CROSSRAIL

Study of
COST EFFECTIVENESS

2.0
THE STUDY BRIEF

Bovis SIR ALEXANDER GIBB & PARTNERS

2.0 THE STUDY BRIEF

The brief for the CrossRail cost effectiveness study was contained within the Terms of Reference issued by the Department of Transport with the Invitation to Tender dated 15 October 1993. Its main criteria were:

Purpose of the Study

* Show how best to achieve the Government's aims within the context set by the objectives of the project.

Government's Aims

* Establish CrossRail as a joint venture attractive to the private sector;
* Improve cost-effectiveness of the project and reduce the cost to the public sector;
* Ensure value for money for the public sector contribution.

Objectives of the Project

* Reduce journey times within the east-west corridor;
* Provide direct access to the central area;
* Relieve congestion on existing rail routes to and within Central London;
* Relieve congestion at existing stations;
* Provide improved interchange opportunities with existing and proposed lines;
* Provide relief of road congestion by attracting road users on to CrossRail;
* Give wider transport benefits;
* Encourage development;
* Improve reliability, quality and safety of the railway.

CROSSRAIL

Study of
COST EFFECTIVENESS

3.0
THE MINIMUM CORE RAILWAY

Bovis SIR ALEXANDER GIBB & PARTNERS

3.0 THE MINIMUM CORE RAILWAY

3.1 Study Objectives

The CrossRail Project was recommended in the Central London Rail Study (CLRS), published in January 1989, as an effective option to relieve congestion on existing lines and cater for future growth.

In order to establish whether CrossRail still effectively satisfies the objectives set out in the Terms of Reference for the CLRS, the study team has reviewed the robustness of the CLRS demand assumptions now that some 5 years have passed since the study was conducted.

The terms of reference of the CLRS were:

* To develop a strategy for improving services for passengers on the British Rail and Underground networks in London, and to provide forecast demand on the two networks up to the end of the century, with particular reference to passenger congestion in the area bounded by the major rail termini and their approaches.

* To have regard to the need to make best use of existing assets;

* To put forward packages of measures, at different forecasts of demand, the costs of which are justified in terms of revenues, demonstrating the extent to which proposed improvements could be financed from fares, and, where necessary, taking account of quantified benefits;

* To present the strategic choices.

Review of CLRS Assumptions for CrossRail

The forecast demands of Central London employment given in the CLRS have been reviewed by the study team and are likely to have over estimated by UP TO 19% the likely total employment for Central London in the year 2001. The effect of this change on the demand forecasts, and hence the timing of the CrossRail project, is discussed in Section 3.10.

CrossRail utilises extensive lengths of the existing Network South East (NSE) surface railway assets, but does not utilise the existing London Underground (LUL) assets in Central London. It was assumed in the CLRS that a comprehensive upgrade of the Underground network would be completed prior to implementation of the recommended projects. Much of this upgrade has not been carried out and is not currently included in the funding programme for LUL.

The strategy recommended by the CLRS was to build two new lines in deep tunnel under Central London. Less ambitious projects were considered, but were rejected because they could not carry the expected growth in traffic. Subsequently, a decision was made to proceed with the Jubilee Line Extension which was not considered in the CLRS and which is intended to support growth in South and East London. Thus, the underlying demand for CrossRail, and the scope for congestion relief benefits, is likely to be different to that anticipated by the CLRS.

At the time the CrossRail Bill was deposited, Government stated a desire that the scheme be taken forward as a joint venture with the private sector. This was a new requirement which had not been considered by the CLRS in developing the scheme.

Objectives for the Minimum Core Railway

This section (Section 3.0) of the study examines whether there is a Minimum Core Railway which reflects current employment forecasts and which can meet the Government's aim to make CrossRail a viable joint venture with the private sector.

This reduced scheme must still meet the Government objectives set out in Section 2. The development by the study team of a Minimum Core Railway has been based on the existing work done by the CrossRail team, particularly on their incremental analysis of a Basic Core Railway and the Minimum Feasible Railway which they considered to be the realistic least cost CrossRail option. The Minimum Core Railway proposed in this study aims to reduce costs without sacrificing benefits and to remain generally compatible with the existing Bill and the CrossRail scheme concept. The principal features of these options are listed in Table 3.1.

FEATURES	CROSSRAIL TEAM PROPOSALS			BOVIS / GIBB PROPOSALS
	FULL DESIGN REQUIREMENTS	BASIC CORE RAILWAY	MINIMUM FEASIBLE RAILWAY	MINIMUM CORE RAILWAY
UPGRADABILITY				
Platform tunnel lengths	12 car / 283m long	8 car / 190 m long	12 car / 283m long	6 car / 120m long
Station Platform Lengths	12 car / 283 m long	8 car / 190m long	8 car / 190m long	6 car / 120m long
Ticket Halls / Station	2 No. sized for 12 car trains	1 No. sized for 8 car trains	1 No. sized for 8 car trains	1 No. sized for 6 car trains
Escalator Access - to platforms	Fully sized shafts with all machines installed	Fully sized shafts with 1 up 1 down machine	Fully sized shafts with 1 up 1 down machine	Sized for single ticket hall with appropriate escalators
-from street level	Escalators	Stairs	Escalators	Escalators
Number of Central Stations	5	2	2	3
Chelsea-Hackney line connections	YES at TCR	YES	YES	excluded
Signalling	30 tph	20tph	30 tph	30 tph
Rolling Stock	New stock	Exsisting stock - 20m cars	Fire Hardned Stock	New stock - 3 car sets
ENHANCEMENTS				
Enhanced Safety Standards:-				
-emergency evacuation	included	excluded	included *	included *
-ventilation shafts	included	1 only	included	included
-emergency services access	included	excluded	included	included
-trackside walkway	included	excluded	included	included
Mobility impaired access	included	excluded	included	included
Environmental mitigation measures againist:-				
-operational noise	included	excluded	included	included
-vibration	included	excluded	included	included
-construction operation	included	not restricted	included	included
COMMENTS		Rejected as being unrealistic	* sited in future second ticket hall locations	* sited in most cost effective locations

COMPARISON BETWEEN RAILWAY SYSTEM REQUIREMENTS

Table 3.1

3.2 CrossRail Routes and Phasing

3.2.1 Route Description

CrossRail has been planned to provide a cross-London link between the existing suburban railways to the east and west of the capital, as shown on Map 3.1. It, therefore, has two key route elements:

* A core section of new underground railway linking between Liverpool Street and Paddington stations, the Central Area Route;

* Connections onto the following NSE and LUL suburban routes:

    * Shenfield to Liverpool Street
    * Reading/Slough to Paddington
    * Aylesbury/Amersham to Paddington

3.2.2 Central Area Route

The current CrossRail route for the Central London section, from Paddington to Liverpool Street generally following Oxford Street, is consistent with the objectives of the scheme. It links the two terminating suburban services through the City and West End to allow through services from east and west across Central London. Given the high costs of building a new underground line, it makes sense building this line as close as possible to the destinations to which most people want to go.

The horizontal and vertical alignments for the central area route have been selected on a sound basis, bearing in mind the wide variety of underground constraints including piled foundations, ground conditions, other tunnels for LUL, BR, Post Office and major utilities. Detailed analysis of route restrictions has been undertaken by the CrossRail team and gives a good degree of confidence in the route selected. It is unlikely that there is a viable alternative route through the central area that would capture sufficient benefits and reduce the cost or impact of tunnelling through London.

No obvious opportunities for cost saving were found by adopting steeper gradients with shorter stations so as to achieve shallower station structures.

3.2.3 Suburban Route Sections

The outer area services planned for CrossRail require the reconfiguration of existing NSE and LUL services on existing lines with some key infrastructure, electrification and signalling works to upgrade the system and provide the necessary linkages.

The initial CrossRail proposal to link the Great Eastern Inners with the Thames and Metropolitan suburban services are little changed since

its conception in the CLRS. The CrossRail project team has concentrated on the refinement of this proposal. A further examination of alternative suburban routes may be appropriate, since inter-working services onto more lines could be beneficial to revenues, even if not to social benefits.

3.2.4 Phasing

CrossRail could be built in phases, either building up from the "Basic Core Railway" to the "Full Scheme" as suggested by the CrossRail project team or by constructing, say, the line from the east initially as far as Tottenham Court Road, with appropriate interim turnback facilities, for a cost of approximately £1,000 million.

The "Basic Core Railway" approach, even modified further into a minimum core railway, does not generate a high benefit:cost ratio, although it would require a smaller absolute capital contribution from Government. This has been established by the CrossRail team in their own review of the cost effectiveness of the project.

Building the line in stages is also technically feasible, allowing the Government contribution to be drawn down over a longer period of time. There would be some amount of abortive expenditure, for example, constructing interim turnback facilities at Tottenham Court Road. However, the overall positive net benefits of the CrossRail project will only materialise upon the opening of the main cross-London services, and the phased construction of the project is unlikely to attract private sector interest in its early stages.

An alternative scenario would be for the Government to demonstrate commitment to the CrossRail project by agreeing to publicly fund the initial phase, i.e. Shenfield to Tottenham Court Road based on CrossRail's existing proposals, or using the Eastern City Link alternative as described in Section 4.0. Once this is underway, private sector involvement to complete the balance of the CrossRail project might be easier to achieve, and thus realise the full economic benefits.

3.2.5 Kings Cross Alternative Routes

Two alternative routes via Kings Cross have been suggested by petitioners to ease what they consider to be key environmental problems with the presently planned route.

The first alternative route includes new tunnels from the east via Moorgate and Farringdon, then to Kings Cross and along Euston Road to Paddington, making the same connection into the western suburban lines as the current CrossRail scheme. This route, however, seems unlikely to offer the same benefits as it misses the key West End destinations along Oxford Street.

Discussions have been held with the CrossRail team on the preliminary feasibility work it is undertaking on this alternative route,

and also with the London Transport (LT) Property Board regarding land-take issues. Important factors that emerge include:

* Ground conditions are worse than the planned alignment;

* Stations at Baker Street and Euston would have to be larger than stations on the planned route for operational reasons, and, in the case of Euston, would be at considerable depth;

* The Paddington Station location presents engineering problems adding to the risks and costs;

* The extent of engineering knowledge on the route is considerably less than on the planned alignment;

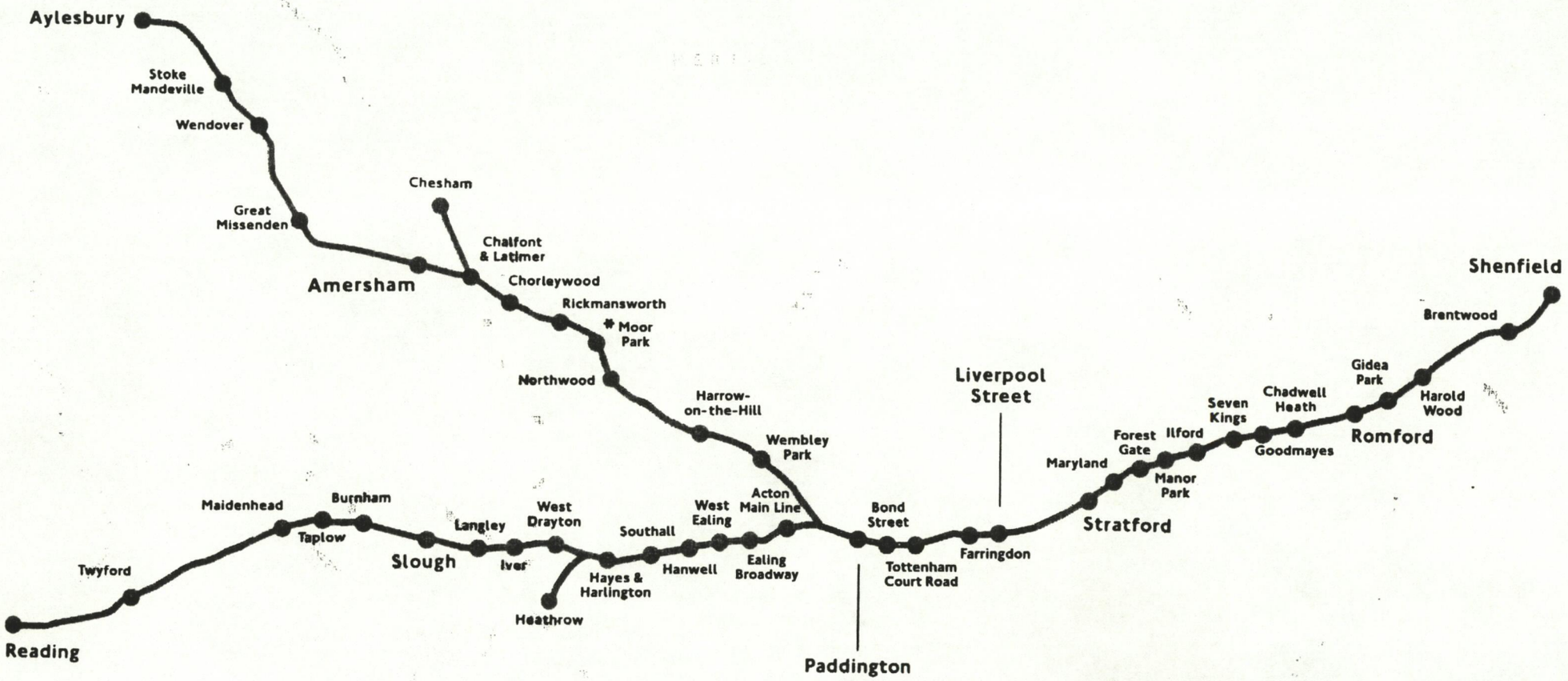
* The associated social benefits are 15-20% lower than on the planned CrossRail route.

Cost estimates produced by the CrossRail team show that the Kings Cross alignment basic cost is 10% higher than that for the proposed route, with the inclusion of contingencies increasing the cost further above the proposed route cost.

The route would offer substantially lower transport benefits and, therefore, the cumulative effect of these lower benefits and higher costs is a benefit:cost ratio of less than that for the proposed route.

Consequently, if new tunnels are to be built from Paddington to Liverpool Street, this more northerly route would not be favoured over the planned CrossRail route.

The second alternative includes new tunnels from the east only as far as Kings Cross, then surfacing and operating onto a variety of existing suburban lines. Although shorter and, therefore, cheaper than CrossRail, this route also misses the West End and is unlikely to attract a proportional share of the CrossRail benefits. It also assumes an extension of the tunnelling eastwards to Stratford. This would increase the cost without providing additional benefits.



*Possible station

THE DEPARTMENT OF TRANSPORT

CROSSRAIL COST EFFECTIVENESS STUDY

THE PROPOSED ROUTE

Map 3.1

Bovis

SIR ALEXANDER GIBB & PARTNERS

3.3 Stations

3.3.1 Provision of Stations

CrossRail's currently proposed central area stations are shown on Map 3.2. The CrossRail project team has conducted incremental benefit:cost analyses of various station combinations. This has been on economic rather than financial terms. Based on their analysis, only Moorgate station appears to be justified in all cases as this is the only station serving the City.

At least one West End station is justified; at Bond Street, Tottenham Court Road or Holborn. Generally, whichever station is added first gives a positive return, with a lower net return for the second and a negative return for the third. The CrossRail team favours Tottenham Court Road as the first choice due to its central location and off-peak traffic potential. It also has potential for interchange with the proposed Chelsea Hackney Line. Bond Street offers better access to Oxford Street shopping and valuable interchange to the Jubilee Line and is their second choice.

The case for Holborn station has been perceived as weak, in part because it has usually been tested as the third West End station. However, if assessed incrementally as the first West End station, there may be a better case for Holborn than for Tottenham Court Road. This requires further study, in particular, on the relative long term strategic value of Tottenham Court Road or Holborn. The combination of Bond Street, Holborn and Moorgate stations would give an even spacing of stations and hence marginal improvements in operational characteristics. However, the introduction of a station at Holborn would require a change to the CrossRail Bill.

Paddington and Farringdon stations currently have costs exceeding total benefits. Therefore, they cannot be justified purely in financial or economic terms. However, these are key interchanges to other rail lines and leaving them out results in an imbalance to the scheme. Although there is a lack of justification in economic terms of either station, a station at Paddington might be considered further taking into account revenue impacts on Intercity and Heathrow Express services.

The provision of a station at Farringdon has been perceived as facilitating the redevelopment of the area as well as providing interchange to other rail services. However, the effect of CrossRail on regeneration is unlikely to be sufficient to produce the necessary benefits to justify the station.

There are two further avenues for investigation. Firstly, if station costs can be brought down, then there might be a case for one or more additional stations. For example, if station costs can be cut by half, then the incremental benefit:cost ratios of Paddington and Farringdon might increase from around 0.6 to 1.2.

Secondly, benefit estimates might be increased. Although peak traffic benefits may be over-estimated based on CLRS demands, due to the use of high employment growth assumptions, the off-peak traffic and revenue benefits may be under-estimated, at least on a station-specific basis. The business evaluation by CrossRail has been based primarily on peak hour traffic models and assuming average fare levels. This approach tends to under-value interchanges and network effects since, in the peak hours, most parts of the Central London network are intensively used. However, off-peak traffic and revenue are much more sensitive to the number of stations and opportunities for interchange to connecting lines. Although the CrossRail team is now estimating all day traffic, using station-specific annualisation factors, this method may still under-estimate the revenue potential from new West End stations.

3.3.2 Station Design

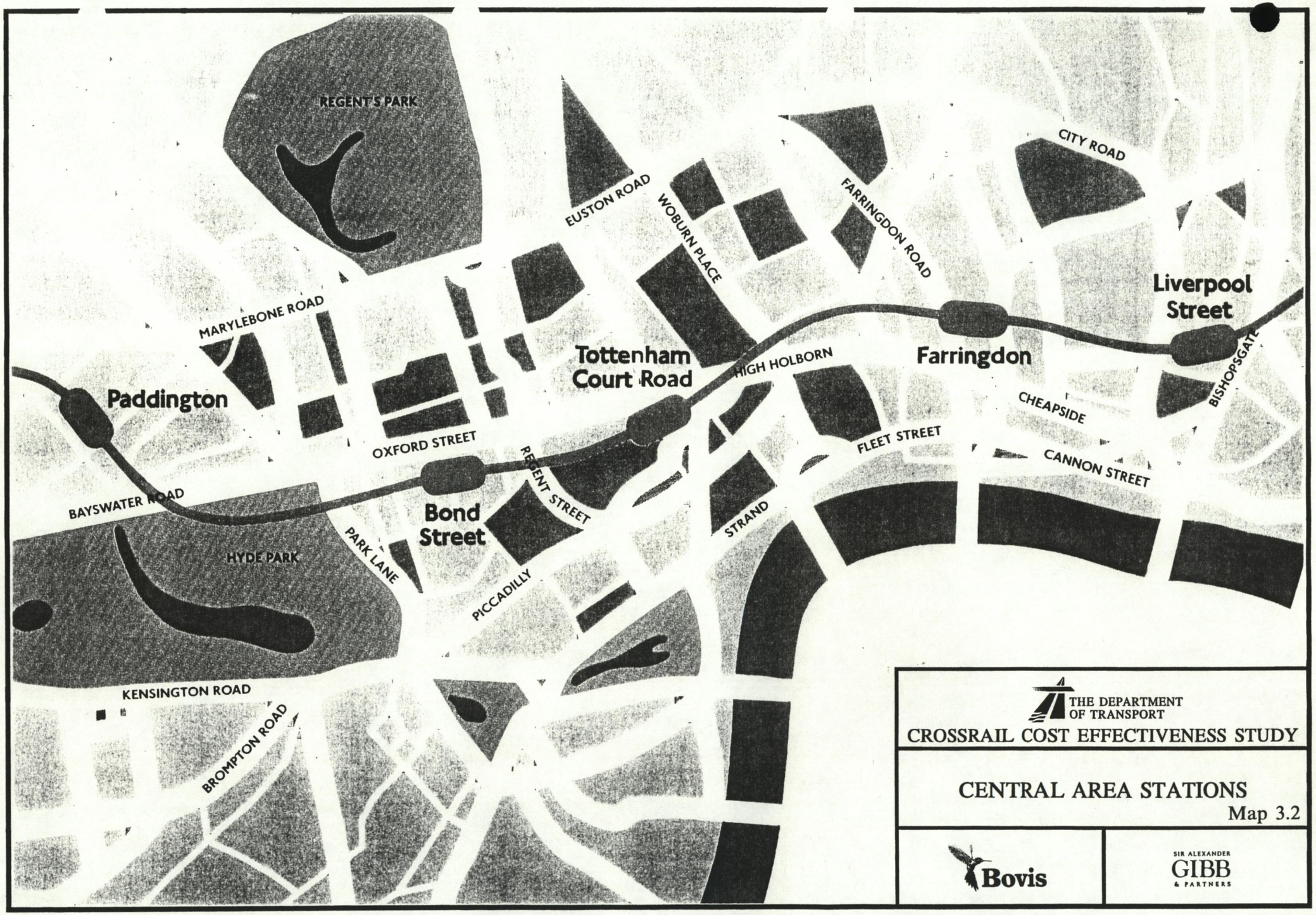
The CrossRail team's current station design for the Minimum Feasible Railway provides for future expansion from 184 metre to 275 metre to increase train length from 8 to 12 car. Provision is also made for ticket halls at both ends of the stations which facilitates emergency exit and gives a wider catchment area for the railway.

In order to reduce the cost of stations and hence improve the benefit:cost ratio, it is proposed that consideration be given to building stations for only 120 metre 6 car operation. This would also permit the use of single ticket halls. Emergency exit would be required from the end not served by the ticket hall. Elimination of all provision for future lengthening and of provision for second ticket halls would reduce costs by approximately £40 million per station.

These reduced provisions would be worth pursuing since the majority of the benefits of the stations would still accrue whilst environmental impact, property acquisition and costs would be reduced.

Detailed re-design of the stations should consider shaft sizes, platform widths and ticket hall sizes for reduced station lengths and 6 car train operation. The provision of compact rather than standard escalators could further reduce costs.

If the CrossRail scheme is progressed, further work should be conducted to evaluate the benefits and costs of each station.


REGENT'S PARK
EUSTON ROAD
WOBURN PLACE
FARRINGDON ROAD
CITY ROAD
MARYLEBONE ROAD
Tottenham Court Road
HIGH HOLBORN
Farringdon
Liverpool Street
BISHOPSGATE
Paddington
CHEAPSIDE
OXFORD STREET
FLEET STREET
CANNON STREET
REGENT STREET
BAYSWATER ROAD
Bond Street
STRAND
HYDE PARK
PARK LANE
PICCADILLY
KENSINGTON ROAD
BROMPTON ROAD
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
CENTRAL AREA STATIONS
Map 3.2
Bovis
SIR ALEXANDER GIBB & PARTNERS

3.4 Tunnelling

The main running tunnels for the project are currently designed as 6.0 metre diameter. Three principal issues have been identified as potentially affecting the tunnel diameter:

* Clearance to overhead electrification;

* Requirement for track level walkway;

* Structural depth for floating track slab.

The Heathrow Express has adopted tunnel diameters of 5.675 metres. This is consistent with overhead electrification (with relaxed headroom constraints relative to CrossRail) and a platform, rather than track, level walkway. Agreement would be required from the London Fire and Civil Defence Authority were CrossRail to accept platform level walkway provisions as on the Heathrow Express tunnel.

The requirement for floating track slab is driven by the environmental standards set for re-radiated noise and the close proximity of sensitive buildings to the tunnel alignment. However, it is not clear that smaller tunnel diameters would not accommodate the required insulation.

Current cost estimates indicate the cost saving could be of the order of £10 million if it were possible to adopt a tunnel diameter similar to Heathrow Express (see Section 3.9). A reduction in diameter would not affect the provisions in the Bill, but would require alterations during the detailed design phase.

Consideration has been given to adopting steeper gradients which, together with shorter stations, might allow a shallower alignment at stations. However, no significant opportunities for cost savings have been established.

3.5 Rolling Stock

A review of the requirement to purchase new, high quality rolling stock for CrossRail has not produced great potential for reducing project costs. To meet modern safety standards, new fire-hardened rolling stock would be required for operation through the CrossRail tunnel.

However, consideration of the use of dual voltage stock, for example, on the Metropolitan Line, would minimise the cost of re-electrification and signal immunisation. Cost savings of up to £100 million might be achievable if all changes to the Metropolitan Line could be avoided, although there would be offsetting costs resulting from the operation of a mixed fleet.

The assumptions made in the CrossRail project costing about the cascading of existing rolling stock may be over-optimistic. The valuation of replacement rolling stock is very uncertain. LUL is now proposing to refurbish the 1963 Metropolitan Line stock, prolonging its useful life well past the proposed opening date of CrossRail. A more realistic assumption of the cascaded value of rolling stock is probably to assess it at 50% of its "best user" residual value.

It has not been possible to conduct, within this stage of the study, a more accurate analysis of the cost, based on the cost of new rolling stock, the cost of rolling stock that would have been required if there were no project and the recovery from cascading redundant rolling stock.

For the social benefit analysis in this report (Section 3.10), rolling stock costs have been assumed at 50% of the purchase cost of the new fleet. This has been assumed for all options, including the alternative investment opportunities described in Section 4.0.

For the financial analysis (Section 3.11), rolling stock has been costed at its full value with no recovery from cascading. In other words, it has been assumed that a CrossRail operating entity would be required to finance the full cost of rolling stock, with the benefit of displaced stock falling to other parties.

3.6 Operating Concept

Central to the CrossRail concept is the operation of conventional mainline rolling stock and full length suburban trains across Central London. Given the high cost of constructing new tunnels and stations under Central London, consideration has been given in this study to the operating strategy and train specification.

CrossRail stations for the full scheme and the minimum feasible railway are currently designed to accommodate 184 metre long trains, essentially 8 "Networker" cars. In comparison, other Underground lines have platforms between 90 and 140 metres in length. CrossRail also proposes to construct station tunnels for future operation of 275 metre long 12-car Networker trains. There is currently no indication as to when these might be required.

One strategy for reducing capital costs without sacrificing benefits would be to operate more frequent, but shorter trains. Modern signalling systems could achieve the required capacity with 120 metre trains, allowing a commensurate shortening of the stations. Shorter stations would also allow reductions in emergency exit capacity, station ventilation, property take and environmental impacts. Shorter, but more frequent trains would, however, require some further changes to signalling on outlying suburban sections, such as through Stratford where there could be capacity constraints.

The Minimum Core Railway proposed in this study is based upon this reduced train length with a commensurate increase in train frequency to maintain the capacity to the same level as proposed by the CrossRail team for their Minimum Feasible Railway (see Table 3.1).

3.7 Property Development Aspects

3.7.1 Introduction and Objectives

LUL estimates that property acquisition costs for the proposals in the CrossRail Bill will be circa £400 million. It has considered private sector funding and forecast recoveries through property development of circa £112 million.

The study team has reviewed its proposals with the following objectives:

* Maximise private sector funding;
* Reduce gross property expenditure;
* Establish property principles to guide engineering decisions;
* Consider property implications of alternative routes.

3.7.2 Property Requirements and Acquisition

The majority of petitions lodged against the CrossRail Bill relate to property or compensation aspects in the central area. The net acquisition costs are only a small proportion (13%) of the total project cost, yet the property implications are of a higher order of importance due to their effect on landowners and occupiers and the inclusion of a number of listed buildings.

Property required for the new railway falls into categories:

* Stations and exits;
* Temporary working space and access;
* Tunnels, track and associated operating space.

The CrossRail Bill contains powers to acquire all the property required.

The CrossRail team proposed a structure whereby major landowners would transfer their land to a site-specific company in return for convertible loan stock and thus share in the development potential. The objective is to defer acquisition cost and perhaps to encourage external investment in the company.

3.7.3 Compensation Principles

The compulsory acquired property is purchased at open market value. Additionally, non recoverable disturbance costs are payable. Landowners and occupiers will inevitably take a full view of their entitlement to compensation and costs and whilst negotiation and, ultimately, a Land Tribunal will resolve this, such claims will have a bearing on the structure proposed by LUL.

Statutory interest will be payable on the compensation.

3.7.4 Enhancing Value by Development

The development potential of a site depends on a number of very specific and detailed factors. Evaluation of the potential of individual sites is outside the scope of this study. Generalisation can be misleading. However, a number of broad principles can be established.

* The compensation and disturbance costs payable for a property in the central area will probably be greater than the development value of the cleared site;

* Development value can be enhanced by the "marriage" of sites; by increasing the size of buildings over that which previously existed and by changing the use of the site to one of greater value;

* Individual private property owners/occupiers are unlikely to contribute to costs in order to influence route or station locations;

* The Planning Authorities will be resistant to significant changes on building size or use and will seek gain from major redevelopment proposals;

* The long period between acquiring the properties and releasing them for development increases the risk to market fluctuation.

* Enhanced value by development, particularly in the current depressed market is unlikely to equal or better the cost of the loss of asset of the existing buildings by demolition, the loss of the income stream for the protracted redevelopment period and the disturbance costs of the existing occupiers.

* Unlike the Jubilee Line Extension, CrossRail does not "unlock" any major redevelopment areas. Benefits to existing sites are diluted by alternative transport options and are insufficient to create significant enhancement to specific property values.

3.7.5 LUL Development Proposals

LUL objectives were:

* To defer property expenditure;

* To reduce gross property expenditure;

* To retain LUL control over design and development;

* To achieve value for money in any new proposals.

Detailed examination of site specific proposals do not form part of this study.

The structure proposed by LUL addresses the objectives, but raises a number of issues.

LUL proposes to produce the development proposals for the airspace over ticket hall sites and to dispose of the development rights by long lease. The justification is:

* To maintain control and use for the safety and protection of the railway;

* To incorporate the required design and structural features in the design of the ticket hall;

* To deal with planning and conservation issues;

In order for LUL to produce development proposals, it must make commercial development judgements that are best left to a commercial property developer. The more controls and constraints that are applied the less attractive and, therefore, the less valuable will be the opportunity to a developer.

The company structure proposed by LUL assumes the willingness of major landowners to defer their rights to compensation and to participate in a long term development venture. Whilst this might be appropriate for some landowners, many will judge their best course to be the pursuit of an imaginative claim for compensation and these claims will become a risk item for the investors in the company.

There must be a question as to the chances of successfully negotiating the entry agreements with major landowners on the terms proposed.

3.7.6 Proposals to Reduce Total Property Costs and to Utilise Private Capital

It is probable that the total compensation costs will out-weigh recoveries in the absence of a windfall gain of a market improvement that outstrips carrying costs. It follows that the simplest way to reduce property costs is to reduce the value of properties to be acquired. Bearing in mind the weight of engineering costs and the importance of maximising revenue, property considerations should be of only medium priority in making route, station and access decisions. However, each decision requiring property acquisition should be tested to establish:

* Can the total requirement be reduced?

* Can the requirement be tailored to fit existing ownership boundaries?

* Can listed buildings be avoided?

* Can conservation areas be avoided?

* Can temporary sites be located on low value sites perhaps remote to properties?

It is axiomatic that ticket halls and access points need to serve the greatest concentrations of potential travellers and these are the areas of greatest property value. It does not follow that entrances need to occupy prime, high value frontages and savings may be effected by moving ticket halls and entrances short distances to avoid locations of high value; without jeopardising pedestrian flows and access. In particular, there are opportunities for significant cost saving at Tottenham Court Road and at Moorgate.

Whilst the prospect of premium payments from private property owners/occupiers is remote, the same may not be true of Local Authorities, Trade Associations and Business Groupings. Such collective bodies may be prepared to contribute to costs to influence routing or entrance/ticket hall decisions. Such contributions would be justified by the general trading and business benefits and prestige brought to an area or district. For example, the enhancement Farringdon would bring to the Smithfield/Clerkenwell area would be of considerable interest to the City Corporation.

The principal development decision is whether LUL should participate in the development process, taking a share of any enhanced value and, inevitably, a share in the risk; or whether the development opportunities should be offered "clean" to the market. Whichever route is considered appropriate, commercial development expertise must be introduced to each proposal before fundamental decisions are made regarding the scheme.

There are ways in which the proper concerns of LUL can be met, yet allowing a developer the freedom to use his skills to maximise potential. An opportunity with hope value will often be more attractive to the market that one which has reached detailed planning.

Considering the variety of development opportunities and the vagaries of the property market, it would be prudent to spread LUL's property exposure by adopting a number of different disposal methods at different points of the railway construction period. These could include:

* Pre-sell development rights, work with the developer on the ticket hall design and handover at slab level with only essential minimum controls;

* Design ticket hall to allow flexibility of design in airspace. Market development rights on completion of slab and outline planning. Developer to be responsible for detailed planning. Development period, therefore, excludes railway construction time;

* Enter into a joint venture arrangement on either of the two previous basis where LUL carries the acquisition and compensation costs to development completion in return for a share of profit;

* Where there are willing landowners, use the LUL proposed structure, but modified to introduce commercial development expertise at an early stage.

3.7.7 Conclusions

* The cost of acquisition and compensation for property requirements will be greater than present day development value;

* Enhancement of development value will be restrained by planning considerations;

* The long period between acquisition and eventual redevelopment increases risk, but also opportunity for windfall gain;

* Property considerations are outweighed by engineering and revenue factors;

* Commercial property expertise should be introduced as early as possible and LUL controls should be minimised;

* LUL proposed structure will be difficult to deliver;

* Examine all property acquisition decisions to minimise and rationalise land-take and to reduce scope for objections;

* Avoid using prime sites and frontages;

* Seek premium payment from "collective bodies";

* Spread property risk by variety of disposal methods seeking "up front" input of private sector funding.

3.8 CrossRail Upgradability

3.8.1 CrossRail Provision

CrossRail's Central Area stations have been designed to account for the longer term anticipated growth in passenger demand by extension to 12 car operation with second ticket halls. The timing of the demand for expansion had not been identified.

This has been justified on the basis that it would be cheaper to undertake the additional work during the initial construction period, and that, in some cases, it may not have been possible to undertake any extension or upgrading work at a later stage without severe disruption or cancellation of services.

The upgradable features incorporated in the CrossRail design include:

* Platform tunnels built for future 12 car CrossRail 341 trains ie.283m long;
* Station platforms built for initial 8 car trains, 190m long;
* Two ticket halls provided at each station complete with access and emergency egress sized for the ultimate 12 car train services;
* Tottenham Court Road station design fully takes into consideration the possibility of interconnecting tunnels between CrossRail and the future Chelsea-Hackney line;
* Provision for a future station at Holborn;
* A signalling system designed for up to 30 trains per hour in each direction.

The economic case for most of the above upgrading provision is not clearly established.

Whilst it would be a mistake to build CrossRail with too little capacity, it would be equally wrong to build it with too much, diverting resources that could be better invested elsewhere. Given the long-term decline in Central London peak-hour commuting, one could argue that CrossRail itself is ample provision for the future, not the present.

3.8.2 Other Design Enhancements

In addition to the provision for upgrading, there are a number of other enhancements included in the original design. These are:

* Higher safety standards than those incorporated into existing systems, especially fire safety;

* Access for mobility impaired passengers;

* Environmental mitigation measures, including train operation induced noise and vibration, and during the construction phase.

The majority of these enhancements should be included in the project, principally because:

1) The absence of them could jeopardise the passage of the Bill through Parliament.

2) A private sector promoter or Joint Venture partner would not wish to put himself at financial risk because of retrospective legislation.

Environmental mitigation during the construction period (ie. noise, dust working sites, and spoil removal by road), however, should be considered further to establish whether cost savings can be achieved without unacceptably compromising the level of mitigation.

3.8.3 Design Requirements

The differences between each design concept as envisaged by the CrossRail team, and those proposed by the study team in arriving at a cost effective project are shown in Table 3.1.

However, even allowing for the omission of the upgrading provision in the Minimum Core Railway, the benefit:cost ratio of the project is only slightly improved. A capital cost saving of between some £270-480 million can be achieved in infrastructure costs alone, with a further saving of £120 million on rolling stock.

3.9 Capital Cost Evaluation

3.9.1 Full CrossRail Scheme

Introduction

This section reviews the cost estimate data for the current CrossRail proposals made available to the study team and draws on discussions with CrossRail team regarding estimating principles and methodology. Given the time parameters of the present study, no attempt has been made to carry out a full audit of the project's design and cost status.

Cost Datum

During the development of the project, the CrossRail team has produced regular updates of anticipated project costs. The dates and associated reported base values of recent significant milestone estimates are:

*	CLRS January 1989	£885m
*	CLRS 1990	£1,436m
*	October 91	£1,703m
*	April 93	£1,706m

In October 1993, costs were updated to take account of probable delays in project implementation. The most likely scenario, deemed "Case 4", assumed the following project milestone dates:

*	Royal Assent	31 Oct 95
*	Construction funds available	01 Apr 97
*	Construction start	01 Sep 97
*	Routewide service	27 Sep 02

On the basis of these programme assumptions, the April 1993 project estimate of £1,706 million was increased to £1,730 million. This figure is stated at March 1990 cost levels and is exclusive of:

* Project contingency and risk allowances;
* The cost of works necessary for the operation of the CrossRail system, but deemed attributable to core LUL and BR budgets.

Adding the cost of the above items, and updating to current costs, results in a median estimate of total project commitment of £2,857 million at December 1993 cost levels. The relationships between

these various elements of the current project budget are set out in Table 3.2.

Cost Attribution

CrossRail cost estimates recognise three categories of cost heads for budgetary attribution, namely:

* Ringfenced costs;
* Safety measures works;
* Core budget works.

i) Ringfenced Costs

Ringfenced costs relate to all works directly attributable to the CrossRail project, i.e. expenditure that would not otherwise be incurred in the projects absence. Sunk costs in the project to date comprise of £56 million actual expenditure through to financial year 92/93 plus an additional projected £53m expenditure in 93/94.

ii) Safety Measures Works

These are works to the existing Tottenham Court Road LUL station proposed to reduce overcrowding. Parliamentary Powers for this work were obtained together with other works at Holborn and London Bridge stations. The cost of the works at Tottenham Court Road, £68 million at March 1990 base case, is included in the project ringfenced total. This would appear to be anomalous, given the definition of ringfencing described above. However, no adjustment in respect of this item has been made in the analysis that follows.

iii) Core Budget Works

These are those works that are essential for CrossRail to meet its performance specification, but are assumed to be funded from BR and LUL core budgets. This assumption is justified on the basis that, if CrossRail were not constructed, the works would still be necessary if BR and LUL are to maintain their existing services.

The principal components of the estimated cost of £446 million (March 1990, base excluding contingencies) are:

* Metropolitan line track renewals and resignalling — c. £100m
* Rolling stock — c. £300m

The treatment of Metropolitan line costs is reasonable and appropriate as it is considered to be understood that this line is in

urgent need of refurbishment. However, the treatment of the costs of rolling stock is questionable, as discussed below.

iv) Rolling Stock

The total cost of new rolling stock required to operate CrossRail is £440 million. However, only £140 million of this figure is attributed to the project ringfenced budget, with the remaining £300 million attributed to BR and LUL core budgets. This calculation has been justified by the assumption of a cascade of the displaced existing rolling stock operating on the Great Eastern (Shenfield), Thames and Chiltern lines onto other parts of the BR network. This assumption does not take account of:

* The intention of Government to take CrossRail forward as a public/private joint venture;

* The imminent privatisation arrangements for BR.

It must be assumed that any future CrossRail operator, as a stand-alone entity, would be faced with financing the entire cost of his rolling stock fleet either by capital purchase or by means of a leasing arrangement within the envisaged future BR framework.

However there would also be some value from the release of the Great Eastern, Thames and Chiltern rolling stock, which is mostly quite new, fairly versatile, and likely to find new users through the rolling stock market.

There is also some value in replacing Metropolitan Line "A" stock. This stock is being refurbished and in the absence of CrossRail will need to be replaced sometime around 2020.

As discussed in Section 3.5, for the purposes of project economic evaluation, it has been assumed that half of the cost of the proposed rolling stock fleet, or £220 million, is included within the project ringfenced budget. In the case of the project financial evaluation the full cost of rolling stock has been assumed to be attributable to the ringfenced budget. The effect of this latter adjustment is shown in Table 3.3, showing an increase in ringfenced costs from £1730 million to £2027 million at March 1990/base cost.

Contingencies and Risks

i) Terminology

The CrossRail team uses the following terminology in connection with project risks and contingencies:

* *Base Cost*: The minimum cost to construct the project, based on the known scope at the time of estimate preparation;

* *Estimating Contingency*: A percentage added to each item of base cost to allow for estimating uncertainties;

* *Design Development Contingency*: A percentage added to each item of base cost to allow for risks on the future development of project scope;

* *Ceiling Cost*: The maximum cost of constructing the project, comprising the summation of base cost, estimating contingency and design development contingency;

* *Median Cost*: The most likely cost of constructing the project and those used in economic and financial evaluation.

ii) **Reported Costs**

The April 1993 CrossRail estimate contains the following calculation of project Ceiling Cost:

Base Cost	£1,706m	100.0%
Estimating Contingency	£161m	9.5%
Design Development Contingency	£284m	16.6%
Ceiling Cost	£2,152m	126.1%

The same April 93 estimate values, included in the October 93 cost update, were used in calculating the following median cost :

Base Cost	£1,730m	100.0%
Median Contingency	£313m	18.1%
Median Cost	£2,043m	118.1%

The median contingency of 18.1% is approximately equal to the Estimating Contingency of 9.5% plus half of the Design Development Contingency of 16.6%.

Both the methodology and percentage values used in these calculations are realistic and appropriate for a project of this nature at the current stage of its development.

Indexation

At the request of Government, to ensure compatibility and comparability of estimates, all CrossRail costs are reported using a March 1990 cost datum. Adjustments from current cost estimates

back to this datum are calculated using the Investment Projects Inflation Index published by BR as a GDP deflator. The values of this index at base and current dates are:

* Mar 90 129.0

* Dec 93 155.2

This index thus suggests an increase in project capital costs of 20.3% between the above two dates. However, during the same period, real construction costs have fallen as the industry has moved from conditions of boom to slump. This fall has been most marked in the building sector, where one of the most frequently applied measures, the BCIS Tender Price Index published by the Royal Institute of Chartered Surveyors, fell from 135 to 109, a reduction of 19.3%. The effect on civils works of an underground nature is more open to debate, but the reported tender returns for Jubilee Line Extension works would also seem to point to a substantial fall.

This divergence between notional and real world trends in construction costs should not have a distorting effect on any cost estimate produced at a particular point in time. It is noted, however, that the apparent stability of the CrossRail budget over the past two years since the October 1991 estimate points to an opportunity to reduce costs in line with construction market conditions.

Conclusions

It is not part of the brief of the current study to carry out a thorough audit of the CrossRail estimate, and indeed such an exercise would not have been possible within the time constraints of the study. However, based on its work within the limited time available, the study team conclude that:

* The scope of the project is generally well defined within the terms of reference of the project team;

* No significant weakness in the estimate build-up are apparent;

* The levels of risk and contingency contained within the estimate are appropriate for a project of this nature at its current level of design development;

* The estimate should be adjusted to more accurately reflect the net cost of the rolling stock in the ringfenced budget;

* Given this single adjustment, the currently reported project estimate appears robust and represents a realistic measure on which to test the viability of the CrossRail scheme as presently conceived;

* The project estimate represents a solid datum from which to derive costs for Minimum Core Railway variants of the present scheme.

3.9.2 Minimum Core Railway

Introduction

This section sets out the features of the "Minimum Core Railway" proposed in this study that form the basis of economic and financial modelling of the feasibility of the CrossRail project.

Quantity Increments

i) CrossRail Study Alternatives

The stage 1 CrossRail Cost Effectiveness Study defined the Basic Core Railway as a line between Shenfield and Slough, with stations at Moorgate and Tottenham Court Road. The quantity increments which were then added to the Basic Core Railway to arrive back to the full CrossRail scheme were:

1: Extension from Slough to Reading

2: Extension to Amersham

3: Extension from Amersham to Aylesbury

4: Addition of Bond Street station

5: Addition of Farringdon station

6: Addition of Paddington station

The present study has taken the following approach in defining a Minimum Core Railway (MCR):

ii) Route Network

The extensions of the outer area network (increments 1, 2 and 3) are included in the MCR. These extensions have a comparatively low cost, but generate significant benefits.

iii) Central Stations

The total cost of the five central stations in he existing CrossRail budget (March 1990, Base Cost) is £800 million out of a total project cost of £1,700 million, i.e. 47%. Costs of individual stations are approximately:

Paddington	£100 million
Bond Street	£150 million
Tottenham Court Road	£250 million
Farringdon	£150 million
Liverpool St/Moorgate	£150 million

In view of these high capital costs, the present study has considered for economic evaluation a MCR with the following combinations of stations:

* All five stations
* Three stations: Bond Street/TCR/Moorgate
* Two stations: TCR/Moorgate

Quality Increments

The CrossRail stage 1 study identified seven "quality" increments in building from its definition of a "Basic Core Railway" back to the present CrossRail scheme. These increments have been handled in the present study as follows:

A. Safety in Infrastructure

B. Safety in Rolling Stock

Both these increments are required to meet present day mandatory safety requirements and are included in whole in the MCR.

C. Mobility Impaired Access

While not mandatory, the provision of mobility impaired lifts has a high political benefit and a low capital cost (£5 million), and is included in the MCR.

D. Environmental Mitigation Measures

The two main elements of this increment are operational noise mitigation and construction spoil removal by rail. The inclusion of noise mitigation measures is considered essential to reduce project risks. Spoil removal by rail may be open to challenge, but has been included in the meantime.

E. Second Station Ticket Halls

Not included in the MCR: see below for discussion of station specification.

F. Metro Rolling Stock

See below for discussion on types and specification levels of rolling stock.

G. Upgradability

No provision for upgradability in MCR. Scheme assumes the use of 6 car trains and 120 metre platforms lengths. See Sections on stations and rolling stock below.

Tunnel Diameter

Previous studies have suggested reducing running tunnel diameter as a means of reducing construction costs. Based on recent tunnel tenders available to the study team, it is estimated that the savings for reducing tunnel diameter from the current 6.0 metres would be as follows:

5.6m (as HEX)	£10 million
5.0m	£25 million
4.5m	£40 million

It can be seen that the saving for reducing to the Heathrow Express (HEX) diameter is minimal. More drastic reductions to 5.0 metres or 4.5 metres diameter show more significant savings, but would require a major review of rolling stock configuration and gauge before being adopted.

The MCR has assumed that the existing 6.0 metres tunnel diameter is retained. Further work to examine reducing the running tunnel bore should be undertaken as a future exercise.

Rolling Stock

i) Specification

The present CrossRail scheme assumes that all rolling stock operating on the system will be new, dedicated Class 341 units. This stock has the following enhancements to the Class 465 Networker specification:

Enhancement	£k/set	£m/fleet
23m bodylength	40k	5.7m
Third door	80k	11.4m
Fireproofing	60k	8.5m
25kV OHLE	70k	9.9m
Air Cooling	40k	5.7m
Passenger information	30k	4.2m
Performance enhancements	130k	18.5m
Total	450k	63.9m

The following approach has been taken to these enhancements in developing a MCR:

* The car extension from a standard 20 metres to 23 metres, and the provision of a third door, have been omitted;

* Fireproofing of stock is mandatory and is retained.

* 25 kV OHLE equipment is necessary and is included.

* Air cooling and passenger information systems have been retained, but should be the subject of a future value engineering exercise.

* Performance enhancements have been retained as the study team has not clarified the basis of their adaptions.

It is considered that a general review of rolling stock should be carried out in the future. In particular, the proposed performance enhancement (an increase in power of 33% over standard Networker stock) seems particularly worthy of review.

ii) Train Configuration

The present CrossRail scheme assumes Class 341 units operating in four car units which would generally be coupled to form eight car trains. The MCR instead proposes the use of three car units operating in six car trains.

Stations

The present CrossRail scheme has central stations designed with two ticket halls approximately 300 metres apart at each end of station boxes to cater for future expansion of the system to twelve car trains.

The MCR assumes that stations will have single ticket halls, with station box/platform length of 120 metres to suit six car trains. It should be noted that this reconfiguration would mean substantial revision of the land-take required at each station location, with a consequent revision of the powers required in the present CrossRail Bill.

Summary of Features of MCR

The features of the realistic Minimum Core Railway, as discussed in this Section, are summarised as follows:

* Full CrossRail outer region network;
* Scenarios for five, three and two central stations;
* 6m diameter running tunnels;
* Single station ticket halls;
* 120m station platform lengths;
* Six car Class 341 trains;
* Revised Class 341 stock specification;
* No upgradability built into the system;
* Compliant with current safety standards.
* Incorporates MIP lifts.
* Allows for environmental mitigation measures.

MCR Capital Costs

The capital costs of the MCR variants that have been subject to economic evaluation are shown in Table 3.4.

The following notes should be read in conjunction with this table:

* Costs have been computed by back-calculation from the existing CrossRail budget. In the timescale available to the study, this has involved some fairly broad-brush assumptions. However, the order of costs derived is believed to be accurate;

* Costs contain the same level of contingencies as the existing CrossRail estimate. As discussed earlier in the review of this scheme, these contingency levels are considered appropriate;

* The costs of rolling stock are shown in the Table fully attributed to ringfenced costs. In accordance with the principles discussed earlier in the critique of existing scheme costs, economic evaluation discounts these costs by 50%.

* The MCR programme for discounted cashflow calculation has been assumed to be the same as that of "Case 4" of the existing CrossRail scheme.

MCR Scheme Optimisation

It is believed that future scheme optimisation and value engineering could make further substantial reductions in MCR capital costs. Areas to be investigated would include:

* Rolling stock specification;

* Further review of safety measures with the Railways Inspectorate;

* Running tunnel diameter;

* Station features and layouts;

* Procurement strategy and project management costs.

	Subsection		Mar 90 Base	Median Risk %	Median Risk £ m	Mar 90 Base + Risk	Index %	Index £ m	Nov 93 Base + Risk
1	Land & Property	Gross	368.9	30.0%	110.7	479.6	-28.8%	(137.9)	341.7
1	Land & Property	Recovery	(129.1)	0.0%	0.0	(129.1)	-28.8%	37.1	(92.0)
2	Running Tunnels		201.2	10.0%	20.1	221.3	20.3%	44.9	266.2
3	Special Works		20.5	20.0%	4.1	24.6	20.3%	5.0	29.6
4	At Grade Works		72.8	15.0%	10.9	83.7	20.3%	17.0	100.7
5	Depots & Stabling		16.0	20.0%	3.2	19.2	20.3%	3.9	23.1
6	Central Stations		503.0	10.0%	50.3	553.3	20.3%	112.3	665.6
7	Site Investigation		8.8	10.0%	0.9	9.7	20.3%	2.0	11.6
8	Service Diversions		26.1	15.0%	3.9	30.0	20.3%	6.1	36.1
9	Remedial Works		47.2	100.0%	47.2	94.4	0.0%	0.0	94.4
10	Rolling Stock		141.4	10.0%	14.1	155.5	20.3%	31.6	187.1
11	Power & OHLE		37.7	25.0%	9.4	47.1	20.3%	9.6	56.7
12	Signalling		56.0	25.0%	14.0	70.0	20.3%	14.2	84.2
13	Trackwork		35.9	15.0%	5.4	41.3	20.3%	8.4	49.7
14	Ventilation		12.0	10.0%	1.2	13.2	20.3%	2.7	15.9
15	Communications		30.3	25.0%	7.6	37.9	20.3%	7.7	45.6
16	UTS		8.0	20.0%	1.6	9.6	20.3%	1.9	11.5
17	Depot Equipment		10.0	30.0%	3.0	13.0	20.3%	2.6	15.6
18	Design & Supervision		115.0	0.0%	0.0	115.0	20.3%	23.3	138.3
19	Management		110.3	5.0%	5.5	115.8	20.3%	23.5	139.3
20	Royal Assent		38.0	0.0%	0.0	38.0	20.3%	7.7	45.7
	Total Project Budget (Ringfenced)		***1,730.0***	***18.1%***	***313.1***	***2,043.1***	***10.9%***	***223.7***	***2,266.8***
	Core Budget Works		446.0	10.0%	44.6	490.6	20.3%	99.6	590.2
	Total Project Commitment		***2,176.0***	***16.4%***	***357.7***	***2,533.7***	***12.8%***	***323.3***	***2,857.0***

Move up to date

TABLE 3.2

EXISTING CROSSRAIL BUDGET

APRIL 93 ESTIMATE WITH OCTOBER 93 "CASE 4" ADJUSTMENTS

	Subsection		Mar 90 Base	Median Risk %	Median Risk £ m	Mar 90 Base + Risk	Index %	Index £ m	Nov 93 Base + Risk
1	Land & Property	Gross	368.9	30.0%	110.7	479.6	-28.8%	(137.9)	341.7
1	Land & Property	Recovery	(129.1)	0.0%	0.0	(129.1)	-28.8%	37.1	(92.0)
2	Running Tunnels		201.2	10.0%	20.1	221.3	20.3%	44.9	266.2
3	Special Works		20.5	20.0%	4.1	24.6	20.3%	5.0	29.6
4	At Grade Works		72.8	15.0%	10.9	83.7	20.3%	17.0	100.7
5	Depots & Stabling		16.0	20.0%	3.2	19.2	20.3%	3.9	23.1
6	Central Stations		503.0	10.0%	50.3	553.3	20.3%	112.3	665.6
7	Site Investigation		8.8	10.0%	0.9	9.7	20.3%	2.0	11.6
8	Service Diversions		26.1	15.0%	3.9	30.0	20.3%	6.1	36.1
9	Remedial Works		47.2	100.0%	47.2	94.4	0.0%	0.0	94.4
10	Rolling Stock		438.8	10.0%	43.9	482.7	20.3%	98.0	580.7
11	Power & OHLE		37.7	25.0%	9.4	47.1	20.3%	9.6	56.7
12	Signalling		56.0	25.0%	14.0	70.0	20.3%	14.2	84.2
13	Trackwork		35.9	15.0%	5.4	41.3	20.3%	8.4	49.7
14	Ventilation		12.0	10.0%	1.2	13.2	20.3%	2.7	15.9
15	Communications		30.3	25.0%	7.6	37.9	20.3%	7.7	45.6
16	UTS		8.0	20.0%	1.6	9.6	20.3%	1.9	11.5
17	Depot Equipment		10.0	30.0%	3.0	13.0	20.3%	2.6	15.6
18	Design & Supervision		115.0	0.0%	0.0	115.0	20.3%	23.3	138.3
19	Management		110.3	5.0%	5.5	115.8	20.3%	23.5	139.3
20	Royal Assent		38.0	0.0%	0.0	38.0	20.3%	7.7	45.7
	Total Project Budget (Ringfenced)		***2,027.4***	***16.9%***	***342.9***	***2,370.3***	***12.2%***	***290.1***	***2,660.4***
	Core Budget Works		119.1	10.0%	11.9	131.0	20.3%	26.6	157.6
	Total Project Commitment		***2,146.5***	***16.5%***	***354.8***	***2,501.3***	***12.7%***	***316.7***	***2,818.0***

TABLE 3.3

EXISTING CROSSRAIL BUDGET

ADJUSTED FOR FULL ROLLING STOCK COST

Ref.	Railplan Run No	Stations	Route	Service tph	Cars/ Train	Stock Cost	Infra-Structure	Rolling Stock	Total £m	% Crossrail
	EXISTING CROSSRAIL									
0	4508	P,B,T,F,M	Full Network	24	8	Part	2,082	188	2,270	85%
1	4508	P,B,T,F,M	Full Network	24	8	Full	2,080	580	2,660	100%
	EXISTING CROSSRAIL (BCR)									
1A	4514	T,M	Slough - Shenfield	15	8	Full	1,400	300	1,700	64%
	CROSSRAIL VARIANTS, 6 CAR TRAINS									
2	4534	P,B,T,F,M	Full Network	24	6	Full	1,810	460	2,270	85%
3	4536	P,B,T,F,M	Full Network	30	6	Full	1,810	580	2,390	90%
4	4522	B,T,M	Full Network	22	6	Full	1,670	420	2,090	79%
5	4524	B,T,M	Full Network	30	6	Full	1,670	580	2,250	85%
	CROSSRAIL VARIANTS, 8 CAR TRAINS									
6	4532	P,B,T,F,M	Full Network	24	8	Full	1,820	610	2,430	91%
7	4520	B,T,M	Full Network	22	8	Full	1,670	560	2,230	84%
8	4526	T,M	Full Network	15	8	Full	1,495	380	1,875	70%

Reduced Xrail before r.s.

P: Paddington
B: Bond Street
T: Tottenham Court Road
F: Farringdon
M: Moorgate/Liverpool Street

TABLE 3.4
SUMMARY OF CAPITAL COSTS

3.10 Economic Evaluation

3.10.1 Methodology

The economic evaluation of the CrossRail options has been based on output from London Transport's RAILPLAN model with a lower level of demand (15% lower) than that used by London Transport (LT). Previous CrossRail tests have made use of a 2001 matrix which is now recognised to be a highly optimistic level of demand as it does not take into account the slump in demand since 1988. Based on an analysis of passenger counts at London Underground stations over the period 1986 to 1991 (approximately 60 stations) and Department of Transport statistics, it is apparent that the forecast 2001 demand matrix currently being used by LT for evaluating CrossRail is of the order of 15% to 20% too high.

The study team, therefore, has applied a global factor of .85 to the 2001 demand matrix used by LT. Given the timescale available, this approach is considered reasonable. All CrossRail tests which have been fed into the economic evaluation shown in this report are based on this lower level of demand.

It has also not been possible to run LT Distribution and Modal Split and Highway Decongestion models. However, from previous work carried out by LT, it has been possible to estimate the benefits of highway decongestion and increased revenue from increased rail patronage resulting from mode transfer (Road-Rail).

Highway benefits have been assumed to be the same for all CrossRail tests. However, for those tests with lower frequencies (i.e. 14 and 16 tph) and a reduced service pattern (i.e. Shenfield - Slough only), the highway decongestion benefits are likely to be lower. Similarly, for those tests with frequencies greater than 24 tph, the highway decongestion benefits may be higher.

Validation of the RAILPLAN model against the LTS model for the CrossRail scheme carried out by LT Planning, has shown that, given identical coding, the two models produce slightly different results and therefore some scaling down of the RAILPLAN passenger hours was carried out to ensure compatibility between the two models. However, the RAILPLAN model used by the study team has a number of network coding improvements compared to the LTS model and the coding of the CrossRail scheme itself is more compatible with current designs. There are therefore differences in model results between RAILPLAN and LTS.

3.10.2 RAILPLAN Results

The RAILPLAN model was used to evaluate the consequences of modifications to the proposed CrossRail scheme at the lower level of demand (i.e. 15% reduction). In addition to the proposed scheme, two main variants were considered, 6 car trains with 6 car stations and no upgradability, and 8 car trains with 8 car stations with no

upgradability. For each of these options, various station combinations and frequencies were considered. In all, nine CrossRail tests were modelled using RAILPLAN. A review of the RAILPLAN results is contained in Appendix E.

3.10.3 Economic Evaluation

The economic evaluation has been carried out using the same values of time and other key assumptions as used by London Transport for the evaluation of CrossRail. A spreadsheet based economic evaluation model was developed and calibrated to London Transport's evaluation for the full CrossRail schemes. The Net Present Values (NPV) and benefit:cost ratios, together with a breakdown in benefits for the nine CrossRail tests, are shown in Table 3.5. All figures are in millions of pounds (£m) in 1993 prices, discounted to 1993 using an 8% discount rate. A more detailed explanation of the cost:benefit analysis assumptions is shown in Appendix F.

The economic evaluation shown in Table 3.5 indicates that all the tests carried out have benefit:cost ratios of at least 1:1. However, only three of these tests have benefit:cost ratios of 1.3 and above, two of which are 6 car options and one an 8 car option.

Both of these options assume no upgradability of the stations. Of the options evaluated the option with the highest benefit:cost ratio is that with a full network service pattern, central area stations at Bond Street, Tottenham Court Road and Moorgate (with no upgradability) running 6 car trains at a frequency of 30 tph. The benefits of running a higher frequency service with smaller trains is clearly shown and serious consideration of this option is recommended. Clearly, the availability and value of the additional 6 train paths on BR (RailTrack) lines to the west and east of London needs to be explored.

The analysis in this section of the report assumes a wholly public sector project. When considering the benefit:cost ratio for the project as a joint venture with the private sector, there will be an impact on the cost side since the total project costs are increased because the private sector demands a higher return, but the Government will only have to contribute a proportion of the total costs. According to current guidelines, there would also be an impact on the benefit side through loss of revenue. The CrossRail team have shown that moving the project from the public sector to a joint venture with the private sector reduces the benefit:cost ratio. This could be important since the project is marginal as a public sector development and the involvement of the private sector may cause the Government's contribution to become unattractive.

There is, arguably, further impact on the benefit side through the effect on other Government entities, in particular LT and BR (including its privatisation), and because risk is being transferred to the private sector. However, how such benefits should be quantified and included, if at all, involves the consideration of a range of issues across different areas.

Range ?

Ref.	Stations	Route	Service tph	Cars/ Train	PT Time Benefits	PT Congestion Benefits	Highway Benefits	Generated Revenue	Total Benefits	Total Cost	Net Present Value	Benefit Cost Ratio
	EXISTING CROSSRAIL											
1	P,B,T,F,M	Full Network	24 each way	8	£695m	£515m	£414m	£397m	£2020m	£1695m	£326m	1.2:1
	CROSSRAIL VARIANTS, 6 CAR TRAINS											
2	P,B,T,F,M	Full Network	24 each way	6	£629m	£365m	£414m	£315m	£1723m	£1484m	£239m	1.2:1
3	P,B,T,F,M	Full Network	30 each way	6	£709m	£479m	£414m	£404m	£2006m	£1548m	£457m	1.3:1
4	B,T,M	Full Network	22 each way	6	£567m	£316m	£414m	£242m	£1540m	£1366m	£173m	1.1:1
5	B,T,M	Full Network	30 each way	6	£689m	£477m	£414m	£383m	£1963m	£1453m	£509m	1.4:1
	CROSSRAIL VARIANTS, 8 CAR TRAINS											
6	P,B,T,F,M	Full Network	24 each way	8	£631m	£506m	£414m	£371m	£1922m	£1514m	£408m	1.3:1
7	B,T,M	Full Network	22 each way	8	£572m	£461m	£414m	£317m	£17694m	£1412m	£352m	1.2:1
8	T,M	Full Network	14 eb & 16 wb	8	£351m	£281m	£414m	£180m	£1227m	£1201m	£26m	1.0:1
9	T,M	Slough Shenfield	14 eb & 16 wb	8	£325m	£229m	£414m	£170m	£1137m	£1113m	£24m	1.1:1

P: Paddington
B: Bond Street
T: Tottenham Court Road
F: Farringdon
M: Marylebone

TABLE 3.5
ECONOMIC EVALUATION OF CROSSRAIL OPTIONS

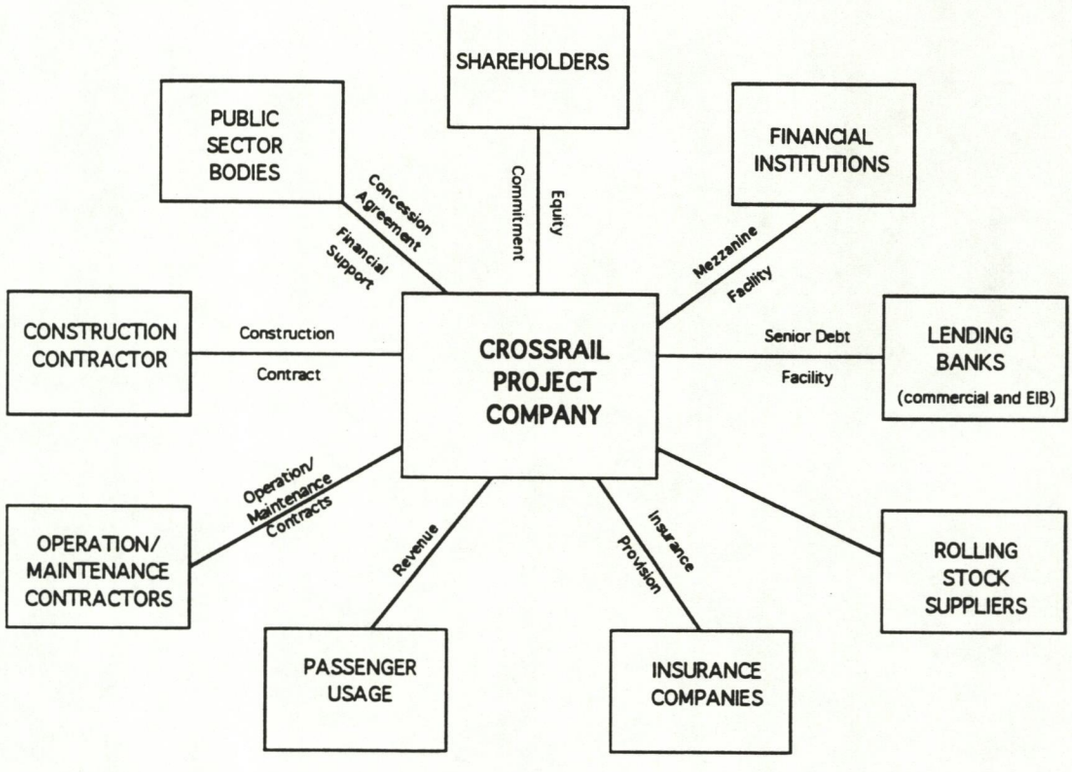
3.11 Project Structure and Financing

3.11.1 Project Structure

The involvement of the Government is essential for the successful completion of the CrossRail project as a joint public/private sector venture. Furthermore, the classification by H. M. Treasury of the project as a private one is vital. There is, therefore, a need to structure the project in a manner acceptable to Government with the maximum transfer of risk to the private sector, subject to the willingness of the private sector to take on risk.

The allocation of risk between the various parties involved in a private infrastructure project would be achieved through contracts specifying in detail the terms under which payments must be made, the specification of each party's obligations, circumstances under which liabilities arise and a definition of force majeure events. The inter-relation between the different parties is shown schematically below:

Crossrail - Commercial Structure



In order to maximise the amount of private sector funding that can be raised for the CrossRail project company, as much risk as possible must be passed on via the individual contracts. Most of the cost and performance risk associated with construction and operation, in principle, may be passed to the construction and operation/maintenance contractors respectively. Many other risks, such as physical loss or damage, may be insured against and, therefore can be passed by implementing a comprehensive insurance package. This leaves the level and robustness of the revenue as the major risk being taken by the project company and it is this, therefore, that largely determines the capacity of the project company to raise funds from the private sector.

The level of revenue is a forecast figure based on assumptions about the future usage by passengers which itself will depend on the assumptions made about the economic activity and social trends expected within London and the surrounding areas. In assessing a potential level of revenue, private sector lenders and investors will look at the reasonableness of the underlying assumptions, investigate the sensitivity of the revenue to a change in the underlying assumptions and compare the forecast revenue level with that seen historically, adjusting for variations in the underlying factors.

The usage level seen will depend on the diversion of demand between competing traffic modes and on the overall level of demand. Diversion itself depends on the relative fare levels as well as many other individual factors associated with the convenience of one route over another. The fare level has been assumed to be the same as other public transport fare levels and so should not have an influence. Assumptions have been made about the other factors in the transport planning model (RAILPLAN) used to generate the passenger miles and there is a risk that these do not reflect what passenger behaviour will actually be.

For the overall demand level, a starting place for producing a forecast is to look at historic data. Over the past thirty years there has been an overall downward trend in the number of people entering London during the morning peak period (7-10 am). The outlook in Central London for employment growth is uncertain, but, combined with an expected increased in off-peak travel in the future, the assumption that there will be some growth in overall demand would seen to be reasonable. This is the assumption underlying the usage figures used here, with the increase in passenger miles once the new facilities are open arising from a transfer of demand from other transport modes.

It is assumed that the full operation of the proposed CrossRail scheme would be the responsibility of the CrossRail project company with the risk of operation being largely passed on to an operator through an operating contract. As originally conceived, CrossRail was assumed to be operated by a joint BR/LUL team. For this to be acceptable to the private sector, appropriate contractual arrangements between these entities and the project company would need to be put in place, so ensuring that the operator takes the risks associated with operation.

However, it is not clear whether it will be practical to follow the original concept for the operation of CrossRail because of the intention to create BR franchises. It is also not clear what appetite there is within the private sector to take on railway operation. Some further thought, therefore, may need to be given to this area to ensure that a successful project structure can be created. One immediate step for consideration would be the formation of CrossRail as a Government Company independent of LT and NSE and reporting directly to the Government. Such a company could then become the initial vehicle for moving the project into the private sector.

3.11.2 Financing Structure

This section considers the financing plan proposed by NatWest Capital Markets for the CrossRail Project Team.

Funds from five different sources are assumed to be available:

a) **Internally Generated Funds**

It is assumed that the project company will derive the benefit of the revenue from the BR line(s) included in the proposed CrossRail schemes from the start of the concession period (1 April 1996). In this way the project company should receive revenue while the new facilities are being constructed and so have access to it as a source of financing for construction. However, the revenue has risk associated with it and its contribution, therefore, will be discounted by the banks.

b) **Senior Debt**

The amount of senior debt available to the project company is assumed to be maximised. As discussed in Section 3.11.1, the capacity of the project company to raise finance will depend on the amount of risk left within the company. The maximum amount that will be available will depend on the net cashflow providing the banks (including the EIB, assuming it is willing to lend on a project basis) with adequate cover through a minimum annual cover ratio and through the concession continuing for a sufficient period after the debt is due to be repaid.

In addition to the robustness of the project itself, there will be other constraints on the amount of debt that might be available to the project. There will be a loan size above which the banks will not lend to a single borrower. Banks will also look at the precedents set by previous similar projects in deciding how much as a proportion of total cost they will lend. Experience on other projects will also have a major impact on the banks' appetite for the project, for instance, the unsuccessful project financing of the Orly VAL Line in Paris. In addition, the difficulties seen with the

Eurotunnel financing may have made some banks wary of UK transport projects.

The very large size of the project, at least as originally conceived, is also likely to be an important factor. There are relatively few international banks who are active in project financing and for a project of such a size most of them would need to be involved at an underwriting stage. Similarly, a project with such a debt facility would require a very large number of banks to be involved at the syndication stage and, inevitably, would include banks with little or no experience of project financing. For instance, for the Eurotunnel project there were 50 underwriting banks with the number of banks participating after syndication rising to around 200. This is likely to result in poor terms being achieved compared with projects of smaller size, in particular loan maturity.

It is not at all certain that such a large amount of money could be raised by the project company in the current market. At the time the project is expected to be taken to the market it may well be competing with the High Speed Rail Link project for funds. In addition, the Eurotunnel project will have a considerable influence on banks' views on transport projects for some considerable time to come, although by the time CrossRail would be taken to the market the performance of Eurotunnel will be much clearer.

c) **Mezzanine Funds**

A tranche of mezzanine financing is assumed to be available. This has been assumed to be in the form of sub-ordinated debt which only pays out the interest due on maturity. Thus, it is equivalent to a zero-coupon bond.

The source of the mezzanine tranche is assumed to be financial institutions. There is some precedent of such funds being available, in particular, for the Queen Elizabeth II Bridge and Second Severn Bridge projects, but not on the scale of the proposed CrossRail scheme. It is not clear, therefore, that any such funding would be available, but a moderate level has been assumed for the purpose of the current analysis. To the extent mezzanine finance is not available, the shortfall may be made up from shareholder funds.

d) **Shareholder Funds**

A tranche of shareholder funds is assumed to be available. For ease of modelling this has been assumed to have the same characteristics as the mezzanine tranche, i.e. a zero-coupon bond, except that the return assumed is higher. However, the size of the proposed scheme is such that the

project company would have to be floated on the Stock Exchange and, therefore, it is unlikely that the shareholder funds would be provided by such an instrument. The most common form of shareholding in quoted companies is equity, although derivative products are becoming more widespread.

e) Grant

To the extent that there is a residual funding requirement over and above the assumed maximum of the other sources of finance, it is assumed, for the purpose of the current analysis, that the shortfall will be funded by the Government through grant financing. However, an alternative would be for the Government to provide its contribution in the form of subsidy during the operating period or indeed a combination of grant and subsidy.

In practice, it may be possible to reduce the funding requirement during the construction period by leasing some of the assets, for instance, the rolling stock. However, this would result in an increase in the cost base during the operating period which would need to be covered by a larger subsidy from the Government. Regardless of the form in which the Government contribution is made, a commitment to make the funds available will be required to allow drawings to be made on the private sector funding. The attractiveness of the alternative forms will depend on political factors, which may also determine from which part of the Government the funds are provided, as well as the relative cost.

To the extent that the Government contribution is made later rather than earlier, this will increase the real amount required and, since private sector finance is more expensive than public sector funds, will also increase the real cost in discounted terms. However, the size of the Government's contribution is such that it is likely to have to spread the contribution over several years at least in order to avoid disrupting funding availability for the wider spending program.

Based on the preliminary cost and revenue assumptions given in Appendix F the indicative level of grant funding is in the region of (50%). However, this result is highly dependent on the net revenue assumed, i.e. the difference between the fare charged and operating costs on a per passenger mile basis, and while there is some confidence in the fare level, the appropriate operating cost figure is much less certain and requires further investigation.

CROSSRAIL

Study of
COST EFFECTIVENESS

4.0
ALTERNATIVE INVESTMENT OPPORTUNITIES

Bovis SIR ALEXANDER GIBB & PARTNERS

4.0 ALTERNATIVE INVESTMENT OPPORTUNITIES

4.1 Study Objectives

Section 3 of this report has considered in detail the CrossRail scheme as planned and variations to the scheme. However, the cost reduction proposals and enhancement of benefits still leaves the project, at best, marginal as a private/public joint venture. In particular as the underlying Central London growth forecasts themselves are now unlikely to be achieved within the envisaged timescale of the project, less capital - intensive projects could be re-considered.

London Transport have themselves identified a range of opportunities for infrastructure investment in the Underground system that would provide significant benefits. The study team has also studied a number of alternatives which seek to achieve some of the perceived objectives of CrossRail, but at reduced cost and complexity and with potential for private financing.

An extensive list of London rail investment opportunities were identified within the target price range. Six were selected which were felt to address best the perceived objectives of the CrossRail project. Of these, five fell within a cost range of £100 million to £300 million.

Schemes were selected primarily according to the extent that they address "CrossRail type objectives". Some of the other schemes which were not studied further, such as the Finchley Road Link, East London Line Extensions, Croxley Link, and some free-standing components of the much larger Northern Line and Thameslink projects, may also offer good returns and be suitable for private finance, but were considered to be outside the scope of this study.

4.2 Scheme Descriptions

4.2.1 Eastern City Link

This scheme attempts to address some of the suggestions of petitioners including the London Borough of Tower Hamlets and Mayfair Residents Association. It makes maximum use of the existing Metropolitan-Circle Line to provide a new through route for trains from Shenfield to Amersham. Key elements and issues are discussed below, and the scheme is illustrated at Map 4.1.

Construction of a new deep tunnel link from Bethnal Green to Moorgate would be required as per the existing CrossRail proposals, but west of Liverpool Street the new line would rise to sub-surface along the existing City Widened Lines beneath the Barbican, to connect onto the existing Circle/Metropolitan Line between Barbican and Farringdon.

Existing Metropolitan Main Line services which terminate at Aldgate would instead run through to Shenfield, replacing the existing inner suburban services to Liverpool Street. Both services are currently operated with 15, 8-car trains per hour.

The technical specification would be as for the Minimum Core Railway, except that train and station length would need to be made compatible.

This scheme assumes closure of the City Widened Lines to Moorgate. This is consistent with the Thameslink 2000 scheme which is not currently funded. A minimum assumption is completion of upgraded electrification from Farringdon at least as far as Blackfriars to provide an alternative terminal for Thameslink trains.

Stub tunnels might be provided under Moorgate for future construction of the full CrossRail scheme via Oxford Street. However, this would only make sense if the tunnel route is safeguarded in perpetuity which would have a considerable cost and could result in long term property blight along the corridor.

Possible alternative routes via Bunhill Fields, as suggested by Winbourne French, and extension of the tunnel to a portal at Pudding Mill Lane, could be considered as options, though they are likely to increase cost without offering any additional benefits.

This option falls outside the target investment range of £100 million to £300 million, but was evaluated because it appears to be the smallest possible increment of the CrossRail project which might bring significant benefits. It also addresses constructively both the Northern Route via Kings Cross and the possibility for phased construction of the main scheme.

4.2.2 Heathrow-City Express

The Heathrow-Paddington Express, now under construction, would be extended on existing Metropolitan/Circle tracks to Moorgate. The scheme is illustrated at Map 4.2 and is described below.

The Heathrow Express to Paddington is to be 4 trains per hour. This same service would be extended through to Moorgate. For operational and commercial reasons, it may be appropriate for this "premium" service to run through intermediate stations "non-stop", although Heathrow trains could not pass other trains as most of the line is only double track.

It has been assumed that all existing Circle Line services remain. Existing services total 20 tph along this line. The required four additional train paths on the Circle Line can be achieved by installing cab signalling, based on SASEM as used on Paris RER or SELTRAC as now being installed on the DLR. Dual voltage trains would be required.

Alternative ways to release the necessary capacity on the Circle Line are considered separately and may prove more cost effective and less technically challenging.

Trains would depart Moorgate every quarter hour, calling at Paddington about 17 minutes later, and then arriving at Heathrow after a total journey time of about 35 minutes. This should be highly competitive with alternative modes, including taxi, from the high value City and West End markets.

Station modifications would be required at Paddington and Moorgate to provide the desired dedicated facility, with lifts for baggage trolleys, convenient taxi ranks, etc. Two platforms would be provided at Moorgate to allow a spare train to layover and maintain a clock-face timetable.

4.2.3 Jubilee Extension to Leytonstone

This scheme is intended to relieve the Central Line through Liverpool Street by making it easier for passengers from Epping and Hainault to use instead the less congested Jubilee Line for journeys to Westminster and the West End. The scheme is illustrated at Map 4.3.

The scheme requires the construction of a new connection between the Jubilee Extension at Stratford and the Central Line near Leyton. Jubilee and Central Line trains would share existing tracks through to Leytonstone, with 15 tph from each line.

The scheme required a reversing facility east of Stratford on the Central Line, ideally at Leyton, to add a further 15 tph to the Central Line westbound.

Modifications to Stratford JLE station would be required. The contract for this has not yet been awarded and it might be possible to avoid abortive expenditure if decisions were made promptly to allow for future extension. The station is on the surface and changes need not delay opening of the main project.

Additional trains would be required for the Jubilee Extension through to Epping, although these simply displace Central Line trains which may be redeployed elsewhere.

4.2.4 Diversion of Hammersmith & City into Bakerloo Slough (or Reading) Services to Barking (or Rainham)

This scheme releases capacity on the large-clearance Metropolitan/Circle Line for use by longer-distance suburban services by converting the Hammersmith & City Line to a tube service and connecting it from Royal Oak by new tunnels into the Bakerloo Line west of Paddington. The scheme is illustrated at Map 4.4.

The existing Hammersmith & City Line, therefore, would become a branch of the Bakerloo Line and be worked with tube stock.

The Bakerloo Line is currently well below capacity, with only 20 trains/hour and these are only 50% loaded north of Paddington. The Hammersmith & City Line is currently 7.5 trains per hour, only 65% loaded west of Paddington. The H&C service could be increased to 10 trains/hour with Queen's Park service reduced to 10 trains per hour which would be adequate for current traffic. The combined Bakerloo service would be 20 tph Paddington-Elephant and Castle, as it is currently.

The conversion of the H&C to tube stock would only require track raising at stations; electrification and signalling are compatible.

The scheme releases 7.5 train paths per hour (tph) on the north side of the Circle Line. Replacement capacity must be provided in the peak hours and the scheme proposes that trains from Slough (or Reading) run through to Barking (or Rainham). This would require electrification from Airport Junction to Slough and turnback facilities at Slough. Dual voltage rolling stock would replace new Thames turbos which would be cascaded to another line.

4.2.5 Diversion of Wimbledon Branch to Central Line

The scheme proposes to divert some Wimbledon Line services into the Central Line via Olympia into Holland Park, releasing capacity on the Circle Line to Edgware Road and relieving train crowding on the District Line through Earl's Court towards Victoria. The scheme is illustrated at Map 4.5.

The existing service is 18 tph from Wimbledon to Earl's Court. In the peaks only a few (three or four) of these can run through via Victoria

because most capacity is used for Richmond/Ealing services. 7 tph terminate at High Street Kensington and 7.5 at Edgware Road.

Earl's Court is identified by CLRS and all subsequent studies as one of the major bottlenecks, both in passenger crowding and in train delays. Earl's Court-Gloucester Road is one of the three congested links in the "low growth" scenario, the others being Euston-Warren Street (Victoria Line) and Victoria-Green Park. This proposal would alleviate part of this crowding and hence accrue many of the benefits.

The western part of the Central Line is currently under-used (in contrast to the overcrowded east). This was recognised in the CLRS which considered a link to the District Line Richmond Branch.

The Wimbledon service could be increased to say 20 trains per hour. 8 would run via Earl's Court as existing, 2 terminating at High Street Kensington and 6 continuing on the District Line via Victoria. The other 12 would run directly via Kensington (Olympia) then by new tubes into the Central Line between Holland Park and White City, then via the Central Line to Liverpool Street.

Currently, Central Line services are 32 trains to White City, then 20 trains west of White City. Wimbledon trains would replace the trains terminating at White City and perhaps increase Central Line capacity through to Marble Arch where capacity can eventually be raised to 32 trains per hour.

This would balance flows on the Central Line, offer a new, faster and direct service from Wimbledon to the West End and City and relieve congestion through Earl's Court on District Line trains through to Victoria. It may also reduce congestion on the Victoria Line from Victoria to Green Park.

Incidental development benefit would be a frequent all day service from the West End to Olympia to replace the current service of a shuttle from Earl's Court.

The effect of the scheme would be to eliminate the need to turn any trains back at Edgware Road, facilitating other services on the north side of the Circle Line as described in earlier options.

Interworking on the Wimbledon branch by District and Circle Line trains may be achieved by alternate station stopping with common changeover at West Brompton and Southfields. Dual platforms would be required to offset the effects of the different rolling stock configurations.

New trackwork would be required between West Brompton and Olympia to avoid conflict with West London Line services.

4.2.6 Kilburn Link - Thameslink

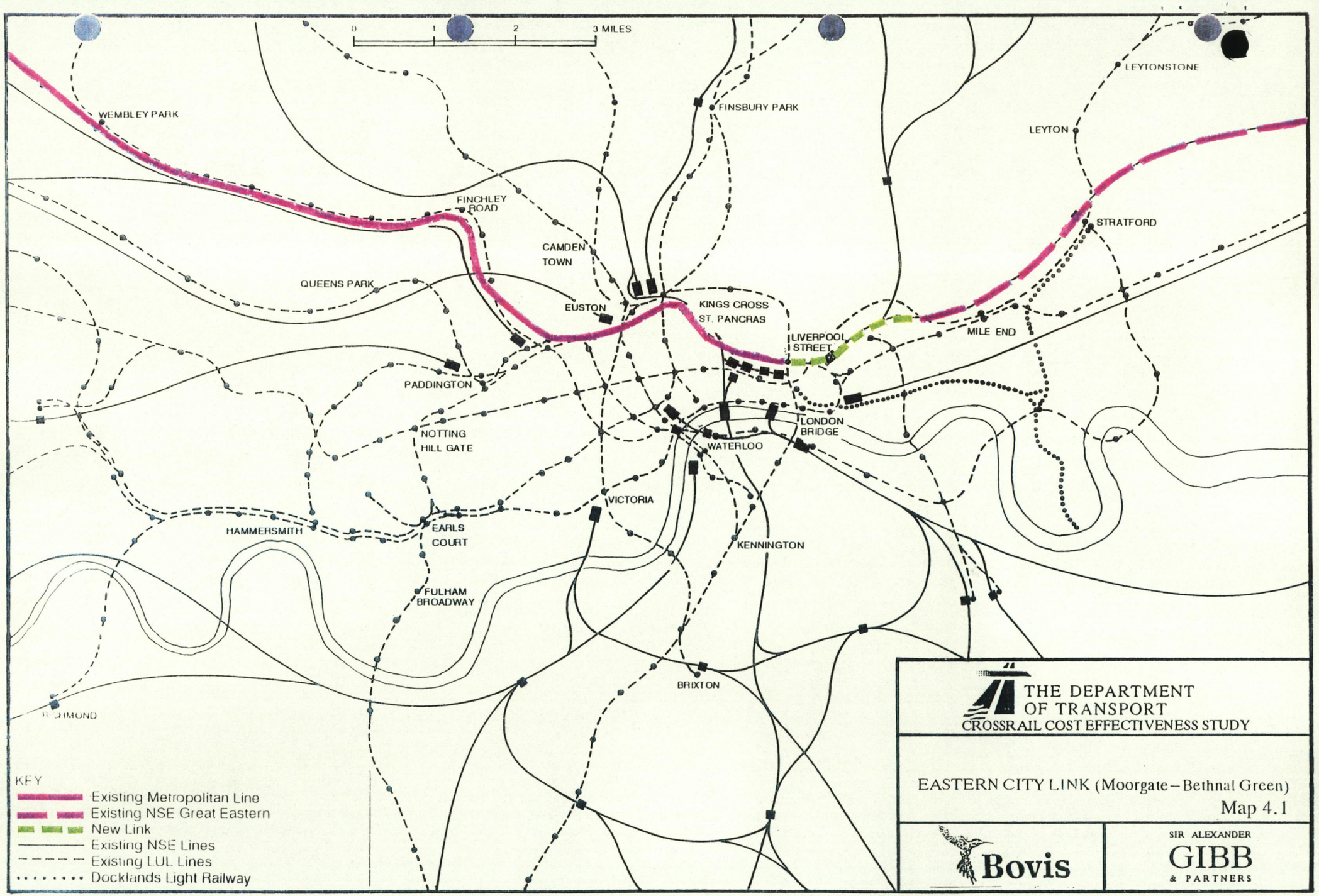
The scheme comprises the construction of a new link from the Metropolitan Lines at Kilburn via West Hampstead to Thameslink. 6 tph, currently terminating at Baker Street, would be diverted to Thameslink, reducing crowding on the north side of the Circle Line. The scheme is illustrated at Map 4.6.

Journey time benefits on Thameslink and the expansion of the Thameslink network are obtained. A new Kings Cross Thameslink station would be required as proposed by Union Railways.

However, the addition of 6 tph to the existing Thameslink services would necessitate a reconsideration of the Thameslink 2000 proposals.

In particular, the case for connection to the Great Northern Lines and the diversion of 12 tph through to Blackfriars might be affected. The Thameslink 2000 project appears to offer significant benefits and should be reassessed with the Kilburn Link as an option.

The connection at Kilburn requires grade separation and use of part of the North London Line. Interworking with the current services on the North London Line requires further study. Some property demolition would be required, but interference with West Hampstead station would be avoided.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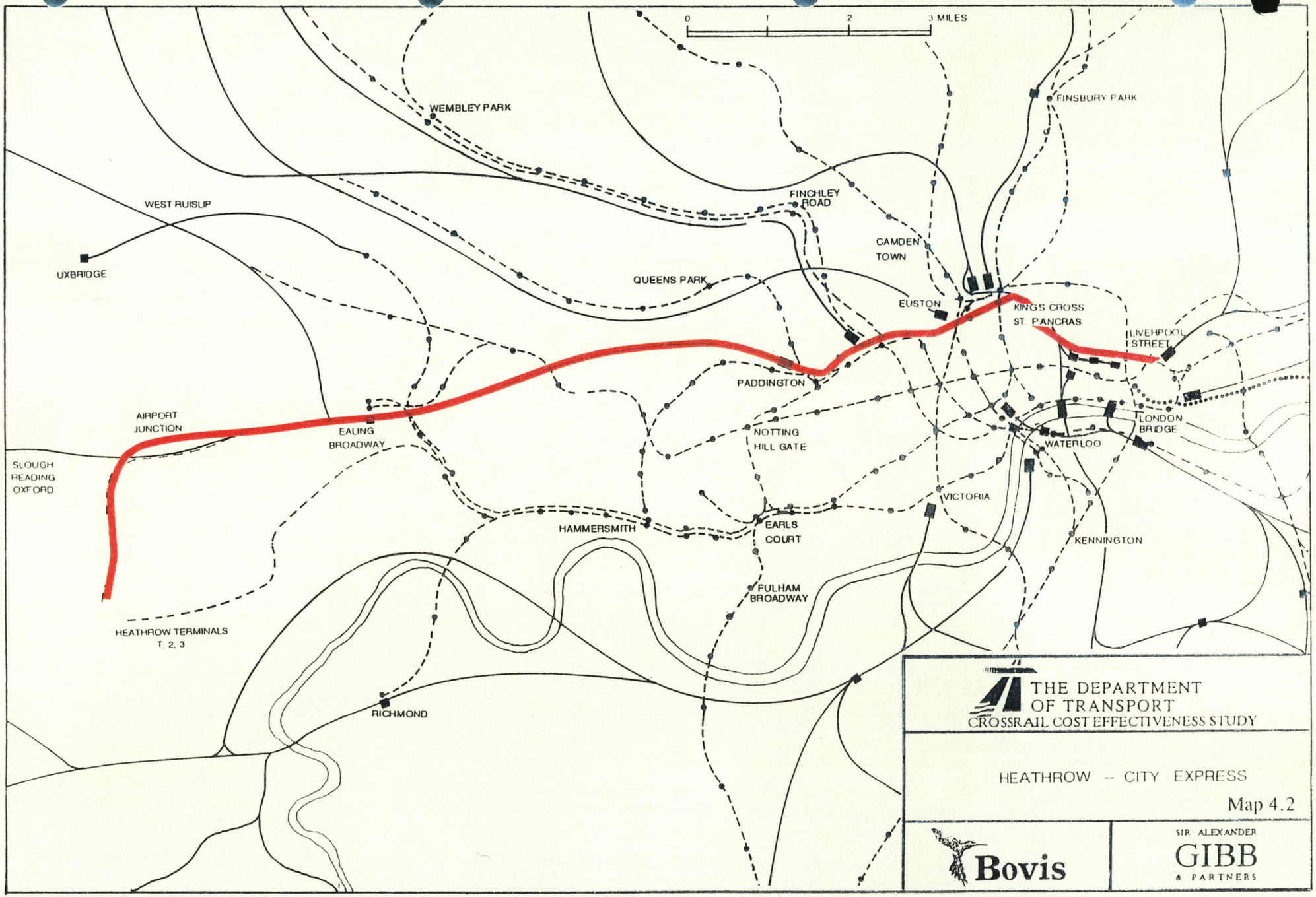
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
KEY
Existing Metropolitan Line
Existing NSE Great Eastern
New Link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
EASTERN CITY LINK (Moorgate – Bethnal Green)
Map 4.1
Bovis
SIR ALEXANDER GIBB & PARTNERS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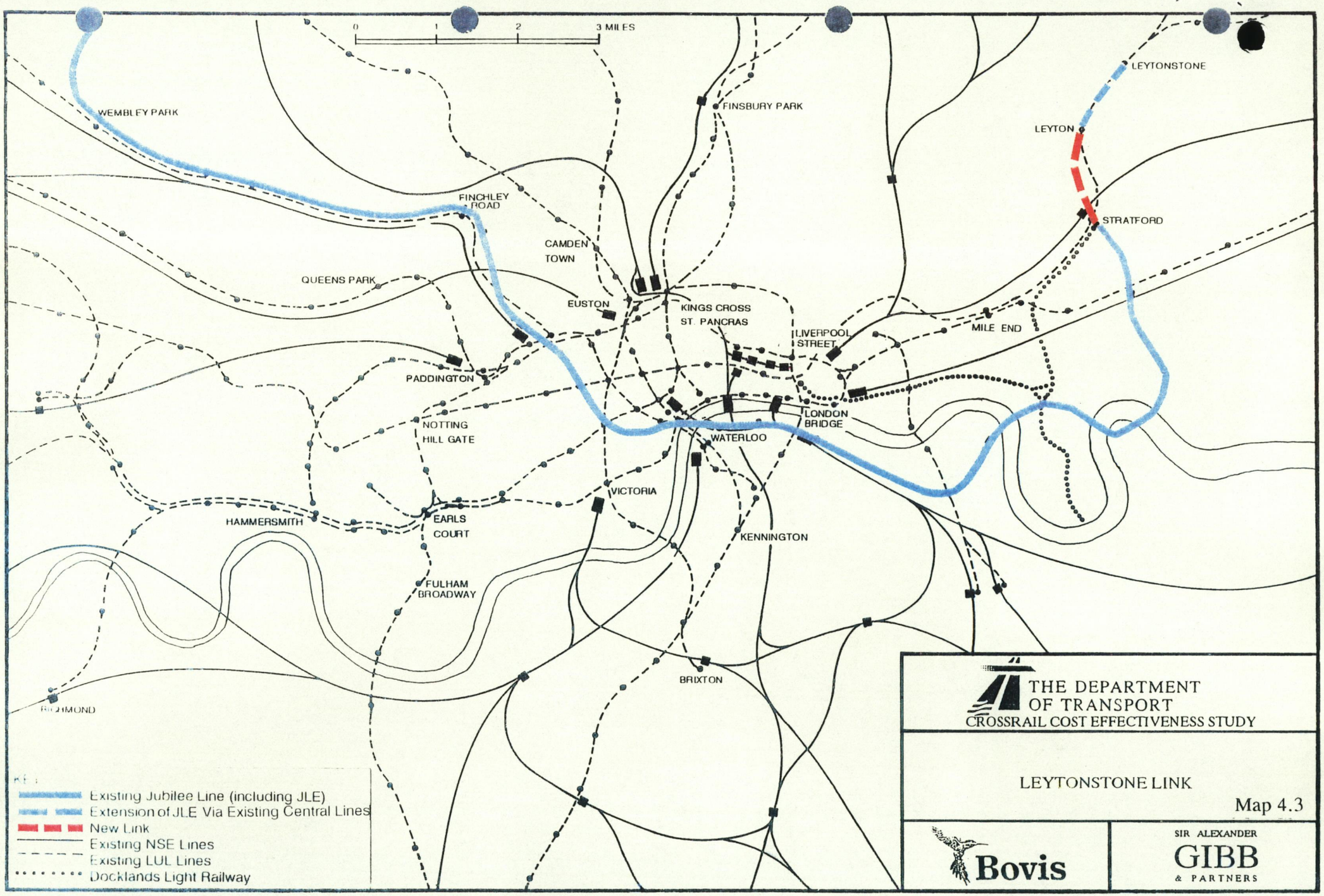
LIVERPOOL STREET
PADDINGTON
AIRPORT JUNCTION
EALING BROADWAY
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
SLOUGH
READING
OXFORD
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
HEATHROW TERMINALS 1, 2, 3
RICHMOND
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
HEATHROW -- CITY EXPRESS
Map 4.2
Bovis
SIR ALEXANDER GIBB & PARTNERS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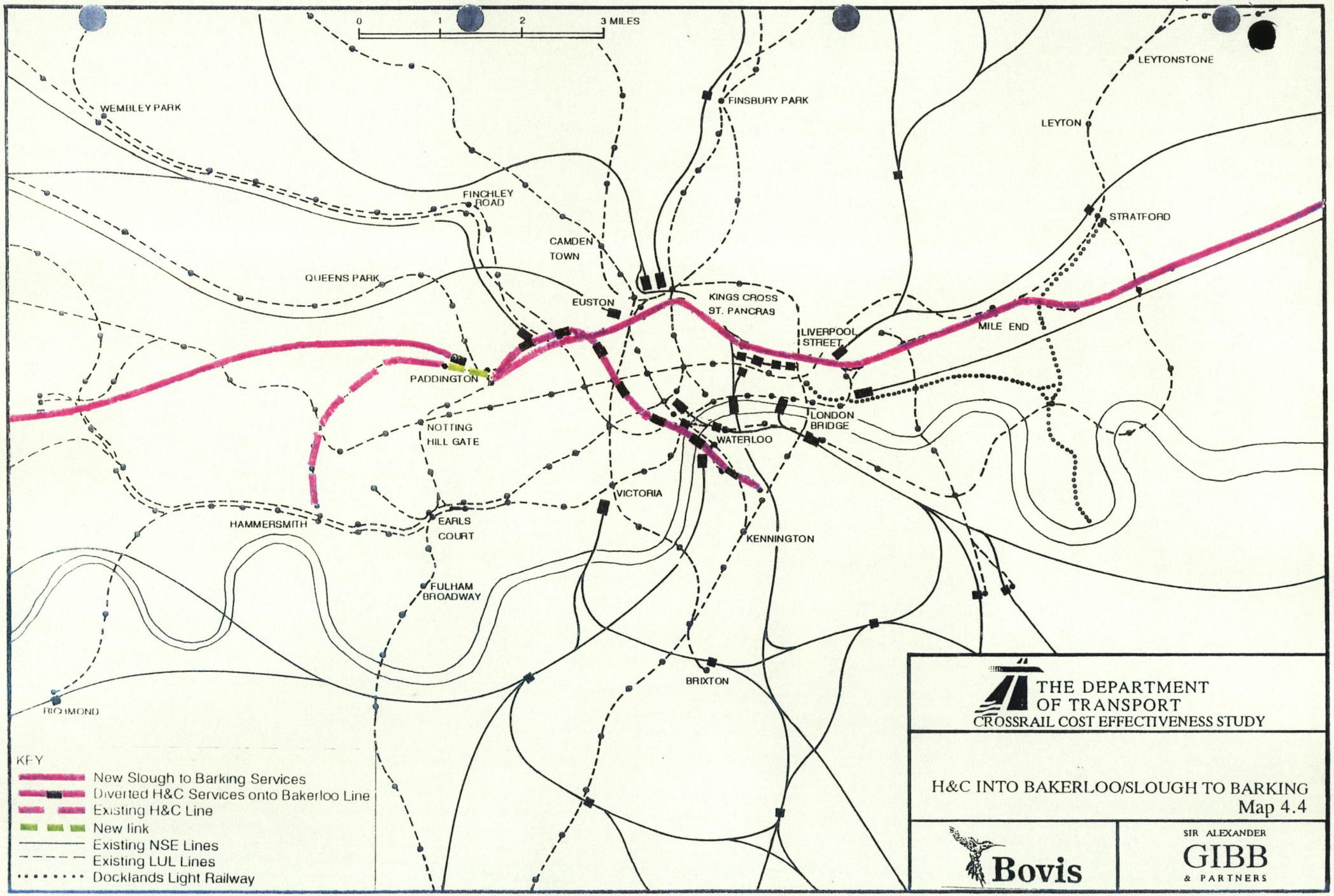
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
Existing Jubilee Line (including JLE)
Extension of JLE Via Existing Central Lines
New Link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
LEYTONSTONE LINK
Map 4.3
Bovis
SIR ALEXANDER GIBB & PARTNERS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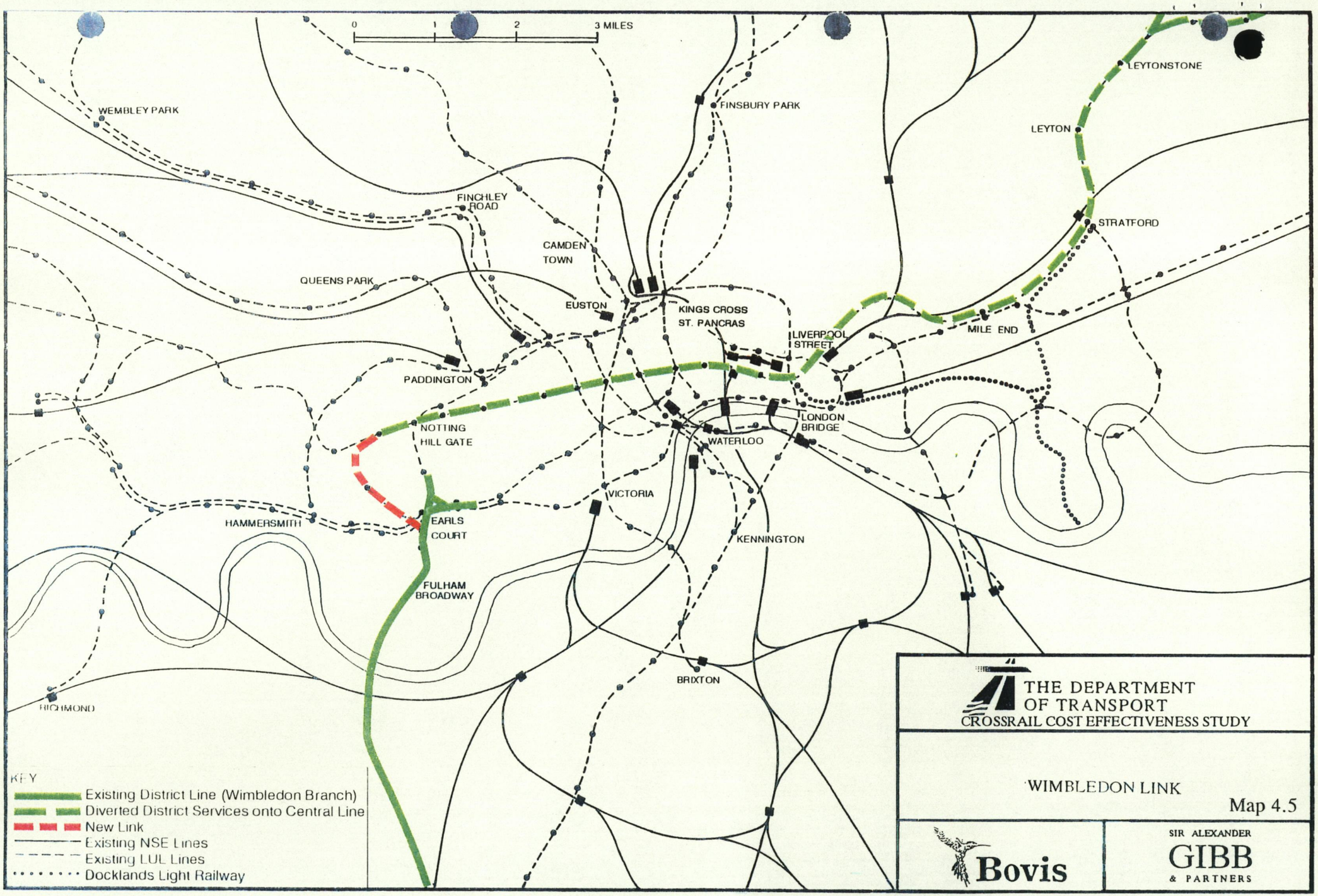
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
KEY
New Slough to Barking Services
Diverted H&C Services onto Bakerloo Line
Existing H&C Line
New link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
H&C INTO BAKERLOO/SLOUGH TO BARKING
Map 4.4
Bovis
SIR ALEXANDER GIBB & PARTNERS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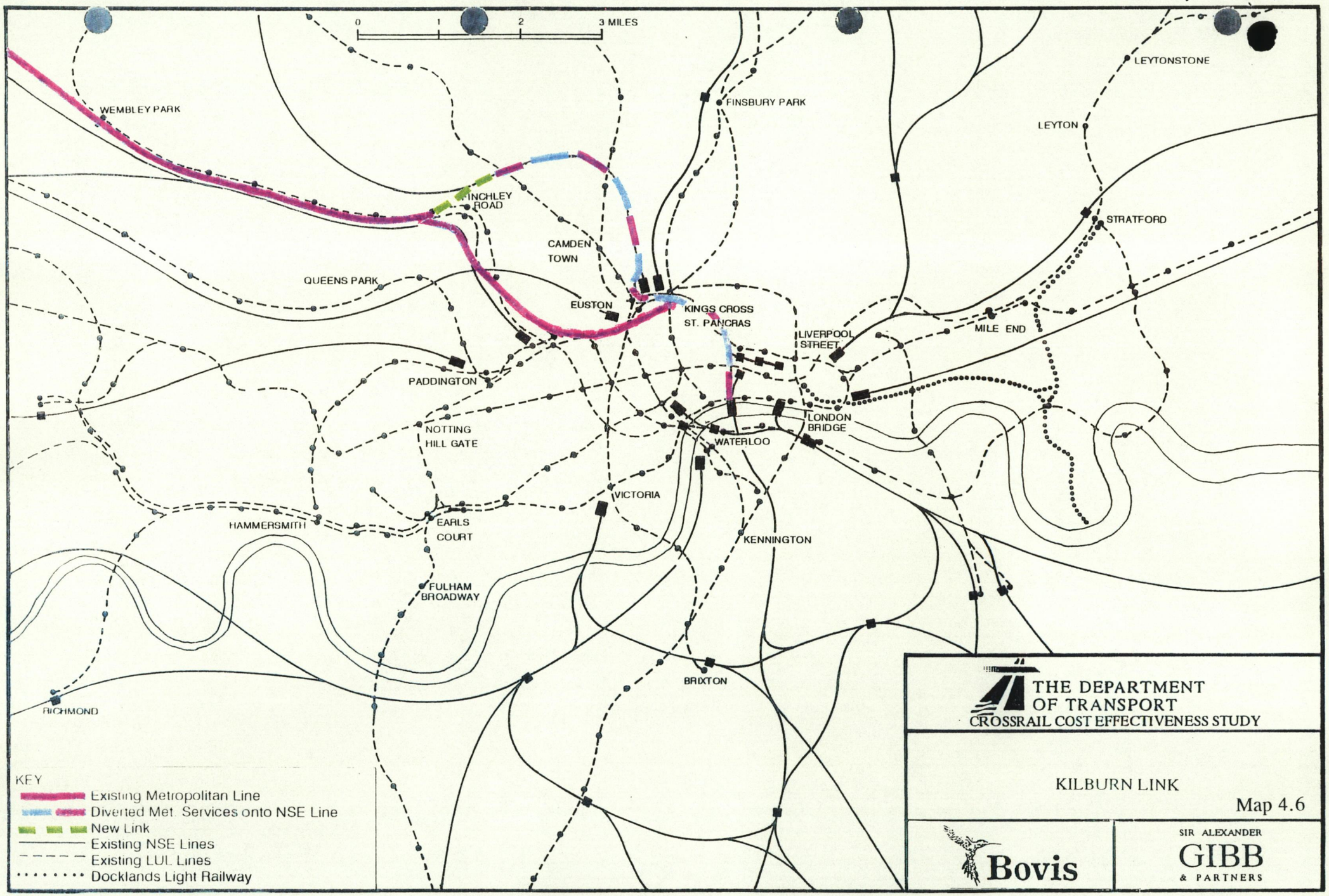
CAMDEN TOWN
QUEENS PARK
EUSTON
KINGS CROSS ST. PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
KEY
Existing District Line (Wimbledon Branch)
Diverted District Services onto Central Line
New Link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
WIMBLEDON LINK
Map 4.5
Bovis
SIR ALEXANDER GIBB & PARTNERS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MILE END
LIVERPOOL STREET
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
KEY
Existing Metropolitan Line
Diverted Met. Services onto NSE Line
New Link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
KILBURN LINK
Map 4.6
Bovis
SIR ALEXANDER GIBB & PARTNERS

4.3 Capital Cost and Economic Evaluation

Capital costs for each of the alternative investment opportunities described in this section. The capital costs are summarised in Table 4.1.

A detailed benefit:cost analysis is also being developed for each of the alternative investment opportunities. However, this involves significant modelling and validation of assumptions using LT's RAILPLAN model and is unlikely to achieve a rigourous and robust result within the timescale of the current study. A preliminary view has, however, been developed in each case based on some broad assumptions on their likely benefits.

4.3.1 Eastern City Link

i) Base Option

Approximately one-third of the peak passengers currently using the Great Eastern services into Liverpool Street are likely to ride through beyond Moorgate to Kings Cross and Euston, with a further third benefiting because Moorgate is closer to the heart of the City. For both groups of passengers, journey times would be reduced by about five minutes compared with the current interchange at Liverpool Street.

Few passengers from the west would be expected to travel through east of Moorgate. Although some passengers might find it attractive to travel to Stratford for interchange to Docklands, other routes via the DLR from Bank and the Jubilee Line from Baker Street will generally be faster.

There is unlikely to be any significant congestion relief benefit, apart from a few passengers completing their journey to Bank or London Bridge on the slightly less congested Northern Line. Passengers for the West End would still need to use the Central Line from Liverpool Street, or the equally congested Victoria and Piccadilly Lines from Kings Cross.

With costs estimated at £250 million for infrastructure and £325 million for rolling stock, it is unlikely that this option will have a very attractive benefit:cost ratio.

ii) Electrification to Aylesbury

Benefits and revenues could be increased by providing overhead electrification from Amersham to Aylesbury and running four trains per hour through as proposed for CrossRail. This is not currently possible because Metropolitan Line trains cannot use overhead lines, fourth-rail is too expensive for such a lightly used service, and it would be difficult to operate a small fleet of dual voltage trains within the existing operation. However, with all

Metropolitan Line trains at Amersham equipped for dual-voltage operation it would be more attractive.

However, whilst it is possible for the Eastern City Link scheme to serve Aylesbury as proposed for CrossRail, the case is likely to remain poor both in economic terms and financially.

4.3.2 Heathrow-City Express

Heathrow Express Limited is currently supporting an investment of approximately £400 million for services from Heathrow to Paddington. There may be potential to expand the demand for the service if it also serves the City.

It is likely that Heathrow Express Limited would be prepared to pay a significant amount for the train paths. This could be sufficient to cover the cost of providing them.

Subject to detailed modelling of train operations, there may also be reliability benefits to existing Circle Line passengers.

This option could provide a very attractive benefit:cost ratio.

4.3.3 Jubilee Extension to Leytonstone

The principal benefit of the scheme is relief of congestion through Liverpool Street. This is achieved by encouraging passengers to make better use of the Jubilee Extension for journeys to Westminster and the West End. This opportunity was first identified in the *East London Rail Study*, which highlighted a propensity of passengers to use the Jubilee Line in preference to the overcrowded Central Line.

Additional passengers diverted to the Jubilee Line by this scheme are likely to achieve benefits roughly offsetting the disbenefits to those who would now need to transfer back onto Central Line trains at Leyton. There will be congestion relief benefits at Liverpool Street through to Chancery Lane, where crowding may be significantly relieved. However, congestion is only a serious problem for a few hours every day, and the economic value of this relief is therefore fairly limited.

This scheme might offer an economically viable benefit:cost ratio for private sector investment.

4.3.4 Diversion of Hammersmith & City into Bakerloo

There are unlikely to be any significant passenger or revenue benefits or disbenefits of linking the Hammersmith branch into the Bakerloo instead of the existing connection into the Circle Line. The scheme is principally of interest when coupled to one of the replacement through services from West London utilising the Circle Line.

Taking either the Slough or additional Metropolitan Main Line trains through to Barking would eliminate an interchange for most passengers.

In the east, services could be projected beyond Barking, perhaps to Rainham, bringing regeneration benefits in the East Thames Corridor.

It appears that this scheme could be developed to provide a good benefit:cost ratio.

4.3.5 Diversion of Wimbledon Branch to Central Line

Passengers using the Central Line services from the Wimbledon branch might save, on average, 5 minutes. The Central Line service would offer competitive journey times to West End destinations, such as Oxford Circus and many Wimbledon branch passengers would be likely to prefer it to the existing Edgware Road services.

There would be savings of a similar magnitude to District and Circle Line passengers who will experience less congestion and a more reliable service through Earl's Court and Edgware Road.

There would also be congestion relief benefits on the Wimbledon Branch itself, which is currently loaded above the planning standard north of Putney Bridge, and along the District Line and potential through Victoria and Oxford Circus stations. There may, however, be some increased crowding at Central Line stations where more people will be alighting from eastbound trains.

This scheme could also provide a positive benefit:cost ratio.

4.3.6 Thameslink-Kilburn Link

Assuming the Kilburn Link is operated with trains currently terminating at Baker Street, passengers using it could achieve a significant saving to the City compared with the interchange at Baker Street and slower journey along the Circle Line.

If the link is operated instead with services currently terminating at Aldgate, then there would be a smaller time saving to passengers using the service, many of whom will need to change at Farringdon or walk from City Thameslink to their jobs. However, there could be substantial operational benefits to the Circle Line service, improving reliability and generating further benefits.

This link could also be used by services additional to those currently operated. There could be a net increase of say four trains in the peak hour from Amersham or Chesham. Since they will need to use dual voltage stock, consideration could be given to installing overhead electrification from Amersham to Aylesbury, as suggested above for the Eastern City Link.

This scheme could also provide a positive benefit:cost ratio.

4.3.7 Summary

Initial estimates of costs, benefits, revenues, and benefit:cost ratios for the six schemes suggest that most, if not all, could provide attractive opportunities for investment. More detailed analysis, currently in progress, may provide a more rigorous assessment of their economic evaluation. However, it is unlikely that this work will be sufficiently developed to provide a robust economic evaluation within the current study.

Ref.	Scheme	Infra-Structure	Rolling Stock	£m Total	Opening Date
2A	Eastern City Link	250	325	575	Apr 2001
3A	HEX to Moorgate	80	45	125	Apr 1999
4A	Leytonstone Link	35	85	120	Apr 1999
5C	Slough - Barking/H&C into Bakerloo	60	200	260	Apr 2000
6A	Wimbledon into Central	75	65	140	Apr 2000
7A	Kilburn Link	40	120	160	Apr 2000
	Total of Options 2 - 7	540	840	1,380	

TABLE 4.1
ALTERNATIVE INVESTMENT OPPORTUNITIES
SUMMARY OF CAPITAL COSTS

All costs in £m at Nov 93 levels
All costs at median risk levels

4.4 Project Structure and Financing

4.4.1 Project Structure

In broad terms, the factors influencing the project structure for the alternative schemes will be the same as for the CrossRail proposals. The discussion of project structure in Section 3.11.1 is therefore also relevant for these schemes.

4.4.2 Financing Structure

The same five types of funds described in Section 3.11.2 are assumed to be available for the alternative schemes for the purpose of the analysis carried out. However, because the alternative schemes require much less investment, there will be differences as to the possible sources of the funds and their likely availability.

In particular, the amount of debt being sought would not be subject to a constraint of the market which should result in better terms, most importantly overall maturity, being available. For the mezzanine financing, there are more similar precedents and therefore the likelihood of raising such finance should be greater. Finally, the project company could still be floated on the Stock Exchange, but probably would not have to be, to raise the shareholder funds. This may allow more flexible financing structures to be chosen, since the Sponsors of the project would be expected to have a controlling interest.

4.5 Implementation

4.5.1 Eastern City Link

A new Eastern City Link CrossRail company would, at a minimum, need to design, build, and operate the new tunnel and Moorgate station. Investors would expect either a guaranteed purchaser of at least 15 trains paths per hour, or a franchise to operate the 15 trains per hour from Shenfield to Amersham or Aylesbury, perhaps also financing some addition parts of the infrastructure including electrification to Aylesbury.

4.5.2 Heathrow - City Express

One possible approach would be for LUL to franchise the existing Circle Line infrastructure for say 20 years. The franchisee would upgrade the track and signalling as necessary and be paid on the basis of delivering reliable train paths and achieving the necessary 34 train paths per hour. The franchisee would also be responsible for building the necessary facilities at Paddington and Moorgate, and building the flyover at Old Oak. Heathrow Express Limited would own and operate the trains, as at present, and would commit to pay the agreed track charges.

Because of the need for Heathrow Express trains to interwork with District, Circle, Metropolitan and Hammersmith & City trains on the same tracks, this arrangement would require these other services also to achieve a rigorous reliability standard.

The only new powers required to complete the scheme relate to construction of the grade-separated connection at Old Oak Common, which is mostly or entirely on existing railway property, as well as some planning permissions for the modifications at Paddington and Moorgate. Neither should present serious difficulties.

4.5.3 Jubilee Extension to Leytonstone

Operation of the scheme depends upon completion of the Jubilee Line Extension. The JLE is projected to operate at a substantial profit, funding for the project is ring-fenced and most of the major construction risks have been transferred to contractors. The largest remaining risks are system integration and operation.

One option to enhance completion of the Jubilee Line Extension and to finance the Leyton Link would be to transfer the entire package, including ring-fenced funding, the existing contracts, and the operation of the entire line to a private group. The cost of the link to Leyton should be affordable out of operating profits. Responsibility for securing powers under Transport & Works Act could be the responsibility of the line franchisee.

4.5.4 Diversion of Hammersmith & City into Bakerloo

The existing Bakerloo Line could be franchised to a private operator, together with the opportunity to promote and build the connection at Paddington and take over the Hammersmith branch. Having completed the new link at Paddington, the operating company could be rewarded with a freehold to the depot at Hammersmith which would become surplus and available for development. With service rationalised, the new two-branch Bakerloo might turn a modest profit which could pay the costs of the improvement.

A new Circle Line depot must be constructed probably in East London. Responsibility for building and operating this should sensibly be assigned to the operators of the Circle Line.

The Slough-Barking services could be provided by a franchised train operating company, paying track charges to Railtrack and the owner or operator of the Circle Line infrastructure.

4.5.5 Diversion of Wimbledon Branch in Central Line

Responsibility for promoting and constructing the necessary works should be the responsibility of the Central Line operator, which could be a franchised company. Completion of the link from Holland Park to Fulham Broadway and the associated works to Wimbledon would probably be a profitable investment for the Central Line company.

4.5.6 Thameslink - Kilburn Link

Responsibility for construction of the Kilburn Link could be given to Railtrack who could finance the necessary infrastructure on the basis of committed train tolls.

4.6 Property Issues

The alternatives suggested are all entirely different in scale and nature to the existing CrossRail proposals. They are unlikely to generate land costs anywhere near those presently budgeted. Property issues identified against each option are:-

Option 2A: Eastern City Link

There is substantial property take required, as in the CrossRail scheme, at the Bethnal Green portal and at Moorgate Station. A new allowance of £20 million is provided.

Option 3A: Heathrow Express

There are no significant property consequences.

Option 4A: Leytonstone Link

Runs across existing railway lands, with some related warehousing effected. Acquisition costs of £5 million are included.

Option 5C: Bakerloo/Hammersmith Link

There may be a disruption to a major redevelopment at Paddington Goods Yard. An allowance of £10 million has been included.

Option 6A: Wimbledon Link

Sub-surface rights are required beneath a dense residential area. Surface works would be entirely on land in railway and associated transportation uses. An allowance of £5 million has been made.

Option 7A: Kilburn Link

This involves taking of about ten houses adjacent to an existing railway viaduct. An allowance of £6 million has been made.

CROSSRAIL

Study of
COST EFFECTIVENESS

5.0
STUDY CONCLUSIONS

Bovis SIR ALEXANDER GIBB & PARTNERS

5.0 CONCLUSIONS

The principal conclusions from this review of the cost effectiveness of the CrossRail project are:

Cost Effectiveness

* The project is well engineered and operationally efficient.

* The provision of stations in the central area is achieved at high cost with a reduction in benefits for an increasing number of stations.

* Moorgate/Liverpool Street and Bond Street stations give positive benefits and form part of the base case.

* Either Tottenham Court Road or Holborn Station should be included in the base case, but not both.

* Paddington and Farringdon stations currently have costs exceeding benefits and are therefore not justified on purely financial or economic terms. However:

    * Paddington has a perceived benefit as a mainline interchange.
    * Farringdon is perceived as a spur to development and an attractive interchange with other services.

    These factors may provide a reasonable case for the inclusion of these stations in the scheme.

* Some cost savings can be achieved through:

    * Reduction of tunnel diameter
    * Standardisation of escalators
    * Deletion of provision for expansion
    * Deletion of provision for expansion in the central area
    * Reduction to a 6 car service

* The alternative northerly alignments show no cost savings and reduced benefits in comparison with the proposed CrossRail route.

* There is no financial or economic advantage in phasing the project.

Economic Evaluation

* The project meets the objectives set out in the Central London Rail Study (CLRS).

* The project could achieve an acceptable benefit:cost ratio for public sector investment. However the project benefit:cost ratio would appear to be too marginal to support joint public-private funding with an acceptable transfer of risk.

* Employment growth in Central London is less than forecast in the CLRS, and demand would not meet the level assumed in 2001 until 2010 at the earliest. This implies that the scheme might be deferred.

Alternative Investment Opportunities

* Options have been identified that could provide alternative investment opportunities and that would achieve some of the CLRS objectives that CrossRail addresses.

* The cost of the options presented in this report fall in a range of £100 million to £300 million.

* These scheme look promising for public -private finance and could be implemented faster than the existing CrossRail scheme.

* Detailed study is required to assess the full cost and implications of the schemes.

CROSSRAIL

Study of
COST EFFECTIVENESS

APPENDIX A

Bovis SIR ALEXANDER GIBB & PARTNERS

APPENDIX A

CROSSRAIL: STUDY OF COST-EFFECTIVENESS TERMS OF REFERENCE

1. Introduction

The Government plans to proceed with CrossRail as a joint venture with the private sector. CrossRail is a new railway across Central London on an East-West Axis with the following objectives:

1.1 To provide direct access to Central London, saving journey time and removing the need for passengers to change.

1.2 To alleviate road and rail transport congestion in and around London.

2. Government's Aims

These are

2.1 To establish CrossRail as a joint venture attractive to the private sector.

2.2 To improve cost-effectiveness of the project and reduce the costs to the public sector.

2.3 To ensure value for money for the public sector contribution.

3. Purpose of the Study

This is to see how best to achieve the Government's aims within the context set by the objectives of the project.

4. Basic Core Railway (BCR)

This is defined as

4.1 A tunnel between Liverpool Street and Paddington.

4.2 Underground stations at Moorgate and Tottenham Court Road.

4.3 A 16 tph x 8 car railway.

The study will also consider whether the government's aims and the objectives of the project could be achieved more effectively by a more northerly alignment between Liverpool Street and Paddington via King's Cross which is advocated by some petitioners. The Study Manager is also free to consider any other route between Liverpool Street and Paddington which in his opinion is likely to compare favourably with the BCR above. The same also applies to different

sites for stations along the existing alignment and different (including lesser) specifications for service frequency and train length.

Safety provisions will only meet minimal statutory requirements and be based on quantified safety criteria. There would be no provision for mobility impaired passengers. Construction methods would only meet minimal environmental standards.

5. Study Approach

5.1 The study will need to define the BCR in greater detail to identify the minimum form in which it would be feasible. The study should then identify all the incremental changes which would be needed to expand the BCR to the current proposals. The study should have regard to the items in the attached note.

5.2 Each element will need to be evaluated on a common basis. It will be important to assess both the effects on CrossRail as a potential Joint Venture project and CrossRail as a contributor to London's transport network, identifying both the effects on direct CrossRail finances and the overall public sector "value for money". Capital and operating cost implications, and revenue effects to the project will therefore need to be identified at the same time as changes in user and non-user benefits and non-CrossRail costs and revenue.

Many elements of the project have already been considered in detail by NSE/LT/LUL and it will be important to draw on this work.

5.3 If additional powers are needed, this should be noted.

6. Study Management

6.1 It is proposed that the Department will appoint a Study Manager who will take full responsibility for the report and recommendations.

6.2 The Study manager should recommend the final form of the project including the additional project elements, indicating those elements which are to be privately funded and those which are not. Any recommended items which are not consistent with the powers contained in the Bill should be identified at an early stage.

6.3 The Study Manager will report to a Steering Group led by the Department of Transport with representatives of the Treasury, LT/LUL and NSE.

6.4 The report should be completed by [date to be agreed with the Study Manager].

CROSSRAIL

Study of
COST EFFECTIVENESS

APPENDIX B

Bovis SIR ALEXANDER GIBB & PARTNERS

APPENDIX B

REPRESENTATIONS RECEIVED

Letters and reports from the following organisations were received.

Steer Davies Gleave J K Steer	23.11.93
Aylesbury Vale District Council B J Quoroll Chief Executive	1.12.93
Newham Council Edwin Doyle Director of Technical Services	1.12.93
Corporation of London Colin Snowden City Engineer	2.12.93
Buckinghamshire County Council Roger Slevin County Passenger Transport Officer	2.12.93
Three Rivers District Council Peter Brooker director of Planning & Engineering	2.12.93
Residents Association of Mayfair Sir Michael Clapham	6.12.93
Winbourne Martin French N J Winbourne	13.12.93
Travel Contacts Colin Murison Small	31.12.93

CROSSRAIL

Study of
COST EFFECTIVENESS

APPENDIX C

Bovis SIR ALEXANDER GIBB & PARTNERS

APPENDIX C

A. PROVIDED BY THE DEPARTMENT OF TRANSPORT

1. Central London Rail Study (CLRS) - report, published in January 1989, identifying two alternative major investment packages involving new railway lines across London as worthy of further evaluation.

2. "CLRS - a Report on Further Work" - report, produced in March 1990, on results of further evaluation recommended by CLRS, concluding that "there is a reasonably strong argument for East-West CrossRail being the first line to be built".

3. CrossRail Steering Group Paper CSG/9 - see below.

4. DOT Press Notice No. 363 - announcement, made on 9 October 1990, that the Secretary of State for Transport had given CrossRail the "go-ahead".

5. Publicity Material - brochure and three leaflets produced by the LUL/BR project team, giving details of route, journey times, etc. -Revised September 1993.

6. CrossRail Bill - deposited in Parliament on 27 November 1991.

7. CrossRail Bill Additional Provision - deposited in Parliament on 25 January 1993.

8. "CrossRail - Audit of Estimated Cost" - report by Scott Wilson Kirkpatrick et al (cost auditors), October 1992, including Performance Specification agreed by DOT and LUL/BR on 15 May 1992 - 3 Volumes.

9. "Options for Cost Reduction" - report produced by cost auditors and submitted to DOT on 25 February 1993.

10. Notes of four meetings ("Mr Skinner's Group") held to discuss detailed cost questions arising from the cost audit on 15 December 1992, 26 January 1993, 29 January 1993 and 16 February 1993.

11. Nine papers prepared for a CrossRail Steering Group, set up to discuss wider questions raised by the cost audit:

    - CSG/2: CrossRail Loading Gauge (note by the Department of Transport).

    - CSG/3: The Client Role in Development of the CrossRail Project (paper by LUL and NSE).

    - CSG/4: Pattern of Services (paper by LUL and NSE).

- CSG/5: Marylebone Station (paper by NSE).
- CSG/6: Running Tunnel Structure Gauge (paper by LUL and NSE).
- CSG/7: Opportunities for Private Finance in CrossRail (paper by Managing Director LUL).
- CSG/8: Report on Detailed Cost Questions by Mr Skinner's Group (including a report on risk by the cost auditors).
- CSG/9: Reappraisal of CrossRail at Lower levels of Demand (note by the Department of transport/Her Majesty's Treasury/LT/NSE).
- CSG/10: CrossRail: Impact on Privatisation (note by Department of Transport).

12. "CrossRail: Income Allocation and Revenue Protection" - note produced on 22 February 1993 by Director, Planning & Marketing, NSE.

13. Note of first (and only) meeting of CrossRail Steering Group held on 14 January 1993.

14. "CrossRail Property Costs: Private Sector Funding - Summary" - paper produced by LT Property in January 1993, describing the CrossRail route in development of the sites above stations.

15. "CrossRail - A Joint Venture - Report on Re-examination" - report by Bechtel and Warburg, 4 May 1993 - 2 Volumes.

16. Note of meeting to discuss CrossRail risk management procedures, held on 14 July 1993.

17. Mr Stevens' letter of 14 July 1993 to Mr Rutnam, Treasury.

18. Mr Rutnam's reply to Mr Stevens dated 21 July 1993.

19. Letter of 2 July 1993 from Nick Montagu (DOT) to Steve Robson (HMT) covering, amongst other things:

    - "Involving the Private Sector in CrossRail" (discussion note by the Department of Transport).
    - HM Treasury guidance on private finance.
    - "CrossRail Joint Venture - Some Initial Thoughts" (discussion note by LT).

20. Note of meeting held on 7 July 1993 to discuss way to proceed on CrossRail.

21. "CrossRail Financing Review - Cost Effectiveness Study - Report by the Railway Operators October 1993" (Copies Nos. 17, 18, 19 and 20) - report produced according to Terms of Reference agreed by DOT and operators on 15 July 1993.

22. Operators' reports on cost reduction proposals - 23 papers.

23. "CrossRail Cost-Effectiveness Study: Operators' Stage II Work" - notes describing Stage II work by DOT/PTLB and the LT/LUL/NSE CrossRail Client Function.

B. PROVIDED BY CROSSRAIL

1. Social Benefits & Quality Enhancements - LJC/25 November 1993.

2. Existing British rail Electrification in London Area Map - Scott Wilson Kirkpatrick October 1992.

3. CrossRail cost summary April 1993.

4. CrossRail (Additional Provision) Amendments -House of Commons Session 1992-93.

5. CrossRail Bill Committee's "Minutes of Evidence".

6. Environmental Statement & Addendum - November 1991 LUL/BRB.

7. London Jobs 1997, Employment forecast in April 1988 LUL.

8. East London Line Extensions - February 1992.

9. CrossRail Low Demand Tests.

10. London Transport Line Loadings - LT Planning 26 November.

11. CrossRail presentation brochure - "Budgets and Cost Control" CrossRail Project Team 30 November 1993.

12. CrossRail Plans and Programmes from above.

13. CrossRail Railway Operators Study - Stage 2. Progress report 3 December 1993.

14. Summary of train service frequencies.

15. CLRS Annualisation (peak period to annual) factors for evaluation.

16. CrossRail Cost Effectiveness Study Report by The Railway Operators: Stage 2.

C. PROVIDED BY OTHERS

1. Letter to M McDonald from City of Westminster -19 November 1993.

2. CrossRail - A regional transit system concept -UTDC INC 90.01.05.

3. New Rail Projects in Westminster - City of Westminster.

4. AC compared with AC/DC Electrification - P Riley 13 February 1993.

5. CrossRail Bill Draft Proof of Evidence - Steer Davies Gleave November 1993.

6. Norman Winbourne article in Estates Gazette 6 November 1993.

7. CrossRail Case for the Alternative Route September 1993 - Residents of Association of Mayfair.

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APPENDIX D

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APPENDIX H

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CROSSRAIL - TUNNELING ISSUES

1. GENERAL

Bovis Engineering Limited Several of the alignment options considered in the Crossrail Cost Effectiveness Study contain tunnel portions. The purpose of this preliminary tunnel study is to prove the feasibility of tunnel construction and to provide a basis for a rough cost estimate.

The tunnel study will concentrate on the issues which are not standard practice in London Underground construction, which are:

- Narrow track alignments (horizontal and vertical)
- Tunnel driving through existing deep piles
- Junctions with existing tunnels.

Some of the issues are similar for several alignment options, others are valid for one particular location only. Due to the early stage of the study firm alignments of the various options are not available and the issues have therefore been generalized. Nevertheless, it is assumed that no major changes to the overall approach will occur when the findings are applied to the final geometric layouts.

Exact subsurface conditions are not known, however, we understand that all tunnel works will be situated in London Clay. This encourages the application of the New Austrian Tunnelling Method (NATM), which is now used at the Jubilee Line and has also been considered for the original Crossrail Scheme.

2. MULTIPLE TUNNELS WITH NARROW SPACING

2.1. Options for Cross Sections

The conditions pertaining requires the arrangement of tracks very close to each other. These may be arranged side by side or on top of each other. Such situtations are typical for subway construction and have led to various solutions in the past.

Looking at the tunnels placed side by side the following approaches have been used·

• Soil pillar solution;
As long as the running tunnels are a reasonable distance apart, the tunnels are excavated and supported separately. The reduction of the thickness in soil pillar is compensated by additional strength of the primary and final lining and sometimes soil improvement or reinforcement measures in the pillar zone.

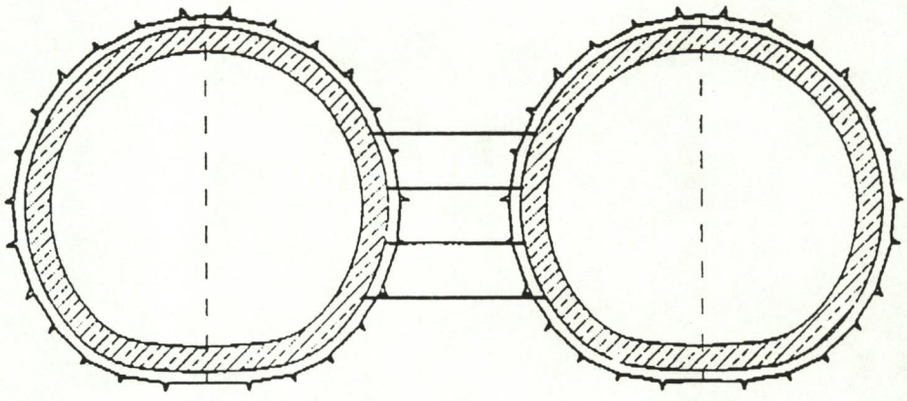


fig.1: soil pillar solution of tunnels placed side by side

• Concrete pillar solution:
When the tunnels come very close, it is better to replace the soil pillar by concrete. This is done by construction of a small central tunnel and placing cast concrete for the pillar. The subsequent steps are excavation of the running tunnels (stepped or synchonous) with primary support und following inner concrete lining.

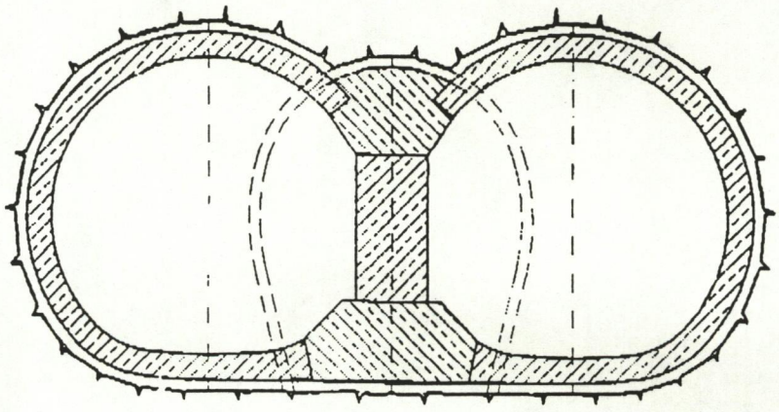


fig.2: Tunnels side by side with pillar tunnel

• Solution with touching linings:
In this approach the first tunnel is excavated and supported by primary and final lining. The second tunnel is then excavated directly beside the completed lining and proper structural connections of the linings are produced. An alternative to this solution is the completion of the primary linings in both tunnels, which requires the first shotcrete lining to receive more thickness and reinforcement in the pillar zone.

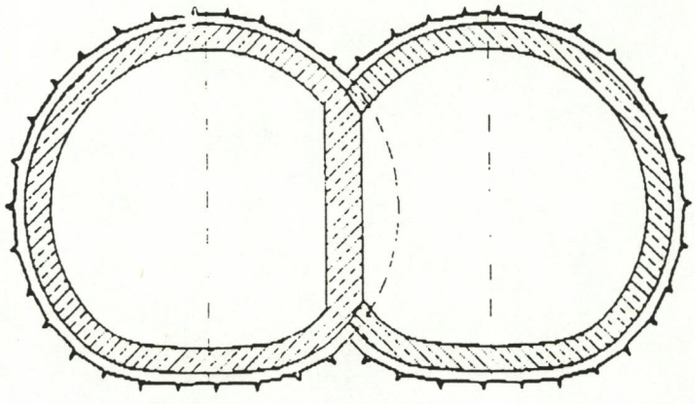


fig.3: Touching linings / inner lining in first tunnel completed when second tunnel is built

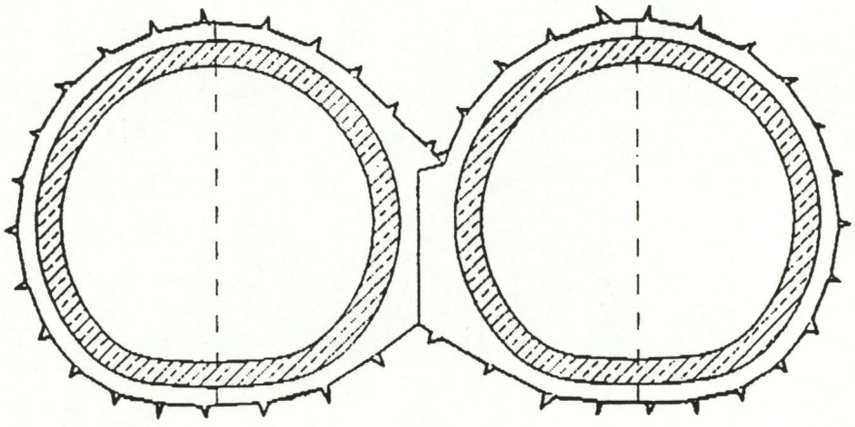


fig.4: Touching linings / primary lining in first tunnel completed when second tunnel is built

• Single tube solution:
Where the tracks come very close the clearence profile does not allow two single tunnels to be constructed. In this case one single tube is built. Although this does save construction material, the greater width and reduced stiffness of this solution is disadvantegeaous with respect to limitation of surface settlements.

Tunnels have been built one above the other. Similar to the side by side case different methods have been applied in various designs. The difference is mainly limited to the question of whether there is a direct structural connection between the inner linings or the primary linings are built to touch each other without structural connection. The latter solution is shown in fig.5.

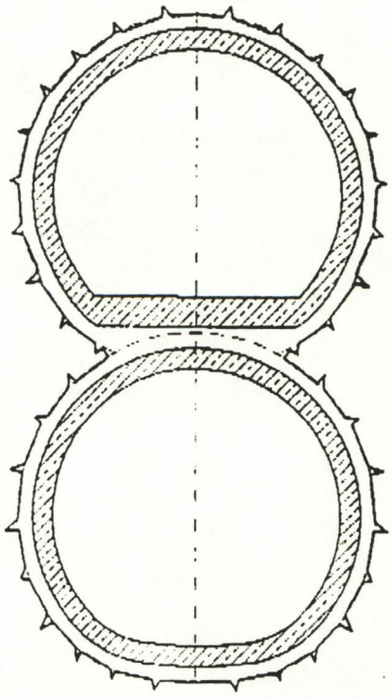


fig.5: tunnels one above the other without structural connection (inner lining not shown)

All the examples shown before are based on separate tubes. Naturally single tubes containing two tracks can be considered also both for the tracks located side by side or on top of each other. The space to be gained is not very much compared to the twin single tubes, however it may be considerably easier and more economic to built in areas where settlements are not so critical.

2.2. Particular Issues to Consider

• Phasing of Excavations, Settlement Control

Since settlement control is a main concern in urban tunnelling, the sequences of excavation have generally to be adapted to minimise settlements. This requires:

- short distances for ring closure within the individual excavations,
- subdivision of larger cross sections,
- sufficient distance between the ring closure of the first tunnel and the excavation of the neighbouring tunnel. The benefit of this measure was for example shown in trials made at the subway construction in Munich (fig.6).

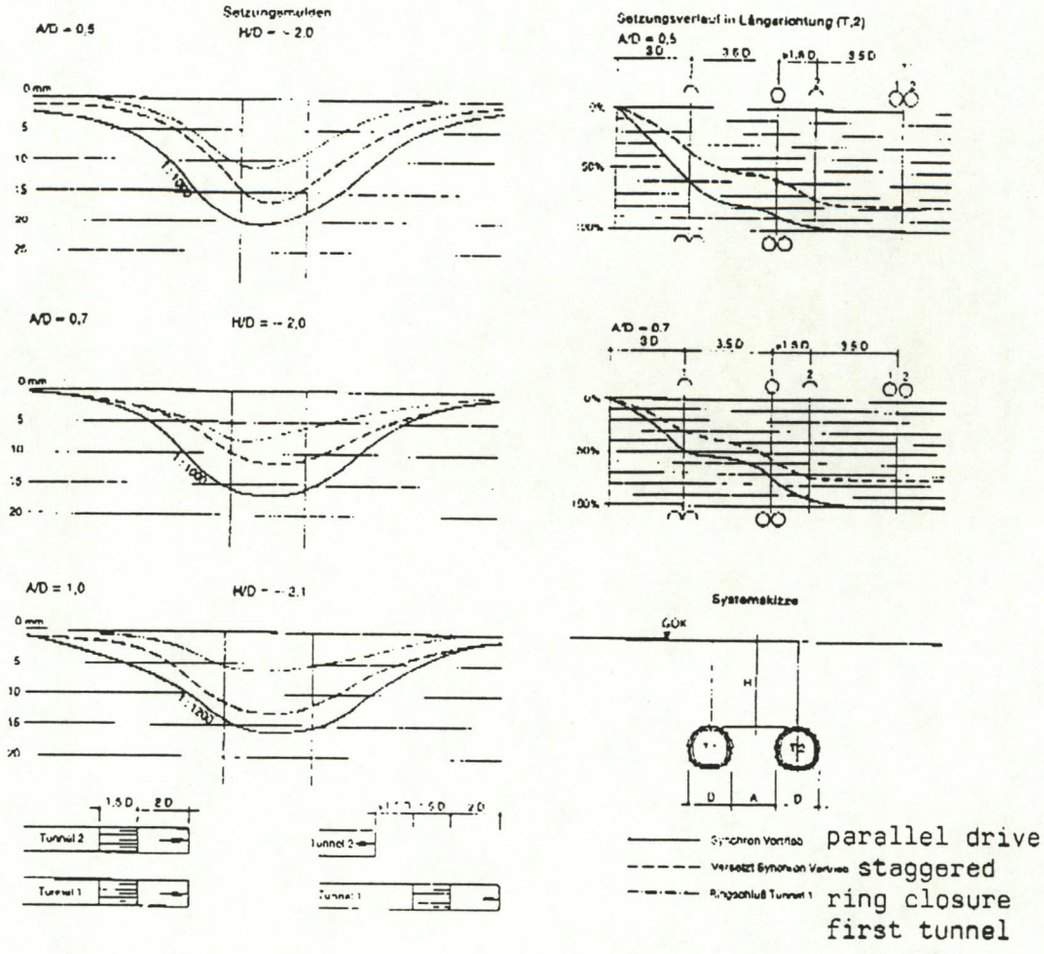


fig.6: Surface settlement trough of parallel and staged construction

- Waterproofing

  In case the tunnels are built in permeable ground with a groundwater table and a waterproofing membrane is considered greatest care is necessary with respect to the connection details of the membrane. Also, other possibilities have frequently been used, like watertight concrete linings instead of the membrane.

3. TUNNEL DRIVING THROUGH EXISTING DEEP PILES

3.1. Problem Identification

A tunnel shall be driven through ground where deep concrete piles exist supporting building foundations. The diameter, type and number of piles is presently unknown.
Undermining such foundations causes mainly two problems to consider:

- first settlements will be introduced by the tunnel construction and will require compensating measures,
- second the loads in the piles need to be transferred to other structural member.

3.2. Actual Procedure Performed at Metro Munich

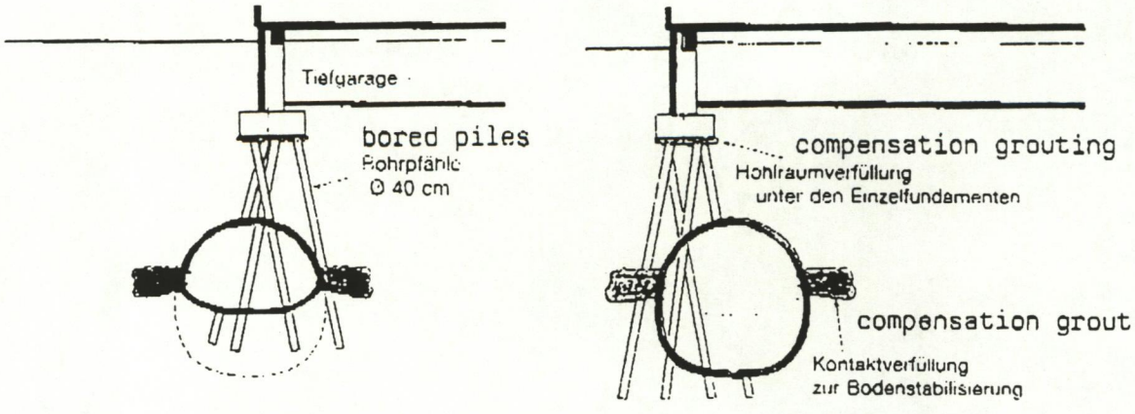
A similar situation was encountered at the line 5/9 in Munich where a tunnel had to be driven through foundation piles beneath a large building. In the area of the piles the tunnel lining was designed to carry the pile loads in addition to the normal lining loads.

The construction was performed in the following steps:

- Grouting of any void spaces directly beneath the single foundations,
- Excavation of top heading: when a pile in the face of the tunnel was encountered, a recess was cut into the pile in the level of the tunnel lining. Into this recess a fairly heavy steel arch was placed in a way to transfer pile loads into the beam. Then excavation was continued around the pile and another recess and steel arch placed on the backside of the pile. To create the minimum necessary space to proceed the tunnel excavation with small equipment some piles were cut in the top heading already. Then bench excavation and ring closure of the primary shotcrete lining was done. The remaining piles were cut after completion of the ring closure.

Sections of this situation and a photo of the tunnel in the top heading stage are shown in fig. 7.

U-Bahn-Linie 5/9
Baulos 14.2
Bahnhof Böhmerwaldplatz mit Streckentunneln



top heading with piles
Kalotte mit Bohrpfählen

full section with piles
Vollquerschnitt mit Bohrpfählen

Bohrpfähle in der Kalotte piles in top heading

fig.7: Tunnelling through piles at lot 5/9 in Munich

4. JUNCTION CONSTRUCTION AT EXISTING RUNNING TUNNEL

It is assumed that the junction is constructed under maintenance of the operation in the existing tunnel with minimum interruptions. The conventional design used in London clay is using segmental lining. Due to the variable geometries involved the use of NATM appears very attractive in this context. The two options are shortly described in the following text with emphasis on the NATM solution.

4.1. Segmental LIning

The segmental lining solution is based on a stepwise enlargement of the cross section in the junction area. Naturally, the section remains always circular in shape which causes very large excavation volumes without permanent use of it. Since the procedure is well known in London no furthers details need to be outlined in this context.

4.2. NATM Solution

The NATM solution allows to consider more flexible geometries than the segmental lining solution. In the relatively dry environment of the London clay formation it is recommendable to use the so-called "single lining" approach for this section. This approach is avoiding the normal cast in-situ concrete inner lining by installing a thicker shotcrete lining of sufficient strength and durability to fulfil permanent requirements.

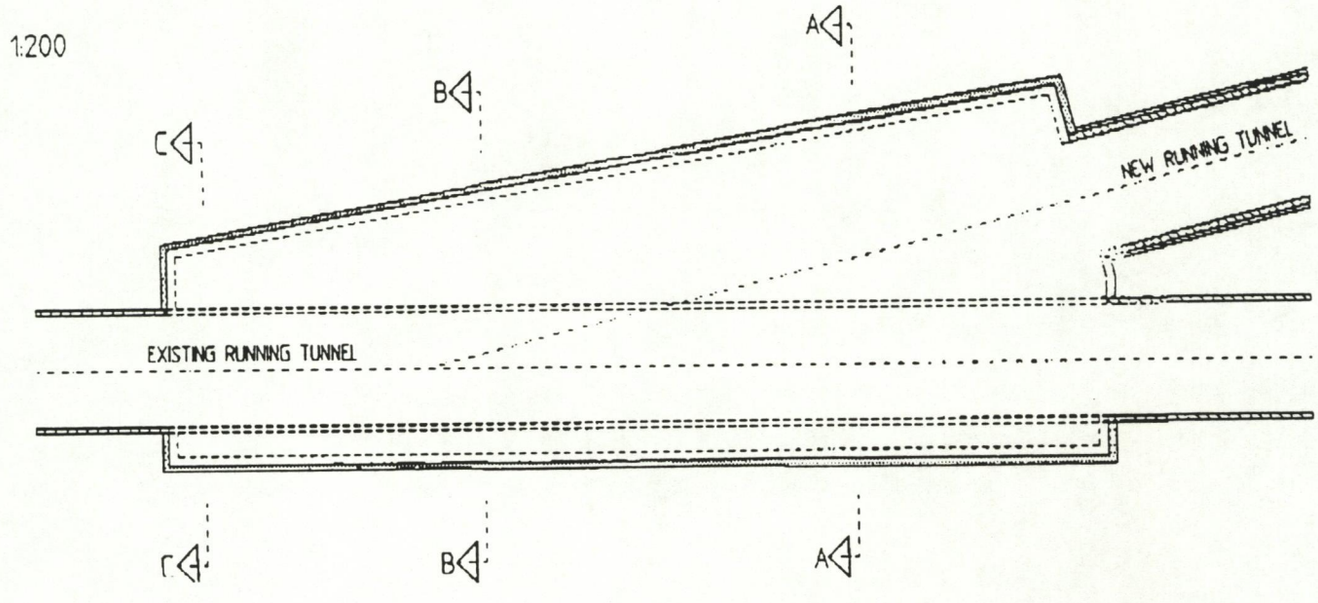


fig. 8: Junction plan with continuously changing geometry

This method is perfectly flexible in the choice of geometries and more appropriate to use in the extremely confined conditions around the existing running tunnel tube. In this case the cross section can be continuously widened (fig.8).
The construction sequence of the junction is shown in 3 different sections (fig. 9 through fig. 11). Coming with the excavation from the new running tunnel, the cross section of the junction needs to be divided into several smaller excavation phases. In the wide part of the junction a temporary shotcrete wall close to the existing segment lined tunnel is required to control the settlements. This part is constructed in a short sequence of top heading, bench and invert closure. This procedure can be maintained to approximately two thirds of the junction length, when this side gallery needs to be terminated for reasons of space. Subsequently the main top heading is excavated and supported on top of the existing running tunnel over the full length of the junction.

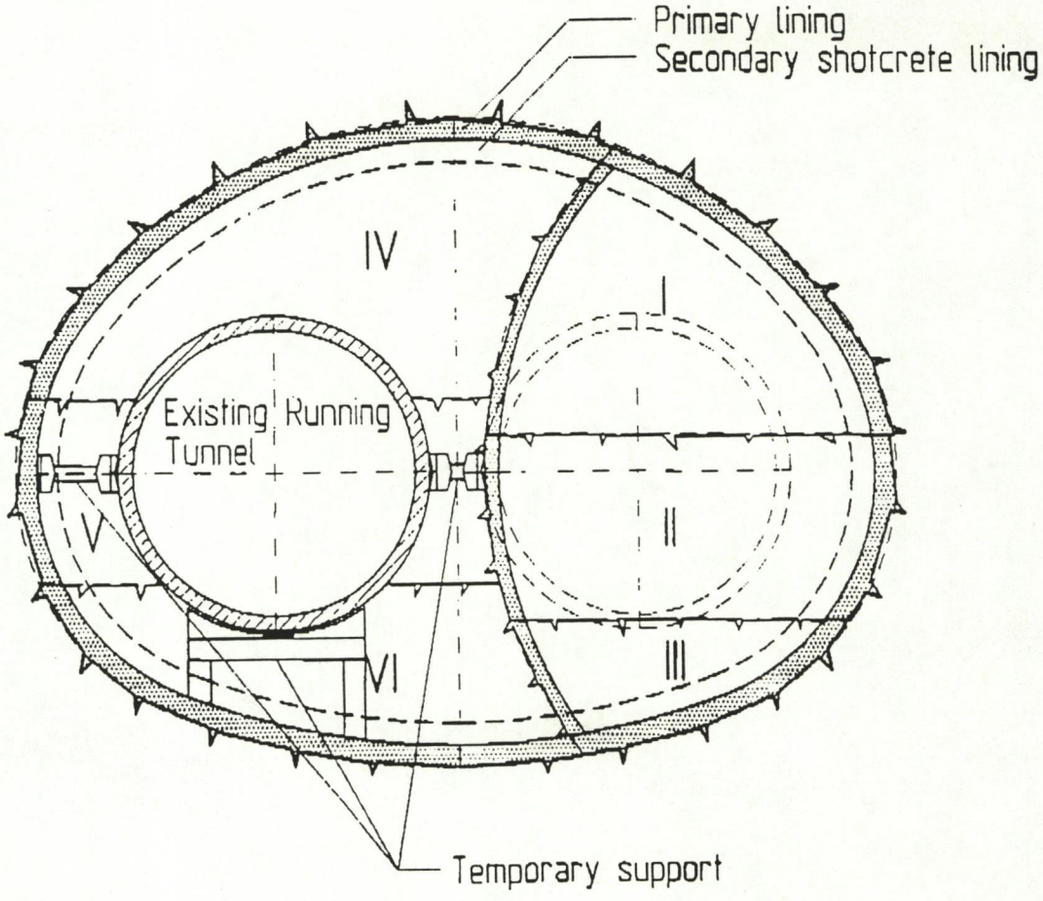


fig.9: Section A-A with construction stages I to VI

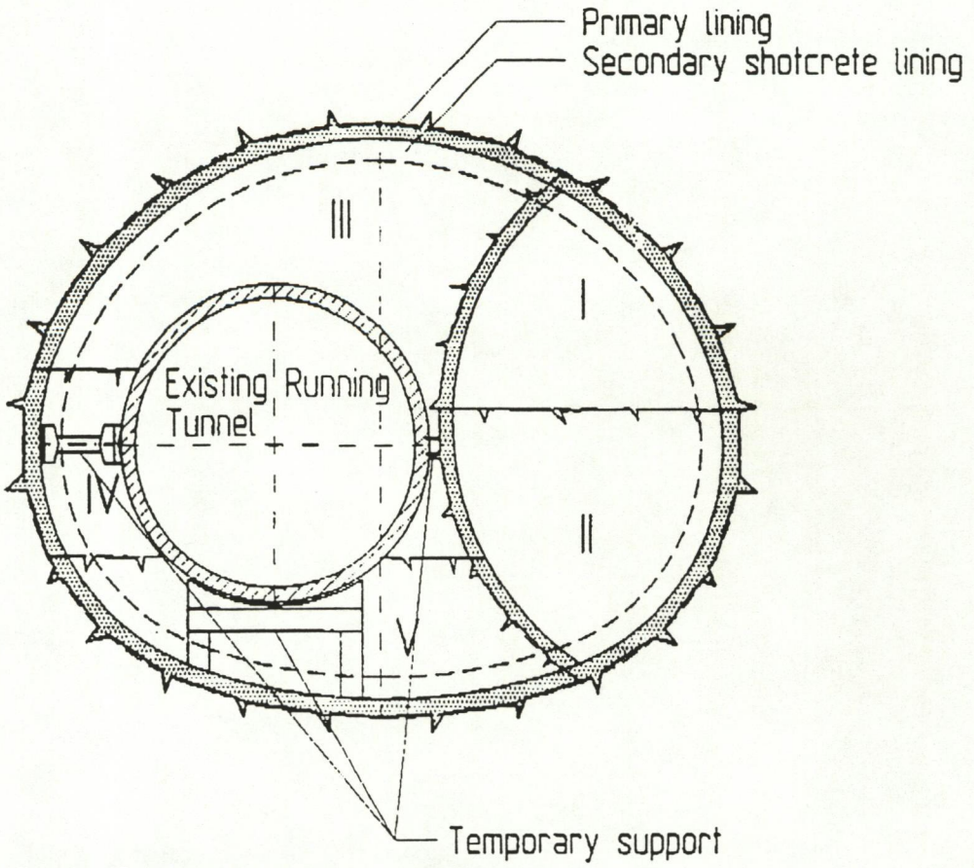


fig.10: Section B-B with construction stages I to V

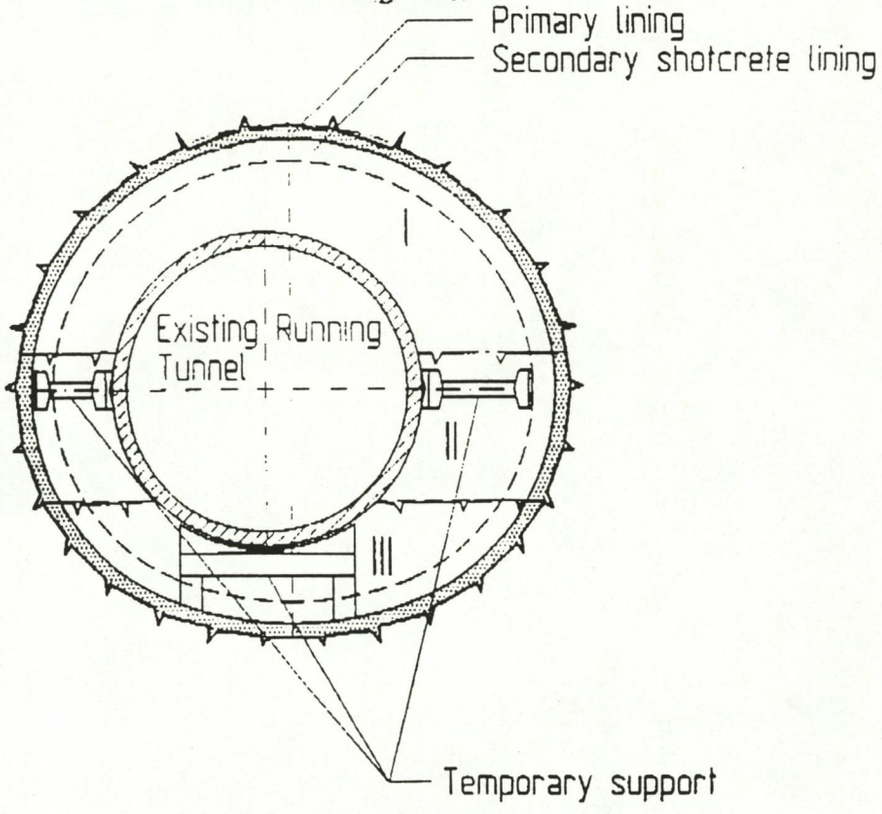


fig.11: Section C-C with construction stages

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APPENDIX I

Technical Evaluation of Alternative Investment Opportunities

This section describes the evaluation of key engineering and operational issues for each of the schemes described.

Many of the issues highlighted will require further attention and resolution. In the timescale of the study, full technical evaluation has not been possible. Much essential background data has not been to hand in the assessment and it has been necessary to make suitable assumptions in order to confirm initial feasibility.

I.1 Eastern City Link

I.1.1 Engineering Issues

To combine the existing Amersham to Aldgate and Shenfield to Liverpool Street services requires major infrastructure works to connect the routes:

i) Construct the Bethnal Green to Liverpool Street portion of the present CrossRail proposals, including the tunnel portal near Bethnal Green and Liverpool Street station. It is assumed that these details remain unchanged.

ii) Design and construct a new railway alignment to bring the deep tunnel bores from Liverpool Street to a sub-surface alignment, connecting with the existing Circle/Metropolitan Lines between Barbican and Farringdon. The latter would require remodelling.

I.1.2 Alignment Design

Design of the Metropolitan Line junction and ramp down to the bored tunnels is complex in the area between Barbican and Farringdon, and has not yet been developed to the point where a firm design proposal can be demonstrated.

In this vicinity, the existing Circle/Metropolitan Lines and City Widened Lines run at subsurface level beneath the Barbican Development and the proposed CrossRail tunnels are located directly beneath. The profusion of pile foundations is likely to dictate that with this alternative scheme the bored tunnels would need to rise beneath the present sub-surface lines providing a known route and minimising the risk to existing structures, but also implying some loss of the present infrastructure - notably Barbican Thameslink platforms.

I.1.3 Operational Issues

Rolling Stock

The existing services are operated separately by BR and LUL. Their combination into one through service would pose technical and operational interface issues which would require resolution.

Present incompatibility exists in the following areas:

* *Signalling systems*: at present LUL operates stock with 'trainstop' automatic train protection (ATP), whilst BR utilises multiple-aspect signalling with automatic warning systems (AWS).

* *Traction supply*: LUL stock operates on a four rail 630 V dc system, whereas the present BR Great Eastern services into Liverpool Street are electrified with the 25kV ac overhead system.

* *Dimensional*: the two systems are presently designed to accommodate different structure gauges. Existing Metropolitan Line trains comprise 8 x 17 metre long cars, and stock designed for through running will need to be accommodated within present clearance restrictions and platform lengths on that line if major infrastructure alteration is to be avoided. Lengthening of platforms between Baker Street and Moorgate is not regarded as practicable.

  Station platforms are a particular difference, in both lateral clearances provided and heights above rail level. Present LUL platforms are marginally higher than their BR equivalent although compromise heights are acceptable which should allow for sufficient compatibility without infringing stepping distance requirements.

* *Permissible weights/axle loadings*: In general LUL rolling stock is of a lighter construction with lower axle loadings than that of BR trains. As a consequence, the infrastructure is also constructed to standards which will limit acceptable axle loads if major infrastructure renewal is to be avoided.

* *Operating systems*: The present Metropolitan Line system of one-person operation will need to be compatible with operating methods and regulations on the existing Great Eastern route to Shenfield.

None of the above operational differences create insurmountable difficulties. A new fleet of dual voltage trains would be required to operate a through service and the stock would need to be designed to be accommodated within both of the present systems.

I.1.4 Safety Issues - Compatibility of Rolling Stock

An important issue of principle is the compatability of mixed types of rolling stock operating on shared tracks. Although extensive interworking of LUL surface stock and BR stock currently exists to the north of Harrow, it cannot be assumed that present approval would extend to new situations.

The new fleet of rolling stock and existing trains should have the following compatabilities:

* Crash loadings.
* Train evacuation in emergencies, especially in tunnels.
* Train "rescue" by a following service, in the event of train failure.

I.1.5 Route Capacity

Concern has been expressed that the restricted train length/car configuration, the latter to provide sufficient rapid loading/unloading at station stops, will be a major disadvantage in the provision of capacity at the Shenfield-Liverpool Street end of the route, on which 8 x 20m car trains presently operate. In effect, the existing Great Eastern route would suffer a reduction in capacity.

This may create the need to continue to operate some services into Liverpool Street, with a possible requirement for a grade separated junction at Bethnal Green. This issue requires further study.

I.1.6 Infrastructure Requirements

In order to support such a new service, a strategy for berthing and servicing the new fleet of rolling stock would be required. It has been assumed that this could be developed utilising the space/facilities vacated by the existing stock (LUL and BR) which would become displaced.

I.2 Heathrow City Express

This scheme provides for the extension of all proposed Heathrow Services through to a dedicated terminal at Moorgate via the existing Circle/Metropolitan Line tracks.

I.2.1. Engineering Issues

Engineering issues are considered to be less complex than operational ones.

Rolling stock for the service would need to be dual voltage to operate on both the 25kV a.c. overhead system west of Paddington (to be installed as part of Heathrow Express) and the existing LUL four-rail d.c. system from Paddington to Moorgate.

At both Paddington and Moorgate, station alterations would be required to provide the required terminal facilities; in the latter case, the station layout will need to accommodate train reversing/berthing.

A scheme will be required to permit the Heathrow Express services to cross from the fast lines to the slow lines approaching Paddington. In the "up" direction a new length of connecting chord can be provided "at grade", on which the electrical changeover could be effected.

"Down" services travelling west towards Heathrow will require to be grade separated. It has been suggested that the existing Hammersmith and City Line underpass between Royal Oak and Westbourne Park could be utilised for this purpose, taking a new connection from this route via existing railway lands to the Down Fast line of the Great Western Main Line.

Such a junction would be located on a sharply curved alignment west of Westbourne Park LUL platforms.

Should this scheme be considered in combination with reconfiguration of the Hammersmith branch route to become a second branch of the Bakerloo Line (see section 4.3.4), there would be an issue associated with working mixed BR and tube gauge LUL rolling stock.

I.2.2 Operational Issues

This scheme will require interworking of non-stop Heathrow Express services between Moorgate and Paddington with present Circle and Metropolitan Line trains which call at all intermediate stations.

The route is already heavily utilised and the presence of a number of at-grade junctions makes service reliability and train regulation very susceptible to delay and disruption. This option actually introduces an additional conflicting movement when terminating Heathrow Express services make an at-grade crossing of the Circle Line tracks to access the terminal platforms at Moorgate.

It is therefore assumed necessary to convert the northern portion of this route, along with all stock using it, to operate with cab signalling rather than the present fixed block arrangement. This could alleviate route capacity problems and permit higher service frequencies with reduced headways.

Modelling of the proposed operation of this route with cab signalling, at grade junctions introducing conflicting movements and a new service pattern of mixed stopping/non-stop services would be required to demonstrate its feasibility.

It may be necessary to consider other methods of reducing the number of existing paths along the Circle Line.

The costs of this option have taken into account the proposed resignalling of the northern half of the Circle Line and cab provision in all rolling stock which would use the route.

I.2.3. Compatibility of Rolling Stock

The introduction of new designs of rolling stock again raises the question of potential incompatibility between services. However, the requirement to replace present designs for the Heathrow Express stock may give the opportunity to adapt it for such interworking so as to be acceptable to the Railway Inspectorate.

Consideration will also need to be given to the combination of train length and platform configuration along the Circle Line route between Moorgate and Paddington.

Although it is not proposed to stop Heathrow Express services at intermediate stations, emergency evacuation of these trains at any platform will probably be required. The trains must therefore be compatible with the present platforms.

I.3 Jubilee Extension to Leytonstone

I.3.1 Engineering Issues

The objective of this scheme is outlined in Section 4.2.3.

In order to connect the Jubilee Line Extension into the present alignment of the Central Line in the vicinity of Leyton, a short length of new railway will be required, necessitating some modification to the present JLE design of the low-level Stratford station.

I.3.2 Alignment Design

Consideration was initially given to a surface or sub-surface level extension to the Jubilee Line, extending beyond the proposed buffer stop location "at-grade" to pass beneath the existing BR tracks east of Stratford station and parallel with the present BR North London Line alignment. A crossing of the latter would then be required on sharp curvature and steep gradient, to permit the two new Jubilee Line tracks to cross the Stratford railway land, passing below the BR Lea Valley lines to make a junction with the existing LUL Central Line to the west of Leyton station. Such an alignment would be far from desirable and its construction would be in difficult ground and disruptive to existing BR routes at Shenfield.

An alternative "high level" alignment was therefore developed to reduce conflict with existing BR routes and the possible alignment of the Channel Tunnel Rail Link through Stratford, and to significantly reduce disruption during construction.

This route diverges from the proposed alignment of the Jubilee Line Extension immediately north of the A11 overbridge, to rise on elevated structure to cross the North London Line and the main BR Stratford station with a minimum 7 metres rail to rail level clearance. This structure could be built on the level and wide enough to permit the provision of new high level Jubilee Line platforms.

To the north of the station, the route descends, again on elevated structure, to run parallel with the Lea Valley lines towards Temple Mills, where a grade separated junction with the Central Line would be constructed. This takes advantage of the existing ramp down to the tunnel portal but in order to avoid property impacts it is anticipated that the Central Line would require localised realignment at the portal.

The key features of this scheme would therefore be:-

* New route length of approximately 1.7km.

* Steeply graded approaches to a high level station

* Extensive elevated structure (approximately 600 metres in length), including high level platforms over the existing station

* Alteration to the current design for the JLE low level terminal at Stratford

* Limited disruption to BR services to/from Liverpool Street during construction

* Grade separated junction with the Central Line west of Leyton, involving localised realignment and reconstruction of the range to the existing tunnel portal.

At this stage only an outline design has been produced to demonstrate the concept of this route option. In addition to a more detailed evaluation, consideration needs to be given to the interface between the railway and the proposed A102(M) link road to the M11 which runs immediately north of the present railway corridor between Temple Mills and Leyton.

I.3.3 Operational Issues

Diversion of the Epping branch services via the Jubilee line would reduce Central Line service levels and leave westbound services under capacity for the demand. This can be resolved by restoring the 30 tph service from Leyton or Stratford, with the extra services either commencing from a reversing facility at Leyton station or on the surface between Leyton and Stratford. One possible option would be to incorporate a reversing siding at a remodelled and reconstructed tunnel portal near Temple Mills.

That layout still requires to be proven, but it would remove any requirement for adding extra tracks through the Leyton to Leytonstone corridor. Its disadvantage would be that these two stations would be restricted to a 15 tph the Central Line service.

If required, a reversing facility for JLE services could be included with the route option described above with no difficulty and minimal additional landtake.

I.3.4 Rolling Stock Requirements

It is assumed that the new Central Line rolling stock cannot be transferred to operate services on the Jubilee Line. Additional Jubilee Line stock would therefore need to be obtained to operate the revised service.

I.3.5 Signalling and Control

It would be necessary to ensure that signalling systems for the two lines are capable of operating together on the shared section of route between Temple Mills and Leytonstone. This requires further study.

I.3.6 Station Provision

A high level Jubilee Line station provided under this option would alter the design for the JLE station, possibly requiring its reconstruction. In this instance there could be a period during which the Jubilee Line could not serve Stratford whilst the high level alignment was under construction.

I.4 Hammersmith & City into Bakerloo/Slough to Barking Services via Circle Line

One of the CrossRail objectives of improving through services from the west to the City can still be achieved by utilising the Circle/Metropolitan Line route. Suburban services which services currently terminate at Paddington would run through via existing tracks to Barking on paths released by the present Hammersmith services which could be diverted onto the Bakerloo Line.

I.4.1 Engineering Issues - Hammersmith/Bakerloo Connection

In developing a connection between the existing Hammersmith and City and Bakerloo Line tubes, the aim was to achieve a grade separated junction north of Paddington (Bakerloo) platforms, thus facilitating service to the existing Bakerloo station.

Detailed horizontal and vertical alignments of the Bakerloo tunnels have not been obtained, and the outline feasibility of the scheme has therefore been developed on the basis of estimated line and levels. Review of the design concept would be a priority once detailed alignment data becomes available.

I.4.2 Alignment Design

North-west of the present Bakerloo platforms and crossover it is proposed to locate a step-plate junction to each separate tunnel bore, from which the new chord lines diverge. In a northbound direction the new chord line rises at a gradient of approximately 1 in 40, initially in bored tunnel and then in cut and cover tunnel, to ground level in the old railway goods yard north of Paddington Station. Although a sharp curvature will be required, this would be no greater than that currently existing on the Bakerloo alignment through Paddington.

The southbound alignment ramps down to a cut and cover tunnel portal also within the old railway goods yard. Entering bored tunnel, the falling gradient is continued further to bring the new alignment beneath both of the existing Bakerloo tunnels, beyond which the alignment curves sharply and rises to make its junction with the southbound Bakerloo tunnel.

Beyond the point at which the new lines gain the surface, a new railway formation can be built to connect into the present Hammersmith branch alignment on the Paddington side of Royal Oak station thus continuing to serve this station.

I.4.3 Alterations to Existing Stations

Conversion of the Hammersmith branch to operation with tube stock will require alterations at each station platform between Royal Oak and Hammersmith.

For tube railways the required platform height is 330mm less than that for sub-surface gauge railways. This reduction could be achieved by lifting the existing tracks rather than platform lowering, although overhead clearances would need to be checked. This applies especially if empty stock working of sub-surface gauge trains were to continue via the branch to Hammersmith (See following comments on Operational Issues).

There will also be a requirement to lengthen each platform since present Bakerloo Line trains are longer than the Hammersmith branch trains. At Hammersmith this is likely to require associated permanent way remodelling.

I.4.4 Operational Issues

Reconfiguration of Hammersmith and City services as described poses a number of operational issues, the primary one being that of depot provision.

Hammersmith Depot is currently the main servicing facility for sub-surface stock operating both the Hammersmith and Circle Line services. Assuming that a connection is maintained at Royal Oak/Paddington it is believed that this arrangement could be maintained, although it must be anticipated that some longer stabling sidings will be required for tube stock at Hammersmith, thus reducing capacity for sub-surface trains.

The proposed train service of 20 trains per hour split between the two "branches" of the Bakerloo Line means that additional rolling stock would not be required to operate the revised service, and current maintenance facilities for the tube stock fleet could remain unaltered.

Interworking of Tube/Sub-Surface Rolling Stock

The compatability of rolling stock types is again an issue, in this instance between LUL tube and subsurface trains.

In the option described, sub-surface stock would run as empty stock to/from the depot at Hammersmith, but it could still be interworking with passenger carrying tube stock.

As with other options, this is an issue which would need resolution. If it were not deemed to be sustainable, Hammersmith Depot would become redundant whilst alternative Circle Line rolling stock facilities would need to be established elsewhere.

I.4.5 Capacity at Elephant and Castle

With a 20 train per hour service, platform capacity at Elephant and Castle is not thought to be an operating problem.

I.4.6 Slough-Barking Services

Extension of the existing suburban commuter services from Slough via the Circle Line and Hammersmith and City line to Barking would provide a through service to the City from the west without requiring interchange.

The engineering required to provide this new through service is straightforward. At one time suburban services were able to work through four platforms at Paddington station to gain access to the Hammersmith/Circle sub-surface tracks. This access could be simply reinstated at little cost or disruption, requiring only some platform modification and track remodelling/resignalling. At-grade connections with the BR slow lines are assumed.

It is also assumed that electrification of the Great Western Main Line slow tracks (provided by the Heathrow Express Scheme to Airport Junction, Hayes) would be extended under this option as far as Slough. To operate the service dual voltage 25 kV ac/four-rail 630V dc rolling stock will be required. Traction supply changeover could be effected at Paddington.

The dual voltage rolling stock will also require to be fitted with BR and LUL signalling systems to permit operation on the through route.

Attention will also be required to ensure full platform compatibility and train length for the train sets to serve existing BR and LUL stations.

I.4.7 Operational Considerations

Again the issue arises of interworking of BR and LUL stock on shared tracks.

A new fleet of dual voltage rolling stock will require a new depot facility for maintenance and stabling. Spare capacity at existing depots cannot be anticipated since none of the existing Great Eastern fleet is displaced by this scheme and stock for the current services from Slough is based at Reading which would not be accessible to electric stock unless the route were fully wired.

Suitable locations for new depot provision need to be found.

I.5 Wimbledon Branch/Central Line Connection

The concept of this scheme is described in section 4.2.5.

Significant engineering issues arise with the scheme.

I.5.1 Engineering Considerations

It is recognised that there is no realistic opportunity of making use of the existing BR operated tracks of the West London Line between West Brompton and Kensington Olympia. These are understood to be utilised at capacity.

It would therefore be a requirement to provide a new and entirely segregated route to link the District and Central Lines.

I.5.2 Alignment Development

In developing a feasible alignment the following key features have been identified:

* At-grade junction on the District Line tracks near West Brompton, immediately east of the BR West London Line.

* A grade-separated underpass of the new District/Central tracks beneath the West London Line. This would involve temporary realignment of the WLL to permit 'top down' construction whilst minimising disruption to existing traffic.

* The new tracks would then rise to surface alongside a new retaining wall, to the west side and parallel with the present West London Line. The surface alignment would run beneath existing bridges and the extended Earls Court arena.

* New platforms at West Brompton are not currently proposed.

* Approaching the existing Kensington Olympia, some realignment of the WLL tracks will be required to create sufficient space for a new double-track railway.

  It is believed that sufficient space exists at the surface to accommodate this new alignment.

* At Kensington Olympia, the present station facilities would be demolished to make way for a new two platform station. Rebuilding will be required, including the provision of new access to the BR platforms. Existing surface car parking would also be lost to the new alignment as it continues immediately north of the new station.

* North of Olympia, the new alignment would drop via cut and cover into two bored tunnels which would curve eastwards

to make a grade separated junction with the Central Line tunnels at Holland Park. These junctions would be via two step-plate junctions.

The tunnels and junction construction would be carried out, from the surface at Olympia. No major property take or demolition is anticipated at Holland Park.

I.5.3 Station Provision

Stations on the Wimbledon branch are built to sub-surface gauge, and are not capable of being served by the longer and lower tube stock of the Central Line. Shared platform facilities are unlikely to be acceptable.

A strategy for platform provision is therefore required if this scheme is to be effective; a possible solution is outlined in section 4.2.5, which would segregate tube and sub-surface platforms. Whatever the strategy, platform modification/alteration will be required. The Wimbledon terminal, must be capable of handling both types of rolling stock if the Central Line service is extended thereto.

I.5.4 Signalling/Control

Extension of Central Line services via the new connection to Wimbledon will require the existing Wimbledon branch to be modified with signalling equipment compatible to that now being installed on the current Central Line.

The signalling system however must still be able to accommodate District Line services, and possibly BR empty stock movement (see below).

I.5.5 Rolling Stock Compatibility

As with other schemes, the interworking of different types of rolling stock is a potential difficulty. In this instance it would certainly involve tube and sub-surface stock, but an added complication also exists in that the route is also used by BR stock workings between Wimbledon and East Putney. One option might be to dispense with these workings by diverting them elsewhere.

Provision of Automatic Train Protection (ATP) along the route (it is understood that it is not currently provided as it is elsewhere on the LUL network) is necessary with this scheme and may be considered suitable protection to allow interworking of different types of rolling stock, but the issue remains outstanding.

I.5.6 Operating Considerations

Many operating issues have already been touched upon above, since there is a close linkage between operating and engineering features of this scheme.

It is recognised that additional Central Line rolling stock will be required to operate to Wimbledon. There is potential synergy here with the Leytonstone Jubilee Line extension scheme which would make some Central Line trains surplus to requirement.

Some concern has also been expressed that removal of the Edgware Road District Line services would lead to unacceptable congestion on the Earls Court - High Street Kensington - Paddington corridor, with only the Circle Line service remaining. This would need further investigation and modelling.

I.6.6 Kilburn Link - Thameslink

The scheme proposes a link between the existing Metropolitan Line and Thameslink routes via the North London Line at West Hampstead. Two new elements of infrastructure would be required:

i) New chord lines between the Metropolitan Line and North London Line, at the existing grade separated intersection near Kilburn.

ii) Separate linkage between the North London Line and Thameslink at West Hampstead. This link has already been developed in detail by BR and powers have been obtained for its construction. Its costs are included as part of this scheme.

I.6.1 Engineering Issues

To achieve connection between the Metropolitan Line and North London Line at Kilburn, two new chord lines will be required between the high level Metropolitan tracks which are carried on viaduct over the North London Line. Advantage is taken of this intersection to propose a widening of the existing structure to permit new Northbound and Southbound tracks to rise and fall respectively between the existing alignments. Horizontal and vertical alignments developed for the scheme are acceptable, and the connection can be made with the North London Line clear of West Hampstead station, upon which there would be no impact. Grade separation with the BR Chiltern Lines has NOT been assumed necessary.

I.6.2 Construction

Construction of this high level grade separated connection would inevitably be disruptive. Two public highways would be bridged, and the viaduct widening itself would require some residential property demolition and permanent landtake.

I.6.3 Operational Issues

Southbound Metropolitan Line services diverting via the new link to NLL/Thameslink would make a straightforward connection from the existing track onto the new chord falling to a new connection with the North London Line.

In the northbound direction the move is more complex. An at-grade crossing of the eastbound NLL track is required, after which the chord climbs on new viaduct to a flat connection with the Down Line of the BR Chiltern route.

It has been assumed that sufficient capacity exists on the Chiltern Lines to permit the Metropolitan service of 6 trains/hour to run on these tracks to a suitable point at which an at-grade crossing to the northbound Metropolitan Line can be made. This removes the

requirement for complex and highly disruptive construction of grade separation at Kilburn.

There is a requirement to identify a suitable BR Chiltern Line to Metropolitan Line connection. Since the Chiltern Lines are not electrified at present, provision will need to be made for extension of electrification to the selected crossover point between the routes.

I.6.4 Through Working of Rolling Stock

Existing LUL Metropolitan Line stock already interworks with BR rolling stock on the shared section north of Harrow.

Since it will be necessary for the 6 Metropolitan Line trains diverted per hour via the Thameslink route to run on both LUL and BR systems, new rolling stock will be required to be:

* Dual voltage dc 4-rail/25Kv ac overhead: If running is extended to the BR 3rd rail dc system there is a possibility that triple voltage stock may be required, although it is understood that there is broad compatibility and no insurmountable technical difficulties in running 3rd rail equipped stock on the LUL four-rail system.

* Signalling systems: Stock would be required to work with BR AWS systems and LUL ATP systems.

* The issue of interworking this rolling stock with existing LUL Metropolitan Line trains is again potentially an issue to be resolved.

The requirement for a new fleet of such rolling stock is recognised, and it is assumed that it would be a straight 'one for one' replacement of existing Metropolitan Line stock which would become surplus to requirement.

The precise number of 8 car trainsets is to be established, depending upon the point on the Thameslink route at which the diverted services terminate and reverse.

I.6.5 Impact Upon Associated Railways

I.6.5.1 North London Line

Diversion of a 6 train per hour service via the North London Line in the West Hampstead area is a key issue. This route is already heavily utilised and to achieve suitable regulation and service reliability with the addition of these new services it is expected that resignalling of part of the North London Line will be necessary.

I.6.5.2 Thameslink

The utilisation of six paths per hour on Thameslink will take capacity from the route which may be required for an enhanced service under the Thameslink 2000 scheme.

It this option were to go ahead the balance between Metropolitan, Midland Main Line and Great Northern services would require review.

The terminating point of the Metropolitan services via Thameslink is also subject to review. Some alteration and remodelling may be required to provide adequate reversing facilities.

LONDON TRANSPORT
LONDON UNDERGROUND LIMITED

CROSSRAIL COST-EFFECTIVENESS STUDY

PRELIMINARY RESPONSE TO GIBB-BOVIS OPTIONS

23rd December 1993

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EXECUTIVE SUMMARY

1. Introduction

1.1 The Government has commissioned a Cost-Effectiveness Study of CrossRail, which has been undertaken by Sir Alexander Gibb and Partners and Bovis. Part of the study involved examining a number of so-called alternatives to CrossRail, the proposed schemes being of a more localised, and therefore cheaper, nature. Six schemes have been proposed and these could be adopted individually or as a package

1.2 London Transport and London Underground have been asked to examine each of the six schemes proposed and to provide comments. This report contains London Transport and London Underground's preliminary professional view of the transport planning, operational and engineering implications of each of the schemes.

1.3. This report represents the initial views of LT, LUL and BR on the six options, each one being considered under three headings: Transport Planning, Operations and Engineering. The assessment presented here is based on the professional expertise of those involved in the consideration of the proposed schemes.

2. Conclusions

2.1 The assessment demonstrates that 5 of the schemes attempt to relieve the operationally complex Metropolitan/Circle corridor of some of its existing services, in order to create train paths for new "cross-London" services. The remaining scheme attempts to relieve the Central line.

2.2 Individually, each of the schemes shows limited benefits, but potentially high costs. All of the options create difficulties for the operation of a safe and reliable railway. The piecing together of different bits of railway hassignificant implications for service control, and the extent of interworking of different types of rolling stock is not favoured either by LUL or HM Railways Inspectorate because of operational and safety implications.

2.3 In contrast, CrossRail would be a modern railway, with all the reliability, quality and safety attributes that one would expect from a totally self-contained 21st Century railway. Service control would be self-contained, for example. Moreover, CrossRail has been planned to have minimal impact on the operation of the existing system during construction, whereas the schemes assessed in this report would all have significant impacts during construction. Considerable work has been undertaken to minimise environmental disbenefits on the CrossRail scheme. Many of the proposed alternatives would require the demolition of properties and potentially serious detrimental environmental impact.

2.4 In addition to the works identified in this report as necessary for each particular scheme, a number of works would be required at other stations to mitigate against congestion as a result of CrossRail not being built. These capacity enhancement works at Central and District line stations could involve a capital cost of approximately £120 million.

2.5 Particular points of note in relation to the individual schemes:

- Option 3A is operationally infeasible during peak periods.
- Options 2A and 7A are very difficult to construct in engineering terms.
- Options 4A and 6A appear to offer few, if any, real benefits.
- Option 5C may have some marginal benefit.

2.6 All of the schemes proposed by Gibb-Bovis have implications for service reliability, whereas CrossRail has been designed as a "seamless" railway, which would ensure maximum efficiency and reliability.

2.7 Moreover, when compared to CrossRail, journey time savings are extremely limited. Indeed, there appears to be only a minimal advantage over the current situation.

2.8 Table 7 compares the six options in terms of how well they meet the 9 key objectives for CrossRail. On this simplistic basis, none of the options perform well in terms of meeting CrossRail's objectives and only option 5C, with through trains from Slough to Barking has any significant impact. However if due weight is given to the more important objectives, such as relief of congestion on existing lines and improved access to the City and West End, such an assessment is likely to show that even this option only meets no more than 10% of the objectives.

2.9 It can be concluded that none of the options are likely give anywhere near the scale of user and non user benefits of CrossRail and none can be a serious alternative to the main proposal.

2.10 This remains the case supposing some or all of the options could be combined. The view is that such combinations would still fall considerably short of the objectives set for CrossRail.

2.11 The construction of CrossRail would assist in maintaining London's status as Europe's World City and would thus contribute to its success. It is quite clear that the schemes outlined above, whether adopted individually or in isolation, could never impact upon the future success of London to the same extent.

INTRODUCTION

As part of the Government's proposal to proceed with CrossRail as a Joint Venture with the private sector, the Department of Transport has commissioned a Cost-Effectiveness Study which has been undertaken by Sir Alexander Gibb and Partners and Bovis. Part of the study involved examining a number of alternatives to CrossRail, the proposed schemes being of a more localised, and therefore cheaper, nature. Six schemes have been proposed and these could be adopted individually or as a package. It is understood that the options have been shortlisted from a longer list of schemes but LT/LUL have not been made aware of these. The six options are being currently tested on London Transport's RailPlan model by the consultants and it is understood that their results will be available within the next week.

London Transport and London Underground have been asked to examine each of the six schemes proposed and to provide comments. This report contains London Transport and London Underground's preliminary view of the transport planning, operational and engineering implications of each of the schemes. It should be recognised however that, given the restrictive timescales available, the analysis was undertaken within the space of less than a fortnight. This report cannot therefore in any way be treated as a definitive analysis of the schemes proposed by Gibb-Bovis; further work, including modelling simulation would clearly be required. However, the analysis contained in this report should provide an adequate assessment to determine whether or not a scheme is potentially feasible or indeed sensible.

This report therefore represents the initial views of LT, LUL and BR on the six options, each one being considered under three headings: Transport Planning, Operations and Engineering.

The transport planning findings are based on LT/LUL professional experience and judgement, in advance of an examination of the consultant's modelling work. To structure the review, the advantages and disadvantages to passengers have been assessed and the options have then been judged against 9 key CrossRail objectives on a simple 4 point scale.

The operational findings are based on the professional knowledge and experience of LUL and NSE operators who have assessed the potential impact of each of the schemes in terms of their own operations and their impact upon the operation of the network as a whole.

The engineering findings are based on an assessment undertaken by LUL in conjunction with an experienced independent Engineering Consultancy, W S Atkins.

1. OPTION 2A - EASTERN CITY LINK

1.1 DESCRIPTION (See plans attached)

1.1.1 This option would utilise the proposed CrossRail route along the Great Eastern tracks from Ilford/Shenfield, with a tunnel portal at Allen Gardens. The tunnel would incorporate a new underground station at Liverpool Street and would ramp up to join the "widened lines" between Barbican and Farringdon. There would be a connection at grade to the Metropolitan/Circle tracks at Farringdon and the route would then follow the Metropolitan line to Watford/Amersham. Metropolitan services currently terminating at Aldgate (15 tph) would divert to the new link after calling at Farringdon and then run via the new Liverpool Street/Moorgate station and on to Stratford. They would then be linked to NSE services to Ilford or Shenfield.

1.1.2 The Thameslink route to Moorgate would be demolished by the option and the services diverted to Blackfriars.

1.2 TRANSPORT PLANNING IMPLICATIONS

1.2.1 <u>Advantages and Disadvantages for Passengers</u>

Advantages:

- Avoidance of interchange on journeys from east London to Farringdon and stations along the Metropolitan line.
- May encourage a small switch of passengers from the Central Line to the through service and hence reduce congestion.
- Reduces passenger congestion at Liverpool Street Circle Line station.

Disadvantages:

- Reduces services on the Circle/Met line between Farringdon and Aldgate and hence reduces accessibility to the City from the west.
- Results in longer access times to the deep level station at Liverpool Street.

The effect of the diversion of NSE services from Moorgate to Thameslink is not assumed to be detrimental as this is proposed under the Thameslink 2000 project.

1.2.2 <u>Extent to which the option meets CrossRail Objectives</u>

The option provides limited relief to existing lines and stations. This is substantially less than CrossRail as low train frequencies and speeds will mean journey times to key central locations will be only marginally improved. From the west access to the City will be generally poorer. The only significant benefit will be the removal of the need to interchange at Liverpool Street. Table 1 below summarises the assessment.

Table 1 Assessment of Option 2A against CrossRail Objectives

Rail Congestion Relief - Lines	1
Rail Congestion Relief - Stations	1
Removing need to Interchange	2
Improved Access to City	1
Improved Access to West End	0
Relief of Road Congestion	0
Improved Regional & Int. Links	1
Longer Term Flexibility	0
Stimulus to London's Economy	0

[3=meets objectives; 2=partially meets objectives; 1=marginally meets objectives; 0=does not meet objectives]

1.2.3 Conclusions on Planning Grounds

It is concluded that Option 2A will provide a limited through service from east London to the northern parts of the central area, thereby reducing the need for interchange for some passengers and providing limited relief of congestion on the Central line and at Liverpool Street station. As a consequence of reduced services in the Circle/Met line it will disadvantage passengers travelling to parts of the City from the west.

1.3 OPERATIONAL IMPLICATIONS

1.3.1 This option requires 48 new specialised dual voltage trains. These trains would need to comprise eight 17 metre cars and be equipped to operate on LUL and BR signalling and electrification systems. The cost of these trains would be approximately £300 million. The Railway Inspectorate has demonstrated serious reservations in respect of any new operations involving BR and LUL trains sharing the same tracks. In particular, crashworthiness and incompatibility of couplings for emergency push-out situations would need to be resolved. It is reasonable to assume an Automatic Train Protection (ATP) system would be required, and all trains operating on common sections suitably equipped.

1.3.2 The different types of rolling stock operating on the route would have different capacities, seating and door arrangements, which could cause excessive dwell times at busy stations and impact upon service reliability. The new trains, being shorter, would have lower capacity than those that they would replace on the Great Eastern lines.

1.3.3 The junction at Bethnal Green with the Great Eastern lines, where some services would continue to operate into Liverpool Street, would also influence service reliability and it is therefore believed that grade separation would be essential.

1.3.4 The operation of such a complex line with a combination of services running on it would create difficulties for service control and hence have implications for service reliability.

1.3.5 Serious congestion could occur at Stratford and Farringdon stations. Flows at these stations would need to be studied carefully to determine infrastructure requirements.

1.3.6 20 "A" Stock trains and 40 BR Class 315 Units would be displaced in this option. The full redeployment of the former would be unlikely.

1.4 ENGINEERING IMPLICATIONS

1.4.1 The ramp section leading up to the Metropolitan/Circle line near Farringdon would be very difficult to construct between the Moorgate Development's piling, and through the Barbican sub-basements.

1.4.2 The ramp would destroy the existing Thameslink station at Barbican, which could not easily be replaced due the gradient required between Farringdon and Liverpool Street stations.

1.4.3 There would be severe disruption to the Metropolitan and Circle lines during the construction of the ramp. The tunnel for this option would sever the Metropolitan Line service to Aldgate Station.

1.4.4 Farringdon Station would need to be improved to cater for increased traffic. This would require capacity enhancements within the station as well as the provision of additional entrances/exits.

1.4.5 Due to the diversion of all Thameslink services via Blackfriars under this scheme, some work would need to be undertaken for the Thameslink 2000 project to increase capacity at Blackfriars, including power supply enhancements and junction remodelling.

2. OPTION 3A - HEATHROW EXPRESS TO CITY

2.1 DESCRIPTION (See plans attached)

This option would provide a direct "Heathrow Express" service to the City. The route would connect from BR's Great Western main line to the Hammersmith and City line at Royal Oak. Circle/Metropolitan line capacity would be increased through new signalling or paths freed by other options.

2.2 Heathrow Express services would be extended through to Moorgate, possibly with a limited stop and premium fare service.

2.2 TRANSPORT PLANNING IMPLICATIONS

2.2.1 Advantages and Disadvantages for Passengers

Advantages:

- Through service provided to the City for passengers travelling to and from Heathrow, avoiding need to interchange at Paddington.

Disadvantages:

- Limited stop service could cause confusion to other passengers.
- Does not benefit commuters.

2.2.2 Extent to which the option meets CrossRail Objectives

The option improves international connections by providing a direct link from the City to Heathrow Airport which would support the City. To this extent it would be similar to the longer term proposal to run CrossRail trains to the Airport, although journey times in the central area would be significantly slower. The option would not meet any of the other CrossRail objectives. Table 2 summarises the assessment.

Table 2 Assessment of Option 3A against CrossRail Objectives

Rail Congestion Relief - Lines	0
Rail Congestion Relief - Stations	0
Removing need to Interchange	0
Improved Access to City	0
Improved Access to West End	0
Relief of Road Congestion	0
Improved Regional & Int. Links	1
Longer Term Flexibility	0
Stimulus to London's Economy	1

[3=meets objectives; 2=partially meets objectives; 1=marginally meets objectives; 0=does not meet objectives]

2.2.3 Conclusions on Planning Grounds

It is concluded that Option 3A would have limited advantages for passengers travelling from the City to the Airport but, by not giving any benefits to other passengers, would not meet the main objectives of CrossRail.

2.3 OPERATIONAL IMPLICATIONS

2.3.1 The line between Paddington and Aldgate currently operates at capacity, handling up to 30 tph and is extremely difficult to operate as there are four flat junctions at which conflicting train movements occur. Operating speeds are low and the service is particularly fragile, where a disruption to one service impacts upon several others.

2.3.2 This option would be inoperable in the peak periods with the current configuration due to the constraints imposed by the flat junctions on the Circle line. Resignalling with transmission based signalling would be necessary to increase the capacity above 30 tph. However, even with the most modern signalling systems available it would not be possible to operate a reliable service in the manner proposed.

2.3.3 The connection between the Great Western main line and the Hammersmith and City line would also need to be grade separated and work would be required to reconfigure the layout at Moorgate station, which - as a terminus - would constrain capacity and flexibility, due to the existence of a flat junction.

2.3.4 Five additional Heathrow Express trains would be required to operate a 4 tph service through to Moorgate. However, since dual voltage trains would be required, the residual fleet of 6½ 6-car trains would need to be converted or replaced. The issue of the incompatibility of interworking LUL and BR rolling stock again applies (see section 1.3).

2.3.5 The proposal envisages a premium fare service. This could mean that trains non-stop intermediate stations resulting in congestion caused by extended intervals between stopping trains and the express service would be frequently delayed between stations. Alternatively, trains would stop at intermediate stations, making it very difficult to administer a premium fare. This would also result in a lower quality airport service.

2.3.6 If a regular clock-face timetable were to be maintained for the Heathrow Express service, an additional spare train would be required to maintain reliability.

2.4 ENGINEERING IMPLICATIONS

2.4.1 The construction of an underpass near Royal Oak would be required. This would involve the slewing of all the main line tracks out of Paddington in order to create enough space to construct the necessary retaining ramps and the underpass. This would be costly and extremely disruptive to Great Western main line services.

2.4.2 A terminal facility to handle airport traffic is a likely requirement at Moorgate. This would be expensive and difficult to construct within the constraints of the current station complex.

3. OPTION 4A - LEYTONSTONE LINK

3.1 DESCRIPTION (See plans attached)

3.1.1 This option proposes a further extension of the Jubilee line beyond Stratford to Epping, via a connection to the Central line at Leyton.

3.1.2 The Central line would continue to operate a service from Hainault, supplemented by additional trains west of Stratford which would reverse in the Stratford area. A proportion of Jubilee line trains would operate as far as Epping, the remainder reversing at Stratford.

3.2 TRANSPORT PLANNING IMPLICATIONS

3.2.1 Advantages and Disadvantages for Passengers

Advantages:

- Passengers travelling from north east London through to Docklands would avoid an interchange at Stratford.
- Some passengers travelling from north east London to parts of the central area, such as London Bridge and Westminster would have a faster journey than via the Central Line.

Disadvantages:

- Passengers travelling from Epping to the City incur an additional interchange.
- Potential additional station congestion at Stratford and/or Leytonstone.
- Possible overcrowding of the Jubilee Line.

3.2.2 Extent to which the option meets CrossRail Objectives

The proposal would partially meet one of CrossRail's objectives by marginally reducing congestion on the Central Line. It would improve regional links to Docklands and to the international terminal at Waterloo which could benefit Docklands's economy, but does little to meet CrossRail's objectives in the Central Area. Table 3 summarises the assessment.

Table 3 Assessment of Option 4A against CrossRail Objectives

Rail Congestion Relief - Lines	1
Rail Congestion Relief - Stations	0
Removing need to Interchange	0
Improved Access to City	0
Improved Access to West End	0
Relief of Road Congestion	0
Improved Regional & Int. Links	1
Longer Term Flexibility	0
Stimulus to London's Economy	1

[3=meets objectives; 2=partially meets objectives; 1=marginally meets objectives; 0=does not meet objectives]

3.2.3 Conclusions on Planning Grounds

In the Docklands' context the extension would be beneficial but the extent to which the benefits here are outweighed by poorer access to the Central Area would need to be carefully addressed. The option does very little to meet CrossRail's objectives.

3.3 OPERATIONAL IMPLICATIONS

3.3.1 Central line 1993 stock trains will not be compatible to operate over the Jubilee Line Extension, now under construction. Therefore, this option would require 14 additional Jubilee Line trains to be purchased, at a cost of £77 million. Twelve Central line trains would be displaced, which could not easily be redeployed, unless incorporated as part of a Northern line modernisation project.

3.3.2 Reversing facilities would be essential east of Stratford on the Central line and at Stratford on the Jubilee line to maintain a high frequency service into the Central are on these lines.

3.3.3 Four tracks would be required between Stratford and Leytonstone in order to provide sufficient line capacity and to ensure the segregation of services to maintain a reliable operation. Cross-platform interchange at Leytonstone would be an important customer requirement.

3.3.4 It is unclear to what extent the new service to Epping would attract traffic away from the Central line. If successful, it could lead to overcrowding at London Bridge and Waterloo. This would require the upgrade capacity of the JLE and preclude the possibility of extending the line from North Greenwich to the Royal Docks and beyond.

3.3.5 Some rebuilding at sub-surface level would be required at Stratford, which could result in temporary closure of the North London Line service to North Woolwich.

3.4 ENGINEERING IMPLICATIONS

3.4.1 The tunnel link from Stratford to Leyton would begin at the north of the existing Stratford station and descend steeply to avoid the Union Rail underground station. This would be expensive to construct in the poor soil conditions of the Lee Valley. For this section of the line, the option would require be on a minimum radius curve to avoid the NLL, which is adjacent.

3.4.2 The extension of the Jubilee Line through Stratford Station would virtually destroy the station layout soon to be built as part of the JLE works.

3.4.3 Due to the requirement to separate the operations of the Central and Jubilee lines, this proposal would require the rail corridor to be widened between Leyton and Leytonstone, at considerable cost and land take.

3.4.4 The stations at Leyton and Leytonstone would need to be expanded in order to increase capacity for interchanging between the Jubilee Line from Epping and the Central Line from Hainault. This would also necessitate problematic land requisition in the vicinity of the proposed M11 link road.

3.4.5 A reversing siding at Stratford for the residual Central Line service would be very difficult to construct, since the existing Central Line station at Stratford has a NSE Line running between the two Central Line tracks to facilitate cross platform interchange.

4. OPTION 5C - HAMMERSMITH & CITY INTO BAKERLOO/ SLOUGH TO BARKING

4.1 DESCRIPTION (See plans attached)

4.1.1 This option involves a new connection between the Great Western main line and the Hammersmith and City line between Royal Oak and Paddington. In addition, a connection would be made from the Hammersmith and City line to the Bakerloo line to the west of Paddington.

4.1.2 Hammersmith and City line services would then be diverted to supplement the Bakerloo line service to Elephant and Castle. Services are to operate from Slough to Barking via Baker Street and King's Cross in slots released by the diversion of the Hammersmith and City line.

4.2 TRANSPORT PLANNING IMPLICATIONS

4.2.1 Advantages and Disadvantages for Passengers

Advantages:

- Passengers from some areas served by the H&C Line west of Paddington will have improved access to the West End via the Bakerloo Line.
- Passengers from local stations to Slough will have improved access to the City and east London, avoiding the need to interchange at Paddington.

Disadvantages:

- Passengers from areas served by the H&C Line west of Paddington will have to change at Paddington to reach the City

4.2.2 Extent to which the option meets CrossRail Objectives

The proposal provides for through services running from east to west London and would improve access from the west to the City and avoid the need for passengers to change at Paddington. However journey times from, say, Slough to the City would be only marginally faster than today and reductions in congestion on other lines would be small. The option would make a modest contribution to meeting CrossRail's objectives. Table 4 summarises the assessment.

Table 4 Assessment of Option 5C against CrossRail Objectives

Rail Congestion Relief - Lines	1
Rail Congestion Relief - Stations	1
Removing need to Interchange	2
Improved Access to City	1
Improved Access to West End	2
Relief of Road Congestion	1
Improved Regional & Int. Links	1
Longer Term Flexibility	1
Stimulus to London's Economy	1

[3=meets objectives; 2=partially meets objectives; 1=marginally meets objectives; 0=does not meet objectives]

4.2.3 Conclusions on Planning Grounds

The proposal has some of the characteristics of the CrossRail proposal. The proposal to link the Hammersmith and City Line through to the Bakerloo Line is incidental to the main proposal and the advantages and disadvantages for passengers are likely to be fairly balanced. Overall the package could partially address some CrossRail objectives.

4.3 OPERATIONAL IMPLICATIONS

4.3.1 This option would require 21 new dual voltage trains to operate the Slough-Barking service, at an estimated cost of £130 million. The incompatibility of rolling stock is again an issue between Paddington and Barking (see section 1.3).

4.3.2 Electrification of the Great Western lines as planned for Heathrow Express would have to be extended to provide access via the slow lines to Slough. Substantial track remodelling west of Paddington would be required for a connection onto the H & C line. Power supplies from the grid would be required to meet the service level planned.

4.3.3 The proposal implies a 29 tph service between Paddington and Elephant and Castle. The Bakerloo line has a current signalling capacity of only 27 tph, and significant modernisation would be required to exceed this, including expensive works at Elephant and Castle to provide higher-speed crossovers.

4.3.4 Additional tube gauge rolling stock would be required to operate the Hammersmith services. This could be obtained by transferring 1972 stock from the Northern line and converting it for One Person Operation (OPO). The minimum number of additional trains required would be five, but could be more depending on passenger demand. The source of replacement trains for the Northern line would have to be resolved.

4.3.5 The Hammersmith and City line west of Paddington would require significant works to accommodate Bakerloo line "tube" rolling stock. These would include platform lengthening and lowering. Hammersmith depot would also need to be remodelled to accommodate 7-car trains.

4.3.6 There would be some operational benefit of improved flexibility and service levels on the Bakerloo line.

4.3.7 16 "C" Stock trains would be displaced and full redeployment is unlikely.

4.4 ENGINEERING IMPLICATIONS

4.4.1 Provision of underpasses, passenger connecting tunnels, rail connecting tunnels and a new underground station at Paddington would be extremely difficult in the congested conditions and would cause severe disruption. All this new work would involve extensive use of long stretches of track at maximum allowable gradients.

4.4.2 In order to allow access for the civil works between Paddington and Royal Oak stations, the recently re-laid NSE and Intercity Main Line tracks would need to be slewed over a considerable length. This would cause severe disruptions to the current services into Paddington and would involve the reconfiguration of a complex area, and may involve additional IECC signalling within the Paddington area. Staging works could only be carried out at 2 periods within a year.

4.4.3 A replacement depot for the maintenance of Circle line trains currently maintained at Hammersmith would be required.

4.4.5 Upgrading siding capacity, including proper suitable servicing equipment for new generation replacement rolling stock (e.g. CET discharge/sidepits) would be required at both ends of the Slough/Barking line.

5. OPTION 6A - THE WIMBLEDON LINK

5.1 DESCRIPTION (See plans attached)

5.1.1 This option utilises the District line from Wimbledon to West Brompton, where it would connect at grade into BR's West London Line (WLL). The route would then use the WLL to Kensington Olympia, after which it would leave the WLL and descend into tunnel to join the Central line at Holland Park. The option then uses the entire Central line to the east, including both Hainault and Epping branches.

5.1.2 Central Line trains currently terminating at White City would be extended to run over the West London Line and the District Line to Wimbledon. The Olympia service from Earl's Court would be discontinued. Some District Line services would operate from Wimbledon to High Street Kensington but through services to Edgware Road would be discontinued, leaving only Circle Line trains serving stations between High Street Kensington, Paddington and Edgware Road.

5.2 TRANSPORT PLANNING IMPLICATIONS

5.2.1 Advantages and Disadvantages for Passengers

Advantages:

- Passengers from the Wimbledon branch would gain a through service to the West End via the Central Line.
- Congestion on the District Lines through Earl's Court could be eased.

Disadvantages:
- Through service from Wimbledon to Edgware Road would be lost.
- Congestion at existing central area stations on the Central Line may increase.

5.2.2 Extent to which the option meets CrossRail Objectives

The option would potentially introduce a complex pattern of journey changes which only modelling can address. It does not meet any of the key objectives for CrossRail as it serves a very different catchment area. Table 5 summarises the assessment.

Table 5 Assessment of Option 6A against CrossRail Objectives

Rail Congestion Relief - Lines	0
Rail Congestion Relief - Stations	0
Removing need to Interchange	0
Improved Access to City	0
Improved Access to West End	1
Relief of Road Congestion	0
Improved Regional & Int. Links	0
Longer Term Flexibility	0
Stimulus to London's Economy	0

[3=meets objectives; 2=partially meets objectives; 1=marginally meets objectives; 0=does not meet objectives]

5.2.3 Conclusions on Planning Grounds

The purpose of this option, in relation to the CrossRail study, is unclear as it proposes a complex network change in an area of London remote from the CrossRail route. It is not possible to say whether or not the proposal would result in a net improvement for passengers.

5.3 OPERATIONAL IMPLICATIONS

5.3.1 This option requires the Central line service to operate along the West London line. It would be unacceptable operationally and to the Railway Inspectorate for the interworking of LUL "tube" stock with 400m Eurostar international high-speed trains, international freight trains, and other freight and passenger services. Hence, the provision of additional dedicated LUL tracks alongside the existing 2 tracks on the West London Line would be essential to ensure separate safe operations.

5.3.2 The extension of the Central Line onto the Wimbledon branch of the District Line would require 15 additional Central line trains at a cost of £60 million. This would entail "tube" stock interworking with LUL surface stock and BR empty stock. In addition to the incompatibilities referred to in section 1.3, platform heights relative to train floors would need to be compromised with implications for the mobility impaired and the safety of all passengers. The extension of Central line signalling and ATO/ATP would be needed from Holland Park to Wimbledon exclusive, in order to meet the new hierarchy of service patterns (District-Central).

5.3.3 The proposal to terminate some District Line trains at High Street Kensington (as opposed to Edgware Road) would worsen the service between High Street Kensington and Edgware Road (from 15 tph to 7½ tph). This reduction in service would not only result in a deterioration of customer service, but also could result in station congestion at, for example, Notting Hill Gate and Paddington. The Kensington Olympia to High Street Kensington shuttle service would no longer be required.

5.3.4 Train service control would be complex and therefore maintaining reliability would be difficult.

5.3.5 Whilst the proposal would reduce the number of train movements in the currently busy Earl's Court area, a higher level of interchange at Earl's Court could result in increased congestion.

5.3.6 10 "C" Stock trains would be displaced by this option. There would appear to be few opportunities to redeploy these trains.

5.3.7 Segregation of BR empty train movements from this route would be advantageous, but difficult to realise in practical terms.

5.4 ENGINEERING IMPLICATIONS

5.4.1 The cost of the tunnel connection from the WLL to the Central Line would be substantial. There could be major demolition of property in the Holland Park area.

5.4.2 There is no available space to build new platforms on the WLL at West Brompton. Levels are significantly different.

5.4.3 The WLL will be part of the major route to the Midlands and north of England for the Channel Tunnel traffic (Eurofreight Route). It would also serve as a link between Waterloo and the Three Capitals Train servicing depot at North Pole. Therefore the WLL tracks would need to be slewed to the west and new tracks for this option laid alongside.

5.4.4 Kensington (Olympia) station would need to be reconstructed as part of the scheme.

6. OPTION 7A - THE KILBURN LINK

6.1 DESCRIPTION (See plans attached)

6.1.1 This option involves a new connection being built from the Metropolitan line at Kilburn station to the North London Line (NLL) and then from the NLL to the Thameslink line before the Belsize Slow Tunnel.

6.1.2 Metropolitan Line trains currently terminating at Baker Street would be diverted to run via King's Cross and Thameslink to Blackfriars or further into south London.

6.2 TRANSPORT PLANNING IMPLICATIONS

6.2.1 Advantages and Disadvantages for Passengers

Advantages:

- Passengers from north-west London would have an improved connection into parts of the City, avoiding the need to change at Baker Street.

Disadvantages:

- Passengers travelling to the West End would have a poorer service.
- Congestion at King's Cross and on the Victoria Line could increase as a result.

6.2.2 Extent to which the option meets CrossRail Objectives

By improving access to the City from north-east London the option partially addresses some CrossRail objectives. Table 6 summarises the assessment.

Table 6 Assessment of Option 7A against CrossRail Objectives

Rail Congestion Relief - Lines	1
Rail Congestion Relief - Stations	0
Removing need to Interchange	1
Improved Access to City	2
Improved Access to West End	0
Relief of Road Congestion	1
Improved Regional & Int. Links	0
Longer Term Flexibility	2
Stimulus to London's Economy	0

[3=meets objectives; 2=partially meets objectives; 1=marginally meets objectives; 0=does not meet objectives]

6.2.3 Conclusions on Planning Grounds

The option is essentially a variant of the Thameslink 2000 project rather than CrossRail, improving travel on a north west to south London axis rather than east to west. It would partially meet some of CrossRail's objectives.

6.3 OPERATIONAL IMPLICATIONS

6.3.1 This option would require 26 new triple voltage trains to be purchased at an estimated cost of £170 million. The incompatibility of interworking LUL and BR stock is again an issue (see section 1.3). 30 "A" Stock trains would be displaced with this option. Full redeployment of these trains is unlikely.

6.3.2 The connection between the Metropolitan and Thameslink lines would not only be physically difficult to construct but would be particularly difficult to operate. Limited paths would be available on the North London Line between freight and other passenger services and the route would entail conflicting working with other services on the Metropolitan line and possibly the Chiltern line. This could have serious implications for reliability.

6.3.3 The option would also create problems for the operation of Thameslink, which would at least require some of the Thameslink 2000 south London works to be constructed. The service on Thameslink would exceed the existing signalling capacity at King's Cross. King's Cross Thameslink station is already severely congested at peak times. Any increase in usage would require the station to be rebuilt at a cost of £60 million.

6.3.4 The service pattern created by this option could result in increased numbers of passengers transferring at King's Cross to the "tube" lines, with the risk of further congestion, particularly on the Victoria line.

6.3.5 Future Thameslink 2000 extensions to Bedford and the Great Northern line are precluded by this scheme.

6.3.6 25 kv overhead electrification as far as Harrow would be required, with a traction changeover point and reversing facility installed there.

6.4 ENGINEERING IMPLICATIONS

6.4.1 The junction at Kilburn/Finchley Road is not possible if Kilburn is to remain as a Jubilee line station. If Kilburn is to be radically remodelled (Estimate £30M), the multi-level junction would cost approximately £25M.

6.4.2 If Kilburn Station could be remodelled, the viaduct at Kilburn would need to be strengthened in order to allow another viaduct to be constructed over the British Rail Chiltern Line on the viaduct. This would be costly, visually intrusive and extremely difficult to construct.

6.4.3 The viaduct to carry the NLL westbound line over the Metropolitan and Jubilee lines at Kilburn would destroy the NLL West Hampstead Station. This is because the viaduct ramp required from the NLL West Hampstead station to pass over the Metropolitan and Jubilee lines would be too steep for current alignment standards.

CONCLUSIONS

The assessment above demonstrates that 5 of the schemes attempt to relieve the operationally complex Metropolitan/Circle corridor of some of its existing services, in order to create train paths for new "cross-London" services. The remaining scheme attempts to relieve the Central line.

Individually, each of the schemes shows limited benefits, but potentially high costs. All of the options create difficulties for the operation of a safe and reliable railway. The piecing together of different bits of railway have significant implications for service control, and the extent of interworking of different types of rolling stock is not favoured either by LUL or HM Railways Inspectorate because of safety implications.

In contrast, CrossRail would be a modern railway, with all the reliability, quality and safety attributes that one would expect from a totally self-contained 21st Century railway. Service control would be self-contained, for example. Moreover, CrossRail has been planned to have minimal impact on the operation of the existing system during construction, whereas the schemes assessed in this report would all have significant impacts during construction. Considerable work has been undertaken to minimise environmental disbenefits on the CrossRail scheme. Many of the proposed alternatives would require the demolition of properties and potentially serious detrimental environmental impact.

In addition to the works identified in this report as necessary for each particular scheme, a number of works would be required at other stations to mitigate against congestion as a result of CrossRail not being built. These capacity enhancement works at Central and District line stations could involve a capital cost of approximately £120 million.

Particular points of note in relation to the individual schemes:

- Option 3A is operationally infeasible during peak periods.
- Options 2A and 7A are very difficult to construct in engineering terms.
- Options 4A and 6A appear to offer few, if any, real benefits.
- Option 5C may have some marginal benefit.

All of the schemes proposed by Gibb-Bovis have implications for service reliability, whereas CrossRail has been designed as a "seamless" railway, which would ensure maximum efficiency and reliability.

Moreover, when compared to CrossRail, journey time savings are extremely limited. Indeed, there appears to be only a minimal advantage over the current situation.

Table 7 compares the six options in terms of how well they meet the 9 key objectives for CrossRail. On this simplistic basis, none of the options perform well in terms of meeting CrossRail's objectives and only option 5C, with through trains from Slough to Barking has any significant impact. However if due weight is given to the more important objectives, such as relief of congestion on existing lines and improved access to the City and West End, such an assessment is likely to show that even this option only meets no more than 10% of the objectives.

It can be concluded that none of the options are likely give anywhere near the scale of user and non user benefits of CrossRail and none can be a serious alternative to the main proposal.

This remains the case supposing some or all of the options could be combined. The view is that such combinations would still fall considerably short of the objectives set for CrossRail.

The construction of CrossRail would assist in maintaining London's status as Europe's World City and would thus contribute to its success. It is quite clear that the schemes outlined above, whether adopted individually or in isolation, could never impact upon the future success of London to the same extent.

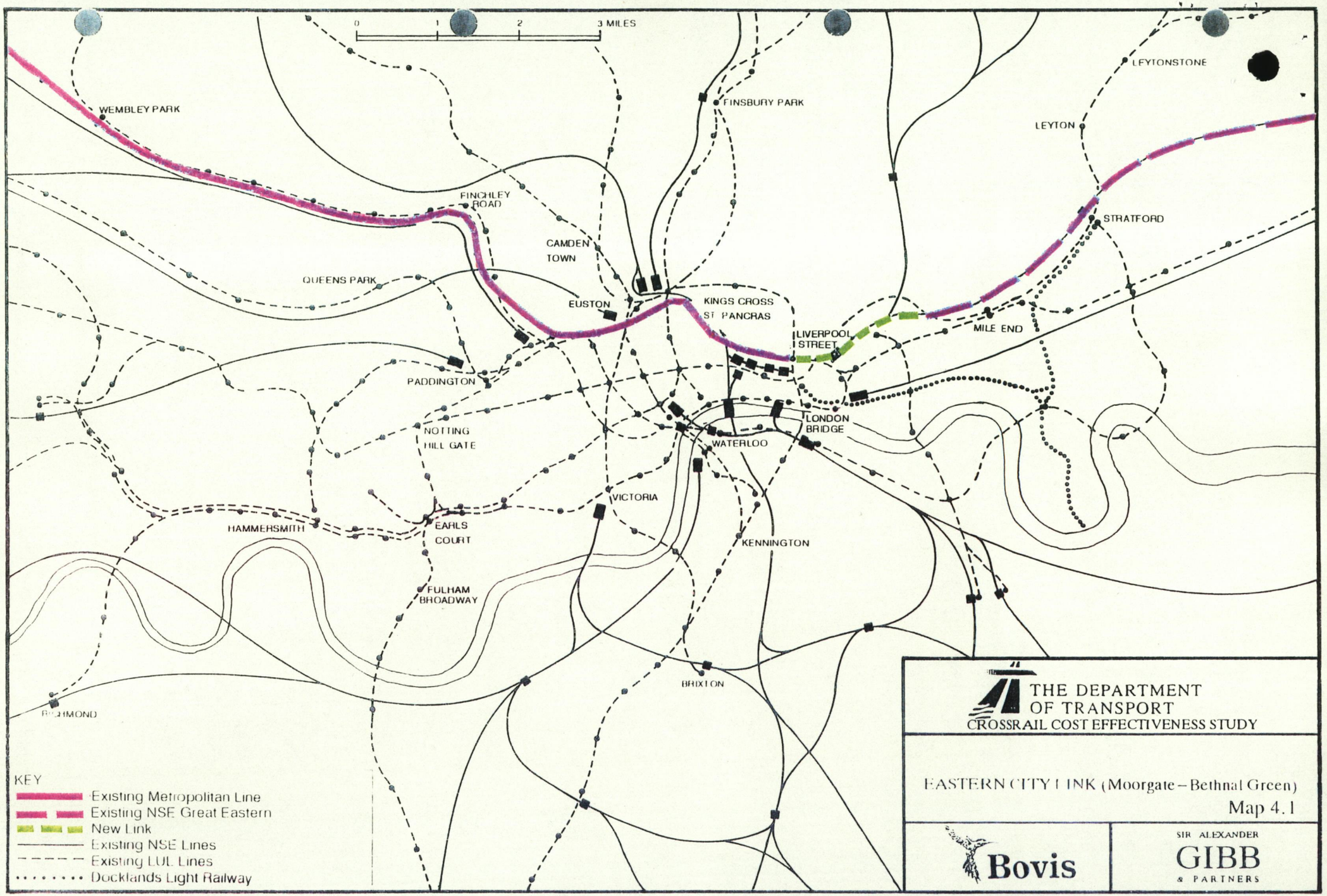
TABLE 7

DO THE SIX OPTIONS MEET CROSSRAIL OBJECTIVES?

	Eastern City Link 2A	Heathrow Express 3A	JLE Extension 4A	Slough-Barking 5C	Wimbledon Link 6A	Kilburn Link 7A
Rail Congestion Relief - Lines	1	0	1	1	0	1
Rail Congestion Relief - Stations	1	0	0	1	0	0
Removing need to Interchange	2	0	0	2	0	1
Improved Access to City	1	0	0	1	0	2
Improved Access to West End	0	0	0	2	1	0
Relief of Road Congestion	0	0	0	1	0	1
Improved Regional/International Links	1	1	1	1	0	0
Longer Term Flexibility	0	0	0	1	0	2
Stimulus to London's Economy	0	1	1	1	0	0
TOTAL	6	2	3	11	1	7

APPENDIX A

OPTION ROUTE PLANS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LEYTON
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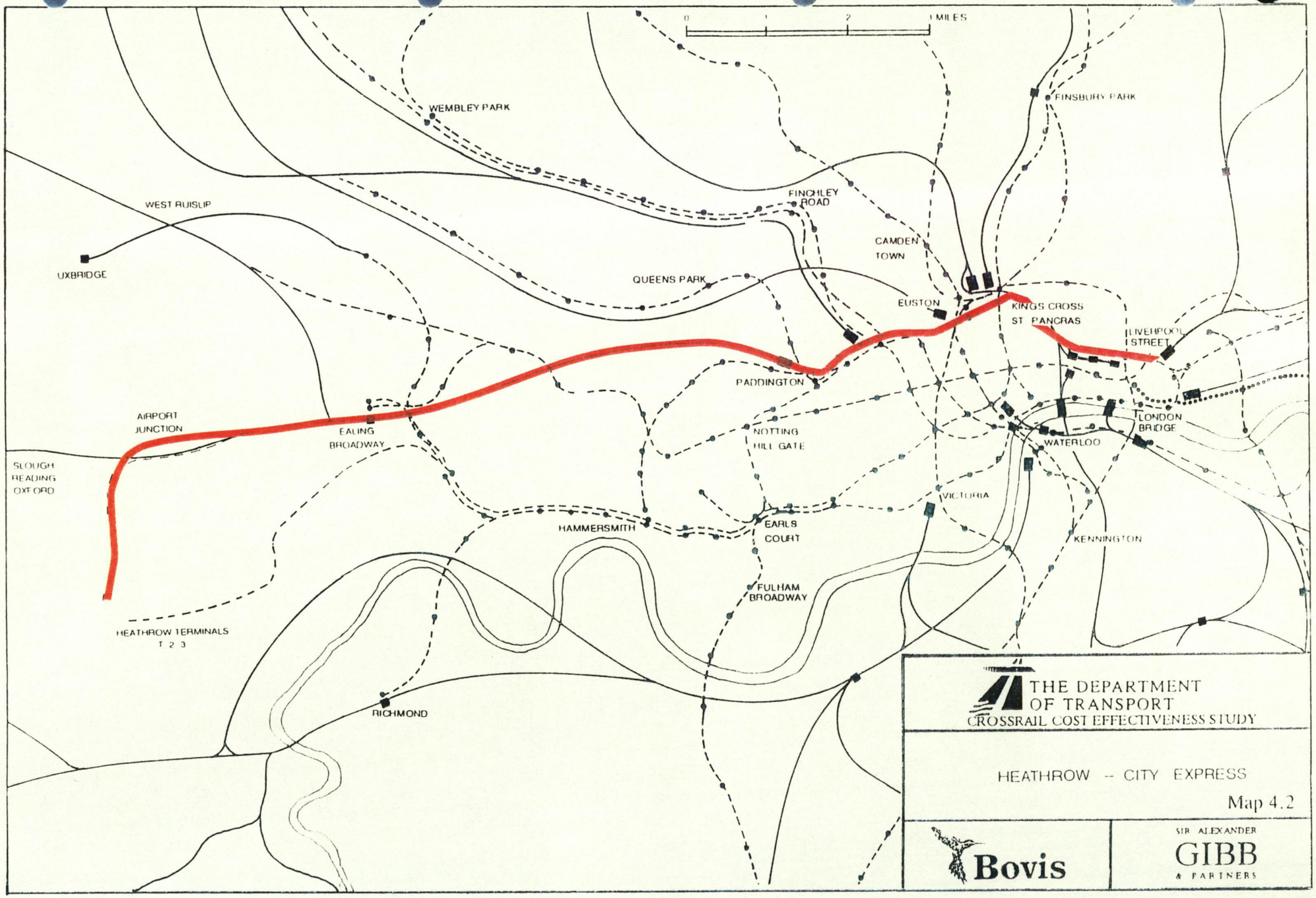
EUSTON
KINGS CROSS ST PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
KEY
Existing Metropolitan Line
Existing NSE Great Eastern
New Link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
EASTERN CITY LINK (Moorgate – Bethnal Green)
Map 4.1
Bovis
SIR ALEXANDER GIBB & PARTNERS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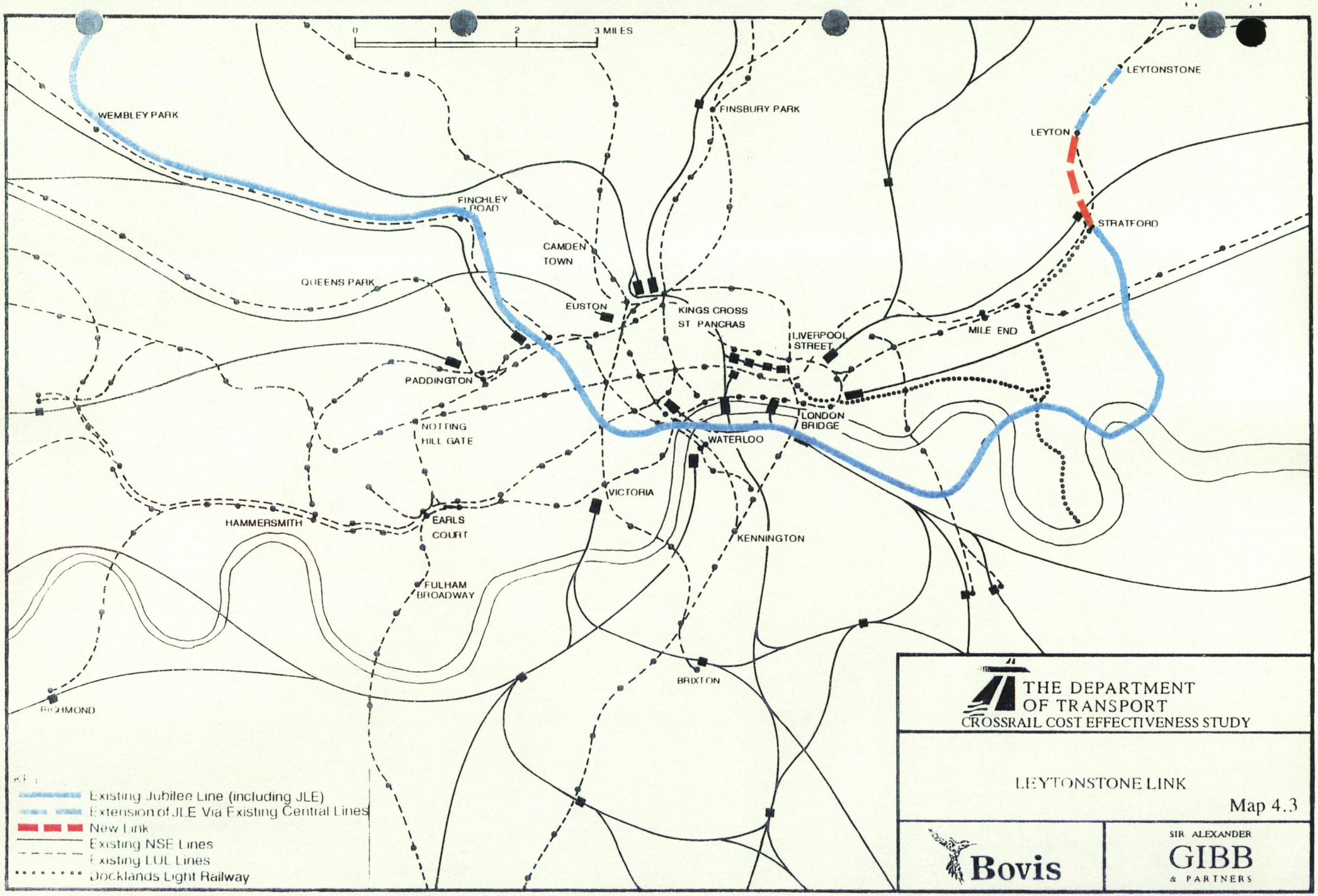
KINGS CROSS ST PANCRAS
LIVERPOOL STREET
PADDINGTON
AIRPORT JUNCTION
EALING BROADWAY
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
SLOUGH
READING
OXFORD
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
HEATHROW TERMINALS
T 2 3
RICHMOND
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
HEATHROW -- CITY EXPRESS
Map 4.2
Bovis
SIR ALEXANDER GIBB & PARTNERS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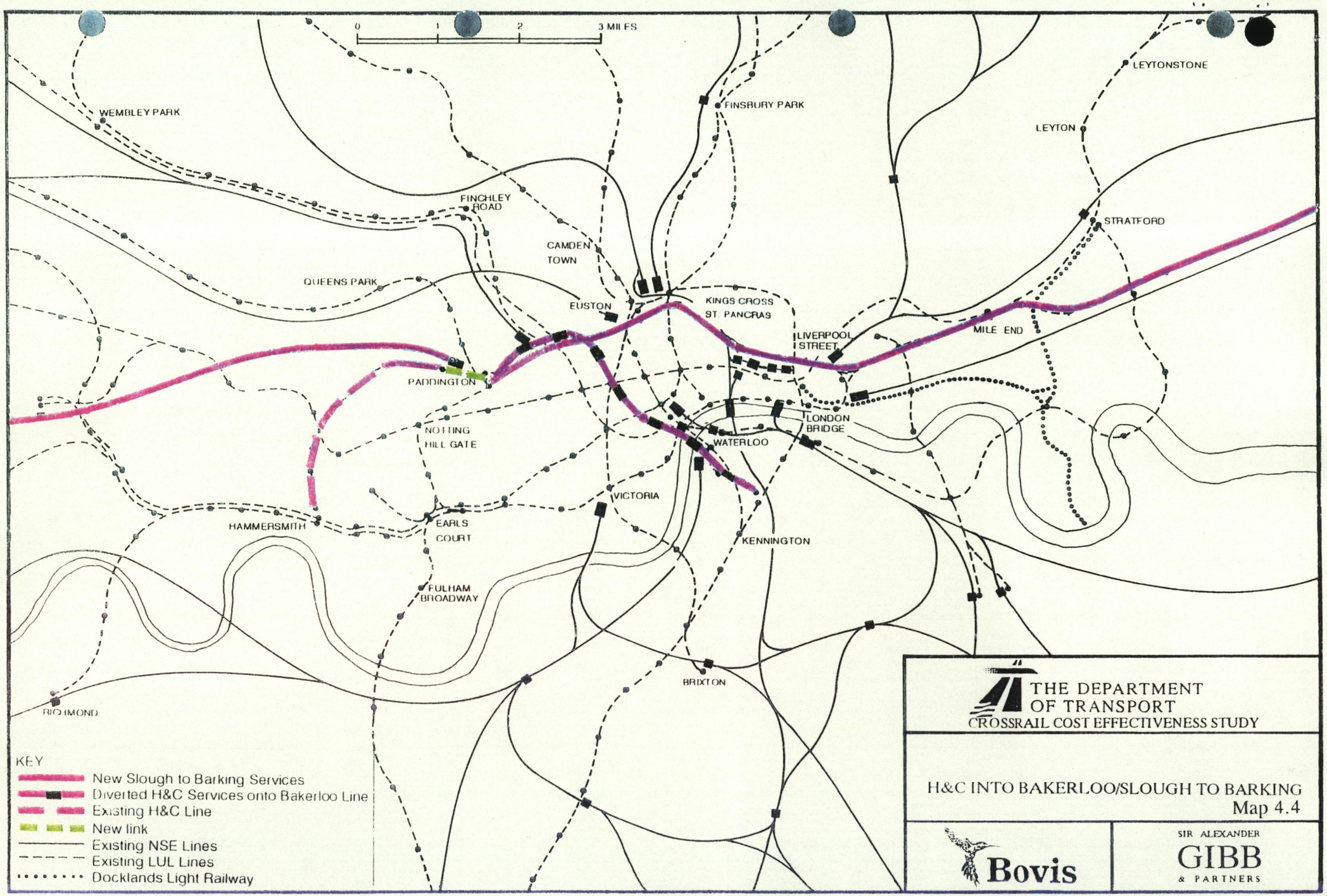
EUSTON
KINGS CROSS ST PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
Existing Jubilee Line (including JLE)
Extension of JLE Via Existing Central Lines
New Link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
LEYTONSTONE LINK
Map 4.3
Bovis
SIR ALEXANDER GIBB & PARTNERS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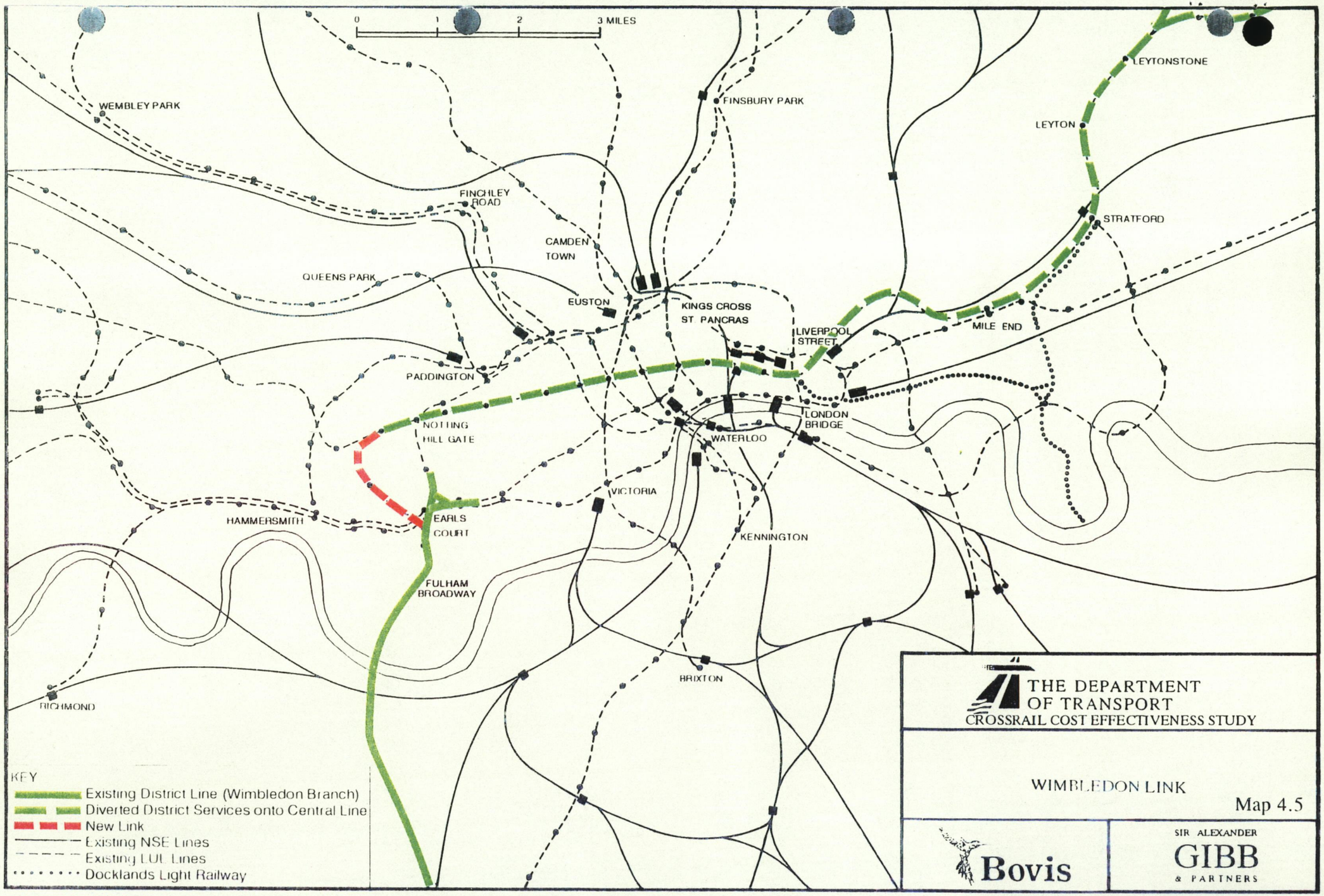
EUSTON
KINGS CROSS ST. PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
KEY
New Slough to Barking Services
Diverted H&C Services onto Bakerloo Line
Existing H&C Line
New link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
H&C INTO BAKERLOO/SLOUGH TO BARKING
Map 4.4
Bovis
SIR ALEXANDER GIBB & PARTNERS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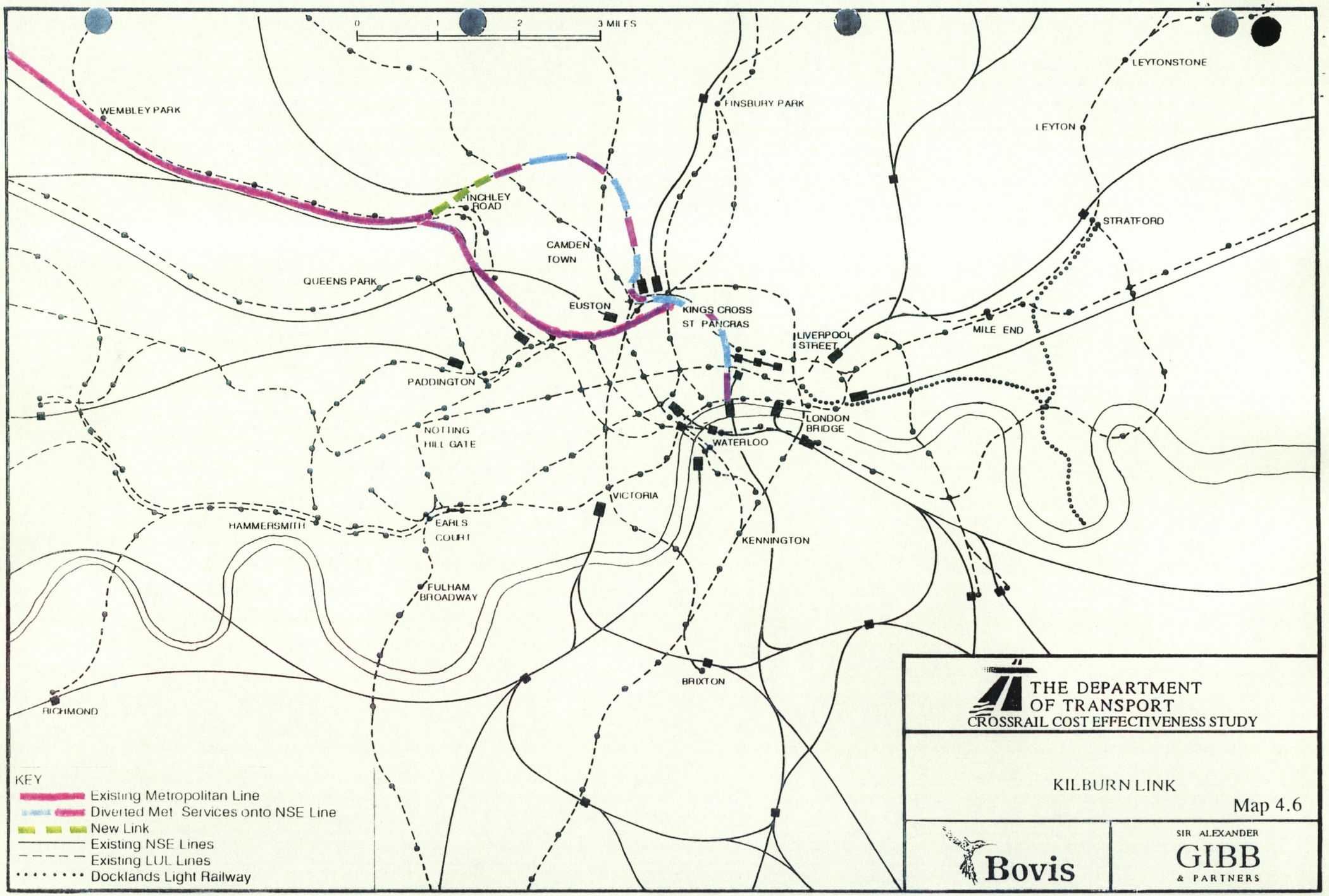
FINSBURY PARK
LEYTONSTONE
LEYTON
FINCHLEY ROAD
CAMDEN TOWN
STRATFORD
QUEENS PARK
EUSTON
KINGS CROSS ST PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
LONDON BRIDGE
WATERLOO
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
KEY
Existing District Line (Wimbledon Branch)
Diverted District Services onto Central Line
New Link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
WIMBLEDON LINK
Map 4.5
Bovis
SIR ALEXANDER GIBB & PARTNERS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CAMDEN TOWN
QUEENS PARK
EUSTON
KINGS CROSS ST PANCRAS
LIVERPOOL STREET
MILE END
PADDINGTON
NOTTING HILL GATE
WATERLOO
LONDON BRIDGE
VICTORIA
HAMMERSMITH
EARLS COURT
KENNINGTON
FULHAM BROADWAY
BRIXTON
RICHMOND
KEY
Existing Metropolitan Line
Diverted Met Services onto NSE Line
New Link
Existing NSE Lines
Existing LUL Lines
Docklands Light Railway
THE DEPARTMENT OF TRANSPORT
CROSSRAIL COST EFFECTIVENESS STUDY
KILBURN LINK
Map 4.6
Bovis
SIR ALEXANDER GIBB & PARTNERS

APPENDIX B

SUMMARY OF COSTS AND BENEFITS

SUMMARY OF COSTS AND BENEFITS

Option	Description	Construction Cost (£m)	Cost Of Disruption During Construction (£m)[1]	Net Operating Cost and NPVs[2] (£m)[3]	Passenger Benefits/Disbenefits
2A	CrossRail tunnel built in part - Eastern portal to Farringdon. 15tph service linking Met with GE suburban.	670	1.3 Also BR GE lines - severe disruption	-0.3 pa -3.89 NPV	+ Some journey time savings, E London-City - Loss of service to Aldgate area
3A	Re-signal north side of Circle Line. Heathrow Express operates 4tph to Moorgate via Circle Line.	430	1.3 Also BR Western lines - severe disruption	1.7 pa 22.05 NPV	+ Through service, Heathrow-City, some journey time savings - Some extended intervals between stopping services on N Circle line
4A	Connect Jubilee Extension to Central line north of Stratford. Epping served by Jubilee, Hainault by Central.	160	1.2 Also BR GE lines - severe disruption	0.7 pa 9.07 NPV	+ Journey time savings, Epping-Docklands/Waterloo - Interchange penalties and potential congestion
5C	Hammermith branch of H&C connected to Bakerloo, BR Western connected to H&C at Paddington. Bakerloo has 2 branches, Slough to Barking.	350	£2.5 Also BR Western lines - severe disruption	3.0 pa 38.85 NPV	+ Some journey time savings, Slough-City/Ladbroke Grove-West End - Interchange penalties, H&C to City
6A	Central connected to Wimbledon branch via West London Line. Central line serves Wimbledon at 10tph, Edgware Rd service cut back to High St Ken at 6 tph.	160	1.1 Also BR WLL - severe disruption	1.7 pa 22.05 NPV	+ Some journey time savings, Wimbledon-West End - Greater journey times, Wimbledon-Paddington/ Edgware Rd. Potential overcrowding, Notting Hill Gate/Paddington
7A	Thameslink connected to Met line at Kilburn via North London Line. Thameslink serves Met line at 6tph.	330	Disruption to Thameslink, NLL, Met, Jubilee and Chiltern lines	1.0 pa 12.95 NPV	+ Some journey time savings, NW London-City. - Potential overcrowding at King's Cross and on Victoria line

1 These estimates are illustrative of a 50% loss of revenue due to 12 weekend closures on the LUL lines affected to enable construction work.
2 NPV calculated over 40 years at a discount rate of 8%.
3 These figures reflect marginal increases in train operating costs only.

APPENDIX C

BREAKDOWN OF IDENTIFIED COSTS

The figures shown here represent in broad terms the identified major costs associated with implementing the options as proposed. These figures are not exhaustive and other costs may also be necessary. Further analysis would be required to determine these.

All costs shown are at September 1993 prices.

OPTION 2A

Costs Identified	£m
New tunnel section (Allen Gdn.-Farringdon) and connections to GE and Met/Circle lines (inc. grade separation at Bethnal Green)	278
48 new dual voltage trains	290
Automatic Train Protection for LUL/BR interworking sections	20
Thameslink south London junction capacity works and power supply enhancements	80
TOTAL	668

Costs Excluded

- Possible capacity enhancement works at Farringdon and Stratford stations.

- Benefit value of re-utilising displaced rolling stock.

OPTION 3A

Costs Identified	£m
Grade separated junction connecting Western main line to H & C line, and associated works	75
5 additional Heathrow Express trains (residual fleet would need replacement with dual voltage - cost assumed to be offset by redeployment)	36
Automatic Train Protection for interworking over LUL tracks	23
Transmission based signalling system (Paddington to Moorgate) (Note: "A" stock equipping involves major engineering of vehicles with limited remaining life)	290
Upgrade of terminal facilities at Moorgate	2
TOTAL	426

Costs Excluded

Station capacity enhancements associated with relieving possible congestion at affected stations on the Circle line.

OPTION 4A

Costs Included	£m
14 additional Jubilee line trains	77
Construction of link between Jubilee line at Stratford and Central line at Leytonstone, including required reversing facilities	82
Transfer of signalling control of Epping branch to Jubilee SCC	2
TOTAL	161

Other Costs	
Upgrade of Jubilee line to operate up to 36 tph	130

Costs Excluded

Property costs at Leyton/Leytonstone

OPTION 5C

Cost Identified	£m
21 new dual voltage trains	126
Automatic Train Protection for interworking between Paddington and Barking	14
Extension of electrification to Slough	15
Power supply enhancements on Western lines	4
New stabling facilities at Old Oak Common	7
New stabling facilities at Barking	2
Track remodelling and platform extensions (Acton-Slough)	11
Transfer of 1972 stock from Northern line and fitting of OPO equipment (minimum 5 trains)	1
Grade separated junction from Western main line to H & C, and associated works	73
New connection from H & C line to Bakerloo line tunnel at Paddington	79
Depot remodelling to stable and service 7-car trains	20
Platform lengthening and lowering between Hammersmith and Royal Oak	2
TOTAL	354

Other Costs	
Resignalling Bakerloo line above current capacity for 27 tph	70
Construction of higher speed crossovers at Elephant and Castle	30

OPTION 6A

Costs Included	£m
15 additional Central line trains	60
Construction of new line connecting District line at West Brompton via West London line to Central line at Holland Park, including a new station at Kensington Olympia	73
Provision of Automatic Train Protection between West Brompton to Wimbledon	18
Stabling facilities required at Wimbledon (inc. property costs)	10
"Holding" loop east of East Putney Junction (for BR ECS trains)	1
TOTAL	162

Other Costs

Extension of Automatic Train Operation from Holland Park to Wimbledon

OPTION 7A

Costs Included	£m
26 new triple voltage trains	169
Installation of Automatic Train Protection for interworking over LUL tracks	15
Resignalling of Thameslink from West Hampstead to Farringdon to upgrade capacity from 18 to 24 tph	5
Resignalling of Chiltern line from 8 to 10 tph	2
Overhead electrification of Met line Kilburn-Harrow)	4
Reversing/diversion facility required at Harrow for traction changeover point	4
Associated resignalling in Harrow area	2
Signalling immunisation (inc. Neasden depot)	60
Stabling/servicing facilities at Rickmansworth and Neasden	4
Construction of junctions and connections from Met line at Kilburn to Thameslink/Midland main line at West Hampstead via North London line	64
TOTAL	329

CROSSRAIL

CROSSRAIL
COST EFFECTIVENESS STUDY
REPORT BY THE RAILWAY OPERATORS:
STAGE 2

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Network SouthEast

CROSSRAIL
COST EFFECTIVENESS STUDY
REPORT BY THE RAILWAY OPERATORS:
STAGE 2

EXECUTIVE SUMMARY

1. The railway operators carried out a study of the CrossRail project in summer 1993 to identify the scheme's components, and particularly to determine the nature and scope of a "Basic Core Railway" which might be substituted for that envisaged in the CrossRail Bill. This work concluded that, while a plan could be devised, it would be unlikely to gain consent to build and operate and that further work would be necessary to develop a scheme which could realistically be expected to gain such consents. It also concluded that a "CrossRail" scheme could be viable at several scope levels, and that the scope which appeared to maximise both the social cost / benefit return and the potential for private sector funding embraced the full route network but had only three of the planned five central area stations. This Stage 2 study develops the previous work and addresses some further issues.

2. The operators have reviewed the central area station combinations assumed in Stage 1 and concluded that, while other combinations offer similar results, operational considerations warrant retaining the previous assumptions in this study. However, all the possible central area stations except Farringdon (not specifically tested in this work), including the possible station at Holborn, can contribute to a worthwhile scheme and the operators consider that no action should be taken at this point to preclude eventual construction of any of them.

3. Further outline scheme development work has identified and costed schemes which have been termed "Realistic", both in relation to the consent process and through their ability to evolve over time to the planned scheme. They include, inter alia, safety provisions, upgradeability to 12-car train operation and safeguarding future stations, and consequently the incremental cost of larger schemes is less than appeared at Stage 1.

4. The Stage 1 work concluded that worthwhile schemes could be devised at several scope levels below the full planned scheme, giving expenditure options. This report confirms that, despite the extra costs in the "Realistic" schemes, the three options considered can be worthwhile under public sector criteria::

   - "Core Scheme": Shenfield - Slough with two central area stations (assumed as Moorgate and Tottenham Court Road);
   - "Reduced Scheme": The full route network (Shenfield - Reading / Aylesbury) with three central area stations (assumed as Moorgate, Tottenham Court Road and Bond Street);
   - "Planned Scheme": The full route network with the planned five central area stations plus tunnel alignment provision for a future Holborn station.

5. The Reduced Scheme appears to perform best in both social cost / benefit and financial terms. The Planned Scheme is also worthwhile under both criteria, but the Core Scheme, while worthwhile in public sector terms, would not be financeable in a public / private joint venture. The operators consider that all these schemes would

meet safety and operational requirements, although some operating problems would have to be resolved in the Core and Reduced schemes.

6. A "CrossRail" scheme via King's Cross as proposed by some petitioners against the CrossRail Bill, has also been evaluated. This would cost around 10% more than the scheme via Tottenham Court Road, with greater risk of cost overruns because it has not been through the detailed design stages during which cost increases often come to light. As the route would not serve the West End, a major destination both for work and leisure purposes, benefits would be less - the value of its principal stations (King's Cross and Baker Street), would be less than a third of the planned route equivalents (Tottenham Court Road and Bond Street). There would be less relief of congestion, and on one key Underground link, congestion would be aggravated. The scheme would be of limited relevance to the proposed Channel Tunnel Terminal at King's Cross as the majority of passengers from the Union Railways domestic services will require City or West End destinations served by existing lines, and international passengers are insufficiently numerous to offset those disadvantages. The railway operators have concluded that this alignment option is clearly inferior and should not be progressed.

7. The planned scheme's benefits have been reassessed under current assumptions, indicating that improvements in station designs and operating plans since November 1991 have increased user benefits and revenue. With other technical changes, but assuming the same CLRS demand levels, the social benefit / cost ratio is now estimated at 1.69 : 1 (compared to 1.3 : 1 in November 1991) assuming Central London rail Study (CLRS) levels of demand.

8. Revised demand forecasts have been prepared to compare with the CLRS forecasts used to date. Applying a 'central' demand forecast to the revised project costs and benefits gives a benefit / cost ratio of 1.52. With a 'Low' demand forecast, which assumes continuation of broadly the present recessionary demand level, theratio is 1.37.

9. Doubt has been cast on the rolling stock "cascade" assumption under which some 16% of the planned scheme cost is assumed to be met from the operators' core budgets. This has been reviewed and the operators still regard it as a reasonable planning assumption, although expected contributions will vary according to demand growth assumptions and rolling stock plans. The operators' view is that much of the rolling stock presently operating the services to be absorbed into CrossRail will be neither life-expired nor suitable for CrossRail operation and hence available for other services. Market forces should therefore realise the collective benefit to the railway industry, although the operators accept that attention may need to be given to financial mechanisms to ensure that it accrues to the CrossRail project's financiers. However, even if no such mechanism could be devised and CrossRail finances all its rolling stock; the benefit / cost ratio is relatively unaffected.

10. In the time available, only the planned scheme has been appraised financially under the latest cost and demand assumptions. With some additional pessimism applied to capital costs, demand and revenues, the estimated Internal Rate of Return on equity finance lies in the required range (15 - 20% over 30 years) and the Minimum Annual Debt Service Cover Ratio is 1.3. While this is at the lower end of the acceptable range, the operators' financial advisers confirm the view reached in Stage 1 that 51% of the planned scheme could be privately financed. Given the earlier findings about the Reduced Scheme's performance, it can be assumed that it would fall clearly into the acceptable range.

CROSSRAIL COST EFFECTIVENESS STUDY
REPORT BY THE RAILWAY OPERATORS: STAGE 2
DECEMBER 1993

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11. This report also examines the public sector return in a joint venture, with the public sector receiving only the social benefits in return for a capital contribution. The "residual" benefit / cost ratio is sensitive to demand forecasts but is estimated at 1.83 : 1 (CLRS demand forecast), 1.29 : 1 ("central") and 0.76 : 1 ("low"). These are calculated using an 8% discount rate for future cost and benefit streams, but in a joint venture, the reduction or elimination of public sector risk would support a 6% discount rate, increasing benefit / cost ratios in all cases.

12. The railway operators' conclusions are:

- The Planned Scheme's overall justification has improved;
- Both the Planned and Reduced schemes are financeable in a joint venture; but the Core Scheme is not;
- All the central area station provisions in the CrossRail Bill could contribute to a viable scheme;
- The planned scheme would still be worthwhile as a public sector project at the "low" demand forecast which envisages only a minimal increase above present levels;
- The public sector can expect a reasonable return on its contributions in a joint venture, except under the most pessimistic demand assumption.

In summary, the difference between the Reduced Scheme scope (which may offer the highest return under both public and private criteria) and the Planned Scheme, which offers the widest benefits, is small in terms of the provisions required to take the project forward.

13. RECOMMENDATION

The railway operators recommend that the CrossRail Bill should proceed without withdrawing any of the powers sought. Having obtained Royal Assent, it is then possible to determine a definitive scheme scope on the basis of established consents and without the uncertainty attached to the statutory process.

CrossRail Client Function (London Underground, London Transport, Network SouthEast),
31 December 1993

CROSSRAIL COST EFFECTIVENESS STUDY
REPORT BY THE RAILWAY OPERATORS: STAGE 2

1. CONCLUSIONS AND RECOMMENDATIONS

1.1 Conclusions

1.1.1 This study addresses the following principal issues:

What is the benefit / cost ratio of the "realistic" scheme options?

What is the effect of more conservative demand forecasts?

Are there any "weak" elements in the planned scheme?

Is an alternative route via King's Cross a better proposition?

Can any of the scheme options attract private finance?

Would the public sector achieve an acceptable[1] return in a joint venture?

1.1.2 This report has confirmed that, in addition to the Planned Scheme, two scope levels could meet operational and safety requirements:

Core Scheme Shenfield to Slough with stations at Moorgate and Tottenham Court Road;

Reduced Scheme Shenfield to Reading / Aylesbury with stations at Moorgate, Tottenham Court Road and Bond Street.

An acceptable benefit / cost ratio can be obtained for both the Planned and Reduced schemes, the latter notwithstanding inclusion of costs such as safeguarding future expansion to the planned scheme. However, the Core Scheme as defined in this report is not financeable, although a Core Scheme without safeguarding for future expansion appeared financeable in the Stage 1 work.

1.1.3 The planned scheme has also been reassessed under current assumptions. Project development has increased its benefits by around 25%, with a further 33% potentially available from additional sources; proportionate increases could be expected in the smaller scope schemes. An appraisal has been carried out using more conservative demand forecasts, taking account of current recessionary demand levels, which shows that, even at a forecast which assumes very little growth from existing levels, the benefit / cost ratio exceeds 1.3 : 1.

1.1.4 Financial appraisal indicates that debt and equity could finance 51% of the gross project cost (i.e. sharing the contributions assumed from the operators' core budgets). With more conservative demand forecasts - which the financial advisers have discounted further, together with other downside assumptions - the Planned Scheme lies within the range attractive to private sector investors. The Reduced Scheme would perform better.

1.1.5 The Stage 1 report suggested that some central area stations might be "weak" elements, having high costs in relation to their benefits. However, it is now evident that four of the five planned central area stations, plus the possible station at

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1: "Acceptable" is defined here as a benefit / cost ratio of 1 : 1 or above; however, London Transport / London Underground core budget expenditure is usually required to satisfy a 1.3:1 target ratio.

Holborn, could contribute to a viable scheme. The operators would consider that powers to construct all the stations should be sought.

1.1.6 The study demonstrates conclusively that the King's Cross alignment is inferior to the planned route; its principal deficiencies are:

Failing to deliver passengers to their ultimate destinations, it gives lower time savings and relief of road congestion;

It achieves less congestion relief and will exacerbate problems on sections of the Underground network around King's Cross;

It will cost more and there is greater risk of cost overruns due to lesser knowledge of construction conditions; scheme development experience shows considerable cost increases can occur between the initial feasibility study and start of construction;

Consequently it offers a consistently lower benefit / cost ratio - at all scope levels - than the planned alignment. It is not therefore intended to spend any further time on this scheme other than as required by the Parliamentary process.

1.1.7 The benefit / cost ratio on the Public Sector capital expenditure in the planned scheme is 1.83:1 assuming an 8% discount rate to a 1993 price base, reducing to 1.29 : 1 under the "central" demand forecast.

1.2 Summary

1.2.1 The principal findings of this work are:

The CrossRail scheme's viability has again been demonstrated on both traditional public sector and current joint venture criteria;

The planned scheme remains viable as a public sector project even with little growth from the present recessionary demand levels;

The scheme is superior to other routes on the east - west axis;

A worthwhile scheme can be devised for more than one level of capital expenditure;

Doubtful elements affect only a very few of the powers sought in the CrossRail Bill, all of which could contribute to a worthwhile scheme, possibly under separate financing arrangements from a venture embracing the overall network.

1.3 Recommendations

1.3.1 The railway operators strongly recommend that the CrossRail Bill should proceed through the Parliamentary process without deletions or amendments, so that further development and business planning can be undertaken to determine the optimum scheme and its phasing. Attractiveness to private finance can be tested conclusively only by marketing an approved scheme.

2. INTRODUCTION TO ANALYSIS AND COMMENTARY

2.1 The railway operators reviewed the CrossRail project during summer 1993 in response to a desire by Government to establish the scheme scope most likely to attract private sector financial support. This work was reported in the "Cost Effectiveness Study" published in October 1993. Its main aim was to identify a "Basic Core Railway", a minimum cost scheme compatible with the project's long term strategic objectives, which might be a basis for attracting a private sector contribution. Using this scheme as a starting point, the work aimed to identify and evaluate components of the project up to the full planned scheme and come to a view about a likely optimum scheme and its potential for attracting private finance.

2.2 The work (subsequently referred to as the "Stage 1 work") concluded that, while a Basic Core Railway scheme could be devised on design and construction principles applied to the most recent major railway projects in London, it would not gain consent to build and to operate as it lacked features now regarded as essential, such as safety provisions and mitigation against construction and operational effects. The operators concluded that while it represented a useful analytical starting point, it was not a realistic minimum scheme and that further work would be needed to develop one.

2.3 The work also suggested that, while the planned scheme met both public and private sector financial criteria, a scheme with the full route mileage but fewer central London stations might perform better. The operators concluded that such a scheme should safeguard stations which might be constructed later while ensuring that safety standards were satisfied in the "interim" phase.

2.4 This report builds on the Stage 1 work in developing the outlines identified there towards schemes which the railway operators would regard as being capable of being promoted through the statutory consent processes. Additionally, the operators have examined a route via King's Cross and Marylebone Road suggested by certain petitioners against the CrossRail Bill whose concerns arise from construction effects in their respective localities along the planned alignment. That scheme has also been examined incrementally so it can be directly compared with the options derived from the planned scheme.

2.5 The Terms of Reference adopted for the Stage 1 work were as agreed between the railway operators and the Department of Transport on 15 July 1993. In October 1993, the Government published Terms of Reference for a study to be carried out by external consultants, which introduced two new elements. The first was a requirement to examine a scheme via King's Cross, which has been reflected in the work reported here. The second was to examine "any other route between Liverpool Street and Paddington which ... is likely to compare favourably with the Basic Core Railway", but as the operators have not been able to anticipate what such a route might be, this aspect has not been addressed[1]. This study therefore continues the approach used in the Stage 1 work, namely to consider variants of scope and route to a "CrossRail" project so that its constituent elements can be identified and better understood.

2.6 The present study covers four areas:

1: A number of alternative investment opportunities have been identified by the Department of Transport's external consultants and are appraised in their report.

i) Refinement of the Stage 1 work, continuing with the Central London Rail Study (CLRS) demand and scheme design assumptions, to test the assumptions on central area station combinations and establish a firm basis for the further work (Chapter 3);

ii) Development and evaluation of "realistic" schemes, incorporating the features lacking in the "Basic Railway" schemes, for both the planned alignment (via Tottenham Court Road) and the alternative via King's Cross, to come to a view on alignment strategy . The CLRS demand forecasts are used to test the relative strength of scope and route options (Chapters 4, 5 and 6);

iii) Revision of the appraisal to include project developments since the November 1991 project evaluation and to test the effect of more conservative demand forecasts (Chapter 7);

iv) A financial appraisal of the scheme (provided by NatWest Markets, the Corporate and Investment Banking arm of the National Westminster Bank), examining both the potential for private finance and the return on the public sector contribution (Chapter 8).

2.7 **Introductory Remarks by NatWest Markets**

2.7.1 The scope of our work in this Stage 1 report is broadly similar to that in Stage 1. However, some additional areas have been covered:

- review of demand assumptions following the reduction in Central London employment since the Central London Rail Study; and

- assessment of the impact on government return of the Private/Public joint venture concept with particular reference to cost/benefit analysis.

2.7.1 In all cases we have used data provided to us by London Transport and British Rail and have relied upon these without independent verification. We would draw attention here to a number of changes to the data provided since the Stage 1 report which we have incorporated into our analyses. These are:

- increase in capital costs by approximately £30m in the full scheme reflecting more accurate estimates; and

- increase in revenue figures by approximately 11% over the Railplan figures reflecting improved timetabling and station design.

2.7.3 Following discussions with London Transport Planning in respect of the demand assumptions mentioned above we have increased the discount applied to our calculations from 10% (used in the Stage 1 report) to 15%. We have applied this in our model by taking LT Planning's Central Demand Forecasts, produced for this report, and capping them at 85%. This level is achieved in the fifth year of operation (2005). Our view therefore represents a "banking base case" rather than an equity upside scenario and necessarily takes a more conservative view about the project.

2.7.4 We have not incorporated any property recoverables although we previously allowed 50% of the predicted sum.

2.7.5 In all our analyses we have held constant the proportions of Government Contribution (49.48%), Private Sector Equity (9.05%) and Bank Debt (41.47%).

2.8 Terms Used in this Report

"Core Scheme": the minimum route and station scope (Shenfield - Slough with two central area stations), also described as "Level 0" in the Stage 1 report. This term does not imply any particular standard of design or treatment of the "quality" elements identified in the Stage 1 work (such as safety provisions).

"Reduced Scheme": the scheme described as "Level 4" in the Stage 1 report which emerged as having the greatest potential return, comprising the full route network (Shenfield - Reading / Aylesbury) and three central area stations. No design or "quality" standard is implied.

"Realistic Scheme": applied to either the Core or Reduced schemes, this embraces those "quality" elements considered by the operators to be necessary to enable a scheme to be promoted and to grow ultimately to the planned scheme.

"Planned Scheme": the scheme as proposed in the CrossRail Bill, with the full route network and five central area stations. This definition also embraces all the "quality" elements identified in Stage 1.

"Full Scheme" applied to the King's Cross alignment scheme only, this is equivalent to the planned scheme, with the full route network and five central area stations.

3. REVIEW OF STAGE 1 REPORT

3.1 The Stage 1 Study investigated seven levels of scheme scope ("quantity" increments) between the Core Railway and the planned scheme. The programme did not allow time to test whether the schemes were operationally feasible or the optimum solutions for a reduced scope project. The railway operators acknowledged these limitations and noted that further work was necessary on any smaller scheme before it could be promoted.

3.2 In this report the Stage 1 analysis and conclusions are reviewed at three scheme levels:

Core Scheme	("Level 0" in the Stage 1 report) - Shenfield to Slough with two Central Area stations, assumed in the Stage 1 work as Moorgate and Tottenham Court Road.
Reduced Scheme	("Level 4" in the Stage 1 report) - the scheme which appeared to maximise the return in transport and financial terms, i.e. the planned network (Shenfield to Reading and Aylesbury) with central area stations at Moorgate, Tottenham Court Road and Bond Street.
Planned Scheme	("Level 6" in the Stage 1 report) The planned network with five central area stations.

These further tests were undertaken on the same basis and using the same methodology and data (corrected for minor errors) as in the Stage 1 study. To maintain consistency with Stage 1, they also assumed the "Basic Railway" approach, i.e. excluding the safety and other features which that work finally identified as being essential in a realistic scheme. Three principal areas have been examined.

3.3 Central Area Station Locations

3.3.1 The Stage 1 work could not examine different combinations of Central Area stations and in particular no CrossRail option excluding Tottenham Court Road station has ever been tested. A series of tests was carried out to determine whether a different combination might be better.

For the Core Scheme, it was considered on an a priori basis (at Stage 1) that if the number of Central Area stations were restricted to two, one should be located in the City and the other in the West End to maximise market penetration. A test was carried out with Central Area stations at Moorgate and Bond Street, i.e. with the "Oxford Street" station further west.

For the Reduced Scheme, the stations assumed in Stage 1 (Moorgate, Tottenham Court Road and Bond Street) were considered to accord with the principal traffic sources. Tests were carried out with Central Area stations at Moorgate, Bond Street and Holborn, giving a more equal spread between stations, and at Moorgate, Tottenham Court Road and Paddington, substituting the Paddington interchange opportunity for a second West End station.

3.3.2 The costs for the individual stations are as used in the Stage 1 report. Those for Holborn have been based on the scheme evaluated during 1992 / 93, which

assumes that the Theobalds Road ticket hall authorised by the London Underground (Safety Measures) Act is constructed at no cost to CrossRail and that a CrossRail station is provided by installing a connection to this ticket hall.

3.3.3 The test results are reported in the conclusions to this section (para 3.5).

3.4 Operational Feasibility

3.4.1 Train service performance

The notional timetable produced in Stage 1 for each "quantity" level has been tested against the demand for schemes forecast by the Railplan model. While the service through the central tunnel was found adequate in both levels, some fine tuning has been necessary to make best use of the available capacity in the suburbs. Rolling stock requirements and operating cost estimates have been recalculated accordingly for the evaluations in Chapters 6, 7 and 8..

3.4.2 Station Capacity

Station capacity (both on the surface and in the Central Area) was also investigated using the Railplan data. At the tunnel stations, passenger flows were generally within the reduced infrastructure's capacity, but higher surface station movements were forecast because fewer Central Area CrossRail stations encourages interchange between CrossRail and London Underground services. The investigation recommended the following enhancements to station infrastructure compared to that in the planned scheme:

Station	Core Railway	Reduced Scheme
Slough	Additional interchange footbridge required.	No Modifications.
Stratford	Potential problems eastbound in the evening peak: see para 3.4.3 below.	Definite problems eastbound in the evening peak: see para 3.4.3 below.
Harrow-on -the-Hill	Not applicable - no CrossRail service.	Additional interchange footbridge required.

3.4.3 Problems at Stratford stem from the absence of a CrossRail connection to the Liverpool Street station area, generating significant interchange at Stratford between CrossRail services and existing services into Liverpool Street). This changes the distribution of flows at Stratford, even though overall usage is no greater than in the planned scheme. Platform overcrowding is likely in the evening peak as passengers wait for eastbound CrossRail trains. This is addressed in the Core Railway by a supplementary service between Chadwell Heath and Liverpool Street (BR terminal). In the Reduced Scheme the problem is further aggravated as passengers boarding CrossRail in the evening exceed the planned scheme by over 20%, but the addition of the supplementary service would increase the total service level above that in the planned scheme. In view of these results an option including the planned scheme's double ended station at Liverpool Street was tested (in addition to the tests reported in para 3.3.1).

3.4.4 Emergency Preparedness

The planning requirement for an emergency in the CrossRail tunnel has been to clear all passengers within 20 minutes, either by train or by detraining at stations. With fewer central stations, this becomes more difficult and some infrastructure is

required to achieve the target. The use of a crossover in the Tottenham Court Road area was examined but rejected on cost grounds (estimated at £20 million); instead, the platform tunnels for Paddington and Farringdon stations would be built and used as emergency detraining points. The cost per station of this infrastructure is estimated to be £2 million (£1 million of which would become abortive if the station were later fitted out for full operation).

3.5 Conclusions

3.5.1 Core Scheme

The station location test results are set out in Appendix 1 (Tables A1.1 and A1.2) and suggest that at the present study's level of accuracy, either of the station combinations tested would have broadly similar results, the higher benefits from Tottenham Court Road being offset by higher costs. However, table A1.2 shows that Bond Street station's usage would be higher than in the planned scheme, suggesting that the single ticket hall would be inadequate; a second ticket hall would eliminate the cost saving by which this combination appears marginally more attractive. Table A1.2 also shows usage at Stratford, where the infrastructure's sensitivity to demand is known; although the difference between the two scenarios is minor, the Tottenham Court Road / Moorgate combination produces lower usage at Stratford and is thus considered preferable.

The Stage 1 assumption (Moorgate and Tottenham Court Road) has therefore been retained for Stage 2 as it is likely to be as optimal as any other combination. If the Core Scheme were to proceed, detailed investigation would be required to identify at an adequate level of confidence the combination generating the best benefit / cost ratio.

With the train service and station infrastructure modifications outlined above, the operators consider that the Core Railway could offer a safe and reasonably reliable scheme, although further work would be needed to confirm it as a basis for seeking statutory consent.

3.5.2 Reduced Scheme

The station location test results for the Reduced Scheme are set out in Appendix 1 (Tables A1.3 and A1.4); again, each combination produces similar results, although that in which Holborn is substituted for Tottenham Court Road performs best due to the low cost of Holborn. Despite the potential accessibility benefits, the second ticket hall at Liverpool Street appears to contribute relatively little in this instance. An examination of platform usage showed that, while platform usage at Stratford is reduced by about 10%[1], the critical interchange movement (see para 3.4.3) is only reduced by a small amount and still exceeds that in the planned scheme. It is thus considered that the cost of the second ticket hall at Liverpool Street is unlikely to be justified in a scheme of this scope. There is no clear solution to the problem of overcrowding at Stratford; the railway operators consider that further development of a Reduced Scheme would require attention to management methods and / or works to increase platform capacity at Stratford.

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1. This comparison is with the "Level 4" scheme in the Stage 1 report, which excluded the Liverpool Street ticket hall.

Of the remaining options, the option including Paddington was discounted as the operability assessment (table A1.4) shows that it places a very heavy load on Tottenham Court Road (the solitary "West End" station), casting doubt on the operability of a single ticket hall. The option including Holborn has lower benefits but performs well because of its apparent lower cost; however, further feasibility work would be required (and is in progress) to determine costs more accurately. On this basis, the railway operators do not have the confidence to adopt it as the basis of the Reduced Scheme.

3.6 Comment by the Railway Operators

3.6.1 The railway operators have concluded that the station locations adopted in the Stage 1 work should be confirmed as the basis for the Stage 2 study, with some small train service and station infrastructure enhancements. The railway operators are satisfied, within the limitations of current knowledge, that the schemes outlined above could operate reasonably reliably and safely.

3.6.2 However, alternative station combinations might be equally valid and stations at Paddington, Bond Street and Holborn could also feature in a cost effective scheme. As stated in the Stage 1 work, although Railplan output is an important first stage in the analysis of individual station provision, or number of ticket halls, it has been found that more complex studies of the many behavioural changes are needed before a clear idea of the overall assessment can be made. Further work would be needed to determine a definitive smaller - scope scheme and validate it as a basis for proceeding through the consent process. In the meantime, the railway operators' view is that capability to adopt any of the station or infrastructure options discussed in this section should be retained within the CrossRail Bill.

3.7 Comment by the Private Sector (Provided by NatWest Markets)

3.7.1 Our comments in this section relate to the financial implications of different station combinations in the Core and Reduced schemes. As in all our assessments we have only contemplated options which include those quality features identified as necessary in the Stage 1 report. Second ticket halls have only been included in the Tottenham Court Road, Bond Street and Liverpool Street configuration for the Reduced Scheme.

3.6.2 The key results of the financial analysis of the station location tests are summarised in Table 3.7.2 below:

Table 3.7.2: Station Combinations: Financial Analysis

Scheme >	Core	Core	Reduced	Reduced	Reduced	Reduced
Stations >	TCR & MGT	BOS & MGT	TCR, BOS & MGT	TCR BOS & LIS	PAD, TCR & MGT	BOS, HOL & MGT
Government Contribution (£000s)	976,765	904,935	1,426,201	1,441,112	1,384,443	1,353,241
Private Sector Equity (£000s)	178,700	165,527	260,876	263,586	253,216	247,509
Bank Debt Drawn (£000s)	818,426	758,429	1,195,089	1,207,763	1,160,378	1,134,228
Total (£000s)	1,973,891	1,828,891	2,882,166	2,912,461	2,798,037	2,734,978
35 Year IRR (%)	16.19	17.14	18.83	18.43	18.70	18.70
30 Year IRR(%)	15.65	16.68	18.48	18.06	18.34	18.35
Minimum Debt Service Cover Ratio	1.16	1.25	1.43	1.39	1.42	1.42

Station codes: BOS: Bond Street HOL: Holborn LIS: Liverpool Street (double ended station)
MGT: Liverpool Street (MGTrgate end only) PAD: Paddington TCR: Tottenham Court Road

3.7.3 From a purely financial perspective:

- of the Core Scheme alternatives, the Bond Street, Moorgate combination is the more attractive although we note the railway operators' comments. In practice, any uncertainty in this area would be addressed by private sector financiers by way of independent study.

- of the Reduced Scheme options, the Bond Street, Tottenham Court Road and Moorgate combination is marginally the most attractive. The differences here are insignificant.

4. THE REALISTIC SCHEMES

4.1 The Stage 1 report tested the scheme at a basic quality level and with seven increments above that level. It concluded that the following quality components[1] had, individually and in total, a small marginal cost and, given that they are critical to the project's success, should be included:

Component A — Safety in Rolling Stock (meeting tunnel operation requirements);

Component B — Safety in Infrastructure (emergency escape and emergency services access and tunnel ventilation);

Component C — Mobility Impaired Access;

Component D — Environmental Mitigation (measures to reduce construction and operational impacts);

Component G — Upgradeability (provision of 12-car tunnel station platforms).

These have been termed "non-discretionary quality" items in this report.

The railway operators also considered that any reduced - scope scheme should include safeguarding provisions so that the planned scheme could ultimately be attained without loss of projected surface sites or excessive disruption to the railway caused by retrospective construction. Appropriate provisions have now been identified, mainly involving construction of the platform tunnels and protection of ticket hall sites not included in the assumed initial scheme.

4.2 The enhancements to the Stage 1 "Basic Railway" at both Core and Reduced levels, deriving from the work summarised above and in section 3, are set out in Appendix 2. The resulting schemes have been termed the "Realistic Schemes", embracing the "non-discretionary" quality features and enhancements needed to permit safe and efficient operation in the interim, while safeguarding future evolution to the planned scheme. They are evaluated in Chapter 7, set aginst the revised scheme benefits.

4.3 Costs for the realistic schemes are derived from the planned scheme estimate of April 1993, advised to Government in July 1993. All costs are quoted in March 1990 prices, and exclude property recoverables and core budget expenditure. Further details on costs are given in Appendix 4. Operating costs are based on assumptions about train services and numbers of stations, and calculated by reference to train and passenger usage and their effect on staffing, fuel and maintenance costs.

4.4 The Core Scheme

This includes:

- A "CrossRail" service between Shenfield and Slough, taking over the inner suburban services on both the Great Eastern and Thames Valley lines using 8 car trains of newly built 20 metre long vehicles, meeting tunnel safety standards;

1: Nomenclature as in Stage 1 report.

- A morning peak service of 16 trains per hour westbound, 14 trains per hour eastbound, supplemented by 4 trains per hour between Chadwell Heath and Liverpool Street (High Level);
- Single ended stations at Moorgate (Amro Bank ticket hall) and Tottenham Court Road (Astoria ticket hall) with 12-car platforms[2] and the sites of other tunnel stations and ticket halls safeguarded;
- Additional provision for interchange flows at Slough;
- Safety provision on trains and within infrastructure;
- Facilities at Central Area stations for mobility impaired users;
- Tunnel spoil removed by rail as existing project proposals;
- Noise and vibration mitigation measures including floating slab track where justified within the Noise and Vibration policy;
- Amended stabling, track layout and surface station facilities to meet operational requirements.

The scheme's Central London section is illustrated in Chart 1.

4.4.2 Costs

Capital — £1363m (March 1990 prices), an increase of 35% over the "Basic Core Railway" cost (£1013m) estimated in the Stage 1 work. This reflects the inclusion of elements now considered necessary, such as safety provisions and safeguarding. The ring-fenced expenditure would be 66% of that for the planned scheme.

Operating — £35m per annum, an increase of 11% over Basic Core Railway estimate (£31.5 m) reflecting the extra train service considered necessary between Chadwell Heath and Liverpool Street.

4.5 The Reduced Scheme

4.5.1 The Stage 1 report indicated that the maximum returns (from both public and private sector viewpoints) could arise from a scheme embracing the planned network with stations at Moorgate, Tottenham Court Road and Bond Street. A scheme definition has been developed applying the same principles as for the Core Scheme, which in the operators' view should be adopted if a scheme is to be promoted in the consent process. It includes:

- A "CrossRail" service between Shenfield and Reading / Aylesbury, taking over the inner suburban services on both the Great Eastern and Thames Valley lines (in addition to part of the Chiltern and Metropolitan lines) using 8 car trains of newly built 20 metre long vehicles, meeting tunnel safety standards;

2: Platform length 283 metre (to accommodate 12 x 23 metre cars), initial train length 160 metres (8 X 20 metre cars). Outer station platforms would be 170m long (or existing if longer) to meet current HMRI requirements for one-person operation.

- A morning peak service of 22 trains per hour in each direction;
- Single ended stations at Moorgate (Amro Bank ticket hall), Tottenham Court Road (Astoria) and Bond Street (Davies Street) with 12-car platforms[3] and the sites of other stations and ticket halls safeguarded;
- Safety provision on trains and within infrastructure;
- Facilities at Central Area stations for mobility impaired users;
- Tunnel spoil removed by rail as existing project proposals;
- Noise and vibration mitigation measures including floating slab track where justified within the Noise and Vibration policy.

The scheme's Central London section is illustrated in Chart 2.

4.5.3 Costs

Capital £1639m (March 1990 prices) an 18% increase over the Basic Level 4 Railway cost of £1392m. The ring fenced expenditure is 80% of that for the planned scheme.

Operating £59m per annum (the same as for the Basic Railway scheme of this scope).

4.6 The Full Scheme

4.6.1 The full network with all central area stations, adopting the "realistic scheme" definition, i.e. excluding the discretionary "quality" elements (second ticket halls and metro rolling stock). The scheme's Central London section is illustrated in Chart 3.

4.6.2 Ring-fenced expenditure would be £1882m, an increase of 10% on the "Basic Railway" cost reported in Stage 1, and 91% of the planned scheme. Operating costs would be £67m p.a., a 3% increase over the Basic Railway Estimate (£65.2m).

4.7 Comment by the Railway Operators

By including safeguarding at the lower levels, the incremental costs of increasing the project scope are different in the Realistic Schemes. The costs now shown allow for future expansion to the planned scheme, although each is costed as if it were implemented in a single phase (i.e. no staging is assumed). The costs quoted in Stage 1 made no such allowance and were thus appropriate to once-for-all decisions with no thought of the future. The operators consider that, as the planned scheme was shown in the Stage 1 report to meet public sector investment criteria, any intermediate scheme should be capable of subsequent evolution to it and therefore the incremental costs as now presented are a better guide to decisions. A comparison between the Stage 1 incremental costs and those in the present study is given in Chart 4 at the back of the report, showing the share of the full project cost at each level.

3: Platform length 283 metre (to accommodate 12 x 23 metre cars), initial train length 160 metres (8 X 20 metre cars). Outer station platforms would be 170m long (or existing if longer) to meet current HMRI requirements for one-person operation.

4.8 Comment by the Private Sector (Provided by NatWest Markets)

4.8.1 In view of our approach of only assessing options which incorporate those quality features identified as necessary in the Stage 1 report, our comments in this section relate to whether provision should be made for the remainder of the scheme to be built at a later date. Therefore, the difference in our figures between the Realistic Schemes described in this chapter and the Basic Schemes described earlier relate principally to the 'safeguarding' of surface sites for future development.

4.8.2 The revenue figures provided to us for these cases carry different annualisation factors from those used earlier in both this and the Stage 1 report. These factors have been provided by LT Planning and are described in Chapter 5.

4.8.3 The results of the comparison of the Realistic Schemes are summarised below:

Table 4.8.1 Financial Appraisal: Realistic Schemes

	Core	Reduced	Planned
Government Contribution (£000s)	1,109,103	1,494,559	1,768,249
Private Sector Equity (£000s)	202,841	273,375	323,411
Bank Debt Drawn (£000s)	929,574	1,252,599	1,481,780
Total (£000s)	2,241,518	3,020,533	3,573,440
35 Year IRR (%)	14.17	17.51	17.18%
30 Year IRR(%)	13.44	17.08	16.72%
Minimum Debt Service Cover Ratio	1.01	1.34	1.31

4.8.4 From a purely financial perspective, the Realistic Reduced Scheme is clearly the most attractive. The private sector would consider very carefully the question of whether or not safeguarding of the remainder of the project was necessary but, as already indicated, we believe that the other quality increments are a necessity.

4.9 Summary

4.9.1 The Realistic Schemes could, in the operators' view, be promoted as acceptable. The principal issue raised in promoting any scheme of lesser scope than the planned scheme is that of safeguarding stations not scheduled for immediate construction. The operators consider that safeguarding is desirable given that the planned scheme appears a worthwhile proposition but recognise the financial implications and the private sector's lesser appetite for long-term investment. The inclusion of safeguarding (which has minimal effects on the Parliamentary process as most of the physical work is below ground) could be a feature which Government might wish to "buy" in consideration for its contribution.

5. ALTERNATIVE ALIGNMENT VIA KING'S CROSS

This chapter describes and comments on a "CrossRail" scheme via King's Cross, with reference to its costs and engineering and operational features. It is assessed in relation to the planned alignment in Chapter 6.

5.1 Introduction

5.1.1 An alignment via King's Cross was proposed by the Residents' Association of Mayfair as an alternative to the promoted scheme, as proposed from Liverpool Street to Farringdon and thence via King's Cross and Baker Street to Paddington. (Charts 5 and 6 illustrate the route through the Central Area). In the Association's view this served the major sources of traffic by linking the main line termini. In July 1992 the Association produced a plan which was used by the CrossRail Project Team as the basis of an engineering assessment and outline appraisal. The Farringdon to King's Cross section of that scheme also reflects the view of the London Borough of Tower Hamlets that CrossRail should provide the alignment for the Union Railways proposal for access to their proposed terminal at King's Cross.

5.1.2 In its full version the scheme has five central area stations:

	King's Cross Alignment	Planned Scheme Equivalent
1.	Liverpool St / Moorgate	Liverpool St / Moorgate
2.	Farringdon / Barbican	Farringdon / Barbican
3.	King's Cross / Euston	Tottenham Court Road
4.	Baker Street / Marylebone	Bond Street
5.	Paddington	Paddington

At King's Cross there would be a station beneath Euston Road with access directly to King's Cross / St Pancras and to Euston via a travelator. Baker Street station would lie beneath Marylebone Road, the eastern end connecting with the existing station and the western end to Marylebone station. At Paddington the station tunnels would lie to the east of the main line station beneath the Grand Union Canal Basin. Trains would reach the surface railways by ramps at Allen Gardens and Royal Oak as in the planned scheme.

5.1.3 The operators regard the design as equivalent to an early pre feasibility study (such as those carried out for the Central London Rail Study) prepared for debate with the petitioners. Specific design and construction concerns are:

Location	Concern
Farringdon	Further scheme development would be necessary to avoid conflict with the piled foundations of major buildings to the east of the station.
King's Cross / Euston	This station is very deep (35 metres), much of it in poor ground with unproven feasibility. More work would be necessary to ensure compatibility with the plans for the Chelsea Hackney line and Union Railways.
Baker Street / Marylebone	The proposed platform separation of 100 metres is undesirable and would increase station manning requirements. The alignment and platform layout in this area needs major design development to identify an acceptable solution.
Paddington	The design would need to be integrated and possibly constructed concurrently with the Paddington Basin development.
Existing piled building foundations	Current underground obstructions are uncertain. The planned scheme's development has demonstratetd that these have a major effect on alignment and costs.
Future Developments along Route	This has a major influence on scheme development but no enquiries have been made to identify possible constraints or conflicts.
Ground Conditions	"Bad ground" for tunnelling affects a higher proportion of the route than the planned alignment.

5.1.4 Some operational shortcomings have been identified, including the designs of the three stations, which would need to be addressed in any design development. Passenger flows at King's Cross and Baker Street stations would be heavily biased towards the eastern ticket halls, giving rise to uneven loading along trains and difficult management of the very large passenger flows (possibly 400,000 per day at King's Cross, compared to 216,000 now). In the light of HMRI requirements at other main line termini, a Joint Operations Room covering the BR terminals at King's Cross, St Pancras and Euston and also King's Cross / St Pancras and Euston Underground stations could be necessary, although this has not been allowed for in the capital or operating cost estimates. Location of the Paddington station beneath Paddington Basin is determined by the alignment necessary to serve Baker Street and renders the station remote from traffic generators other than the proposed development. Access to the existing British Rail and Underground stations would be by a lengthy subway, which is an unsatisfactory feature. For evaluation purposes, however, it has been optimistically assumed that some mitigation of these features could be achieved by design development without significantly increasing the total cost.

5.2 Scheme Definitions and Cost Estimating

In addition to the full scheme, notional schemes have been developed for "Core" and "Reduced" schemes to permit comparisons between the two routes at the three

scope levels evaluated for the planned alignment. These adopt the "Realistic Scheme" principles outlined in para 4.1 and exclude the discretionary "quality" items, second ticket halls and metro rolling stock. Details are given in Appendix 3.

5.2.1 The scheme definitions are the basis of construction cost estimates prepared by the CrossRail Project Team, using the same (March 1990) price levels as the planned scheme. The costs for the alternative alignment contain higher allowances for engineering uncertainty, i.e. a 22% addition to base costs compared to 12% on the planned scheme, although this is less than the allowances applied to the planned scheme when the CrossRail Bill was deposited in November 1991. Further details of the cost comparisons are given in Appendix 4.

5.2.2 The King's Cross route is similar in length to the planned scheme and train and station operating costs have been taken as broadly similar, with minor differences, such as lower fuel and lower track maintenance costs due to lesser forecast demand, offset by the larger central area stations compared to those on the planned alignment, requiring about 30% more platform staff.

5.2.3 The Core Scheme would comprise:

- A "CrossRail" service between Shenfield and Slough taking over the inner suburban services on both the Great Eastern and Thames Valley lines using new "Networker" type rolling stock meeting tunnel safety requirements;
- An AM peak service of 14 trains per hour eastbound / 16 trains per hour westbound;
- Single ended stations at Moorgate and King's Cross;
- Facilities for mobility impaired users;
- Environmental mitigation measures during construction (running tunnel spoil removed by rail) and operation (noise and vibration mitigation such as floating track slab).

The estimated costs are:

Capital:	£1479m (March 1990 prices), 9% more than the equivalent scope scheme utilising the planned alignment.
Operating	£36m per annum.

5.2.4 The Reduced Scheme would have:

- A "CrossRail" service between Shenfield and Reading / Aylesbury taking over the inner suburban services on both the Great Eastern, Thames Valley and part of the Chiltern and Metropolitan lines using new rolling stock meeting tunnel safety (but not Metro) requirements;
- An AM peak service of 22 trains per hour in each direction;
- Single ended stations at Moorgate, King's Cross and Baker Street;
- Facilities for mobility impaired users and environmental mitigation measures as in the Core Scheme.

The estimated costs are:

Capital: £1747m (March 1990 prices), 7% more than the comparable scheme utilising the planned alignment.

Operating £60m per annum.

5.2.5 The full scheme would add single-ended stations at Farringdon and Paddington and a train service of 24 trains per hour would run in the peak hour. The estimated costs are:

Capital: £2067m (March 1990 prices), 10% more than the equivalent scheme via the planned alignment.

Operating: £68m per annum.

5.3 Comment by the Railway Operators

5.3.2 The King's Cross alignment may be up to 10% more expensive to build than the planned alignment via Tottenham Court Road, principally because the stations at King's Cross and Baker Street are larger and more complex than those at Tottenham Court Road and Bond Street.

Station	Underground platforms (existing)	Underground platforms (after CrossRail and Chelsea - Hackney line)
King's Cross / Euston	14	18*
Baker Street / Marylebone	12	14
Tottenham Court Road	4	8
Bond Street	4	6

*: Includes Chelsea - Hackney line but excludes King's Cross Thameslink.

5.4 Summary

5.4.1 As an infrastructure project, the King's Cross alignment has shortcomings not present in the planned scheme which expose it to risk of construction cost overruns and to long term operating problems. However, the scheme's overall performance is dependent on its passenger and external benefits and on attractiveness to the private sector, issues addressed in the next Chapter.

6. TRANSPORT PLANNING AND ECONOMIC ASSESSMENT

This chapter presents the cost / benefit and financial evaluations of the three schemes (Core, Reduced and Planned) via each alignment and comes to a view on the alignment issue. CLRS demand forecasts are used throughout; alternative demand and evaluation assumptions are explored in Chapter 7.

6.1 Introduction

6.1.1 The Stage 1 work took the November 1991 evaluation for the planned scheme (using the LTS model) as a benchmark for evaluation of all options. In this chapter, that approach has been maintained in testing the three scheme options[1] via both alignments. The Benefit / Cost ratios for all tests are set out and discussed in para 6.3 below and the demand forecasts in para 6.4.[2]

6.1.2 As in Stage 1, particular attention is paid to certain benefits, reflected within the Benefit / Cost ratio, expected from the planned scheme, namely:

- Reduced journey times within the east-west corridor;
- Direct Access, improving Central Area public transport accessibility in the corridor directly served by the line;
- Congestion Relief along the east-west corridor, particularly on NSE services between Ilford and Liverpool Street, the Central Line between Liverpool Street and Chancery Lane, the Met/Circle line between Finchley Road and the City via Baker Street and the District and Piccadilly lines east and west of Earl's Court;
- Interchange Benefits, improving access through connection with:
  - nine Underground lines
  - thirteen Network SouthEast suburban lines
  - InterCity services at Reading, Slough, Paddington and Liverpool Street
  - (future) Heathrow Express
  - the bus network
- Relief of station congestion, particularly along the Central Line corridor in Central London and at the main line termini at Paddington and Liverpool Street.

These are discussed in para 6.5 below.

1: The tests employed the scheme definitions in Chapter 3 (for the proposed alignment) and Chapter 4 (for the Kings Cross alignment).

2 All demand forecasts for CrossRail contained in this chapter are based on the forecasts for the full scheme generated by the Department of Transport's LTS model with additional analysis using the London Transport Railplan model; the latter is a quicker and more readily available tool for studies of short duration. Results using this methodology are consistent within themselves and are strongly indicative of the conclusions which would be reached using the full LTS model. However, it is not possible to compare LTS generated forecasts directly with those from Railplan. Any conclusions drawn frrom the current study would be directly verified by use of the LTS model prior to final decision.

6.2 Evaluation Assumptions:

Capital Costs are derived from those quoted in Chapters 4 and 5, expressed in present values reflecting expenditure phasing, and including post-completion land and property recoverables. £17m has been added to each option to reflect the construction start deferral relative to that assumed in the cost estimates. The appraisal approach is as in Stage 1, i.e. cost elements with non-transport benefits (e.g. safety infrastructure) are excluded but environmental mitigation costs are included. "Networker" type rolling stock has been assumed in the Core and Reduced schemes, and "Metro" type in the Planned Scheme. In line with previous CrossRail evaluations, the costs of the Safety Measures Works at Tottenham Court Road[3] are excluded.

Operating Costs: are based on the revised services and associated changes outlined in Chapters 3 and 4.

Benefits: the LTS and RailPlan models generate benefits for the AM peak three-hour period, and an "annualisation factor" is applied to determine annual benefits. Each station has its own annualisation factor derived from the observed off-peak and weekend demand. The overall factor for the CrossRail network is an average for the stations served, weighted by the numbers of passengers at each. A specific annualisation factor has thus been calculated for each option tested[4]:

Planned Alignment:

- Core Scheme: 1025
- Reduced Scheme 1049
- Planned Scheme 1049

King's Cross Alignment:

- Core Scheme: 949
- Reduced Scheme: 954
- Full Scheme 976

The King's Cross alignment factors are lower because the route does not serve the West End, London's major off peak attraction with extensive shopping, leisure and tourist facilities.

Technical: construction is assumed to begin in 1996 with the service opening in 2001. Benefits and operating costs are assumed constant throughout the scheme's life. Net costs and benefits are based on the London-wide rail network, expressed in £m at 1990 prices, discounted over 30 years at 8% from a base year of 1993.

6.3 Results

The benefit / cost ratios are shown in tables 6.3.1 and 6.3.2 (planned alignment) and 6.3.3 and 6.3.4 (King's Cross alignment).

6.3.1 On the planned alignment, all schemes perform well, but the Core and Reduced schemes perform best. Incremental evaluation shows that the highest benefit / cost

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3: The "Astoria" ticket hall and escalator shafts to the Northern and Central lines.
4: In Stage 1, a common factor (1050) was applied to all options.

ratio is obtained by moving from the Core to the Reduced Scheme (1.8 : 1), and the step from the Reduced to the Planned Scheme is less than unity. This confirms the findings of the Stage 1 work.

6.3.2 A similar conclusion can be drawn for the King's Cross alignment, but performance is significantly worse at all scope levels for both benefits and costs.

Table 6.3.1 Social Cost / Benefit Evaluation: Planned Alignment

All figures are present values over 30 years; benefits are based on CLRS demand forecasts. No allowance for Union Railways terminal at King's Cross. Each option is compared to the "without CrossRail" situation.

Scheme	Central Area Stations	Capital Costs £m	Operating Costs £m	Net Cost £m	Net Revenue £m	Social Benefits £m	**Benefit / Cost Ratio**
Core (Shenfield - Slough, "Networkers")	Moorgate Tottenham Court Road	683	41	724	205	997	**1.7**
Reduced (Full Network, "Networkers")	Moorgate Tottenham Court Road Bond Street	864	60	925	274	1293	**1.7**
Planned (All features)*	Five Stations	1272	112	1383	323	1646	**1.4**

*: The LTS - based evaluation of the planned scheme acts as the benchmark.

Table 6.3.2 Social Cost / Benefit Evaluation: Planned Alignment - Increments

All figures are present values over 30 years; benefits are based on CLRS demand forecasts. No allowance for Union Railways terminal at King's Cross.

Scheme Change	Additional Central Area Stations	Capital Costs £m	Operating Costs £m	Net Cost £m	Net Revenue £m	Social Benefits £m	**Benefit / Cost Ratio**
Core > Reduced (Full Network, same rolling stock)	Bond Street	181	19	201	69	296	**1.8**
Reduced > Planned	Farringdon Paddington	408	52	458	49	353	**0.9**

Table 6.3.3 Social Cost / Benefit Evaluation: King's Cross Alignment

All figures are present values over 30 years; benefits are based on CLRS demand forecasts. No allowance for Union Railways terminal at King's Cross. Each option is compared to the "without CrossRail" situation.

Scheme	Central Area Stations	Capital Costs £m	Operating Costs £m	Net Cost £m	Net Revenue £m	Social Benefits £m	**Benefit / Cost Ratio**
Core (Shenfield - Slough, "Networkers")	Moorgate King's Cross	783	46	829	214	785	**1.2**
Reduced (Full Network, "Networkers")	Moorgate King's Cross Bond Street	966	65	1032	266	1039	**1.3**
Planned (All features)*	Five Stations	1429	117	1546	300	1398	**1.0**

*: The LTS - based evaluation of the planned scheme acts as the benchmark.

Table 6.3.4 Social Cost / Benefit Evaluation: King's Cross Alignment - Increments

All figures are present values over 30 years; benefits are based on CLRS demand forecasts. No allowance for Union Railways terminal at King's Cross.

Scheme Change	Additional Central Area Stations	Capital Costs £m	Operating Costs £m	Net Cost £m	Net Revenue £m	Social Benefits £m	**Benefit / Cost Ratio**
Core > Reduced (Full Network, same rolling stock)	Baker Street	183	19	203	52	254	**1.5**
Reduced > Planned	Farringdon Paddington	463	52	514	34	359	**0.8**

6.3.3 The difference in total scheme benefits is 15%, but this masks a major difference within the central area, as many of the benefits are contributed by the outer sections common to both alignments. Taking as an illustration a "base case" comprising only Paddington, Farringdon and Liverpool Street, the relative value of adding Bond Street / Tottenham Court Road against that of Baker Street / King's Cross can be assessed. Table 6.3.5 shows the incremental AM peak time savings:

Table 6.3.5 Relative values of Central Area stations

Comparison with notional base scheme; CLRS forecasts; no allowance for Union Railways terminal at King's Cross.

Test	Hours Saved
Addition of Bond Street & Tottenham Court Road	8040
Addition of Baker Street and King's Cross	2194
Baker Street / King's Cross as % of Bond Street / Tottenham Court Road	27%

6.4 Demand

6.4.1 The following tables show two measures of demand, numbers of boarding passengers and increase in total network passenger miles travelled, in each case as a percentage of the planned scheme forecast. Both tables refer to the AM peak three hours.

Table 6.4.1 Boarding Passengers (% of planned scheme)

CLRS forecasts; no allowance for Union Railways terminal at King's Cross.

Alignment	Core Scheme ("Networkers")	Reduced Scheme ("Networkers")	Planned / Full Scheme (Metro stock)
Planned	61	80	100
King's Cross	61	76	89

Table 6.4.2 Net Increase in Passenger Miles (% of planned scheme)

CLRS forecasts; no allowance for Union Railways terminal at King's Cross.

Alignment	Core Scheme ("Networkers")	Reduced Scheme ("Networkers")	Planned / Full Scheme (Metro stock)
Planned	65	85	100
King's Cross	73	91	100

6.4.3 The difference between the measures indicates that, despite lower usage of the King's Cross alignment schemes, there is a greater increase in passenger miles than with the planned alignment. This shows that average trip length via King's Cross is longer due to the need to change to other lines to reach the final destination.

6.5 Other Passenger Benefits

This section compares the two routes by reference to the factors in para 6.1.2.

6.5.1 Direct Access to Central London: the principal employment and leisure areas lie within walking distance of stations on the planned route, but are remote from those on the King's Cross route. Charts 7 and 8 (at the end of the report) show areas better served by each routes respectively; it can be seen that there are virtually no areas where the King's Cross alignment offers better access to Central London.

6.5.2 Congestion Relief: CLRS forecasts predicted that several sections on the Underground would be crowded[5], including:

- Marylebone - Oxford Circus (Bakerloo);
- Leyton - Chancery Lane (Central);
- Finchley Road - Bond Street (Jubilee);
- King's Cross - Farringdon (Metropolitan)
- Northwick Park - Great Portland Street (Metropolitan);
- Baron's Court - Green Park (Piccadilly)

Tables 6.5.1 and 6.5.2 compare the alignments using two measures employed in congestion modelling; "crowded hours", a weighted time reflecting the severity of crowding and the "crowding ratio", a load factor indicator. They show clearly that the King's Cross alignment achieves less overall congestion relief than the planned, also that it is less effective in relieving crowded sections of the Underground; it is more effective on only one of the links listed, is equal or less effective on others and in one particular sensitive case (Piccadilly Line south from King's Cross), crowding would be made worse than in the "no CrossRail" case.

Table 6.5.1 Crowding Relief (% of planned scheme)

Figures are the percentage of the forecast reduction in AM peak "crowded hours" from the planned scheme achieved by each option. Figures in brackets on the bottom row are the percentage of a planned alignment scheme achieved by the equivalent King's Cross alignment scheme. CLRS forecasts; no allowance for Union Railways terminal at King's Cross.

Alignment	Core Scheme ("Networkers")	Reduced Scheme ("Networkers")	Planned / Full Scheme (Metro stock)
Planned	52	79	100
King's Cross	50 (96%)	72 (91%)	95 (100%)

5: "Crowded" is defined as demand exceeding the planning guideline, approximately one person standing per seated passenger. The "crowding ratio" is the demand / planning guideline ratio; links with a ratio exceeding 1 are considered crowded and with a ratio exceeding 1.2 severely crowded.

Table 6.5.2 Crowding on Key Links

Table shows crowding ratios in the AM peak hour. CLRS forecasts; no allowance for Union Railways terminal at King's Cross.

Link	Base Case (no CrossRail)	Planned Scheme	Full Scheme (via King's Cross)
Marylebone - Oxford Circus	1.12	0.91	1.01
Leyton - Chancery Lane	1.30	1.00	1.13
Finchey Road - Bond Street	1.08	0.92	0.98
Northwick Park - Great Portland Street	1.08	0.90	0.90
Baron's Court - Green Park	1.11	1.02	1.00
King's Cross - Farringdon	1.04	0.91	1.04
King's Cross - Oxford Circus	1.28	1.25	1.28
King's Cross - Leicester Square	1.26	1.23	1.41

6.5.3 Interchange benefits arise from new direct access reducing the need to interchange, and from creation of new interchanges which open up new journey opportunities. Table 6.5.3 compares interchanges for the planned scheme and the full scheme via King's Cross, showing that the King's Cross route offers the greatest number.

Table 6.5.3 Interchange with Underground and British Rail lines

Planned scheme via Tottenham Court Road; Full scheme via King's Cross

Alignment	Underground lines connecting with CrossRail	Interchange with BR lines (in central area)	InterCity Interchanges	Interchange with Heathrow Express?
Planned	Bakerloo Central Circle / District Hammersmith & City Jubilee Meropolitan Northern (Charing Cross branch) Northern (City branch)	Great Eastern Thameslink West Anglia Great Northern Northampton Thames	Reading Slough Paddington Liverpool Street	Yes
King's Cross	Bakerloo Central Circle / District Hammersmith & City Jubilee Meropolitan Northern (Charing Cross branch) Northern (City branch) Piccadilly Victoria	Great Eastern North London Thameslink West Anglia Great Northern Northampton Thames Chiltern	Reading Slough Paddington Euston St Pancras King's Cross Liverpool Street	Yes

The King's Cross alignment requires greater interchange opportunities as the modelling suggests that a significantly larger proportion of passengers will need to change to reach their final destination. Table 6.5.4 compares the percentages of CrossRail passengers changing trains at the central area stations and shows that, except at Farringdon, the proportion of passengers reaching their final destination by CrossRail is lower on the King's Cross alignment.

Table 6.5.4: Percentage of CrossRail Passengers Interchanging

Planned / Full schemes; AM peak period; CLRS forecasts; no allowance for the proposed Union Railways terminal at King's Cross.

Planned Alignment		King's Cross Alignment	
Station	% of CrossRail Passengers changing	% of CrossRail Passengers changing	Station
Paddington	39	50	Paddington
Bond Street	27	81	Baker Street
Tottenham Court Road	44	58	King's Cross
Farringdon	16	5	Farringdon
Liverpool Street	32	42	Liverpool Street

Sources: Planned alignment: "Design Year Forecasts" (LT Planning, February 1993). King's Cross alignment: RailPlan results

The implications for the existing Underground infrastructure of accommodating these flows, at the interchange stations and on the onward links, have not been investigated in this study. Some of these flows would use areas already operating at or above capacity and further examination could show a need for capacity enhancements beyond the CrossRail areas.

6.5.4 Station Congestion Relief: a CrossRail objective is to relieve congestion at key Underground stations, particularly Liverpool Street and Oxford Circus. Table 6.5.5 compares the alignments in respect of changes to movements within three important stations, showing that the planned scheme is much more effective in relieving congestion at Oxford Circus and particularly in reducing ticket hall movements, the location of which makes expansion very difficult. The effects at Paddington and Liverpool Street are similar, the planned scheme offering slightly more relief at Liverpool Street. The conclusion is that the planned scheme has a wider station congestion relief benefit than a scheme via King's Cross.

Table 6.5.5 Station Movements

Planned / Full schemes compared to "no CrossRail"; AM peak period; CLRS forecasts; no allowance for the proposed Union Railways terminal at King's Cross.

Station	Passenger Flow	Planned Alignment	King's Cross Alignment
Paddington	To / from BR trains	- 38%	- 38%
Oxford Circus	Total	- 13%	- 6%
	Interchanges	- 8%	- 10%
	To / from street	- 18%	- 1%
Liverpool Street	To / from BR trains	- 32%	- 30%

6.6 Implications of Union Railways terminal at King's Cross

6.6.1 Current plans are for the Channel Tunnel Fast Link to be used by both international and Kent domestic services with a terminal at King's Cross. This section examines the implications for domestic passengers of a CrossRail scheme via King's Cross; the volume of international passengers is not expected to be significant enough, particularly in the peak periods, to change the conclusions.

6.6.2 Would Union Railways benefit from a CrossRail scheme via King's Cross? Chart 9 shows that the majority of Union Railways AM peak domestic passengers require the City and West End. For onward travel to the City, access to the existing Underground lines will be quicker and easier than to the CrossRail station which will be very deep and thus few are likely to choose CrossRail. The chart also shows that the proportion of passengers travelling west from King's Cross is also small; again the stations' relative accessibility will discourage choice of CrossRail.

6.6.2 What would be the combined effect of Union Railways and CrossRail at King's Cross? Para 6.5.2 showed that, without taking the Union Railways plan into account, congestion on lines radiating south from King's Cross could be increased. In view of the proportions of Union Railways passengers requiring the West End destinations served by these lines, those problems would be further aggravated.

6.7 Comment by the Railway Operators

6.7.1 The King's Cross alignment performs less well on every measure of passenger benefit and operational performance. Connection with the Union Railways terminal at King's Cross is of no practical advantage, as the CrossRail service could neither distribute passengers to their final destination nor attract passengers from the existing lines which it would duplicate. It could also aggravate existing congestion problems on the Victoria and Piccadilly lines, which will be addressed by the other main CLRS scheme, the Chelsea - Hackney Line. Perversely, a CrossRail scheme via King's Cross could advance the need to construct this new line rather than complement it as will the planned scheme.

6.7.2 Of the planned alignment schemes, the two smaller options appear capable of safe and reliable operation while being capable of evolution to the planned scheme in the longer term. All scheme levels satisfy public sector criteria but a final view on which could be taken forward must await the private sector appraisal which follows.

6.8 Comment by the Private Sector (contributed by NatWest Markets)

6.8.1 This section addresses the financial attractiveness of alternative alignments, at each of the three scope levels.

Table 6.8.1 Financial Appraisal of Scheme and Route Options

	Planned Alignment			King's Cross Alignment		
	Core	Reduced	Planned	Core	Reduced	Full
Government Contribution (£000)	1,109,103	1,494,559	1,768,249	1,134,532	1,507,153	1,842,800
Private Sector Equity (£000)	202,841	273,375	323,411	207,491	275,647	337,088
Bank Debt Drawn (£000)	929,574	1,252,599	1,481,780	951,100	1,263,344	1,544,338
Total (£000)	2,241,518	3,020,533	3,573,440	2,293,123	3,046,144	3,724,226
35-year IRR (%)	14.17	17.51	17.18	12.34	14.55	13.80
30-year IRR (%)	13.44	17.08	16.72	11.33	13.87	13.04
Minimum Debt Service Cover Ratio	1.01	1.34	1.31	0.86	1.06	0.99

6.8.2 As highlighted in the operators' comments, the capital costs of the King's Cross alignment are moderately higher than for the planned alignment, and the combination of this with the reduced revenues suggests that the King's Cross option is unlikely to be financeable. We also believe that there is an intangible factor here in that, when attracting private finance, a general confidence level must be easily

attained. We believe this to be instinctively the case for the planned alignment and rather more questionable for the King's Cross alignment.

6.9 Conclusions

6.9.1 The view reached in Stage 1 that the Reduced Scheme appears to offer the maximum return on investment, from both public and private sector criteria, is confirmed. However, the range of station options must be noted and flexibility to adopt any of them retained.

6.9.2 The view in Stage 1 that the Planned Scheme can meet public and private criteria is also confirmed. However, in contrast to the view reached at Stage 1, the Core Scheme does not now appear viable as a joint venture because of the inclusion of costs of safeguarding; it has also been affected by the general application of more pessimistic financial appraisal assumptions.

6.9.3 The CrossRail schemes via King's Cross are worse than the planned alignment equivalents on public and private criteria, as well as on engineering and operational considerations. The railway operators have no hesitation in recommending rejection of this alignment option.

CHAPTER 7: EFFECT OF REVISED DEMAND FORECASTS

7.1 Introduction

7.1.1 The evaluations in Chapter 6 retain the planning and technical assumptions used since the November 1991 LTS - based evaluation, including the Stage 1 work. In this chapter, a new evaluation framework is adopted, with updated project benefits and revised demand forecasts. The effect of project and technical changes is first illustrated by an updated evaluation using CLRS demand forecasts; this is followed by evaluations using more conservative forecasts derived from recent work which gives the current "best estimate" of future demand. Finally, a sensitivity test is shown, illustrating the effect if the assumed rolling stock "cascade" could not be achieved and the whole CrossRail fleet had to be financed by the project.

7.1.2 The Planned Scheme is evaluated throughout this chapter; in the time available it has not been possible to conduct equivalent evaluations of the Core and Reduced Schemes, although the relative values shown in Chapter 6 could be expected to apply.

7.2 Benefits

7.2.1 The evaluations in Stage 1 and Chapter 6 assumed the November 1991 scheme definition, since when the normal project development processes (outlined in Appendix 7) have brought about improvements in the train service and station layout plans which have been incorporated into the RailPlan tests reported in this Chapter. Further "technical" changes have been made in the definition of the links between stations and the surrounding origin / destination zones within the model. The scheme's user benefits have consequently improved by some 25%, of which 12% reflects train service and journey time improvements, 9% better station layouts and 4% the technical changes.

7.2.2 In the longer term, the revised scheme definition will be incorporated into LTS model runs. Meanwhile the economic assessments in this chapter conservatively assume only a 20% increase in "passenger hours" benefits compared to the November 1991 evaluation; this leads to a 11% increase in revenue and road user benefits.

7.2.3 The treatment of capital costs is different from Stage 1 and Chapter 6. The costs shown in the evaluation tables include the "non-discretionary quality" items identified in Chapters 4 and 5. Benefits of these items cannot be quantified in transportation modelling, so a notional benefit equal to the cost has been included to reflect the value placed on them by society. This is a conservative estimate as the benefits of some, especially the safety items, are likely to exceed the costs.

7.2.4 A review is under way to identify further sources of benefit not included in the present evaluation. Initial estimates (see Appendix 5) suggest that their value could be substantial and work will continue to establish values acceptable for evaluation purposes.

7.3 Costs:

7.3.1 Capital costs used in the evaluation are the median costs reported in Chapters 4 and 5, including items referred to in para 7.2.3, but excluding the cost of the Tottenham Court Road Safety Measures. The effect of diminishing contingency allowances has been to reduce the non-discounted "evaluation cost" from £1909m

in November 1991 to £1871m now (both at March 1990 prices for comparison purposes).

7.3.2 Operating costs used are the net increase in rail network costs; the most recent assessment is £18.5m p.a. (1993 prices), with a present value of £126m.

7.4 Technical Changes

i) The November 1991 evaluation discounted back to 1991, the present to 1993. This increases Net Present Values for both costs and benefits but would have no effect on the benefit / cost ratio if costs and benefit assumptions remained unchanged.

ii) Costs and benefits have been uplifted to 1993 prices, costs by 9% in line with the Construction Cost Index and benefits by 13% in line with the GDP inflator.

7.5 Comparison of Evaluation Results

Table 7.5.1 sets out the effect of the successive changes in assumptions and method between November 1991 and this work, showing an improvement in the benefit / cost ratio from 1.3 : 1 to 1.69 : 1.

Table 7.5.1: Planned Scheme Evaluations

All assuming CLRS demand forecasts; no allowance for Union Railways terminal at King's Cross. Costs, benefits and revenue shown as present values, discounted over 30 years at 8%.

	Capital Costs £m	Operating Costs £m	Net Cost £m	Net Revenue £m	Social Benefits £m	**Benefit / Cost Ratio**
Bill Deposit (November 1991, 1990 prices)	1352	95	1447	321	1563	**1.30**
Stage 1 Report (September 1993, 1990 prices)	1269	112	1380	323	1593	**1.39**
Present Report, Table 6.3.1 (September 1993, revised to 1993 prices)	1353	126	1479	361	1842	**1.49**
Revised Evaluation (December 1993, 1993 prices)	1431	126	1557	422	2210	**1.69**

7.6 Revised Demand Forecasts

7.6.1 CLRS formed a view of employment, population etc., which was then assumed to remain steady throughout the scheme's life. The assumptions were fed into the LTS model to provide traffic forecasts and economic evaluations. However, with the subsequent recession, that scenario must now be considered optimistic.

7.6.2 Recent work within London Transport[1] has updated Central London employment assumptions, drawing both on forecasts from other sources and on trends in estimated employment over the past decade. The key future influence is likely to be the long term "equilibrium" levels of financial and business services employment. "High", "Central" and "Low" employment scenarios have been prepared for CrossRail evaluation purposes, shown in Chart 10 at the end of this report. These have also taken into account implications for the usage of existing and projected Central London office space. It will be evident that the "Low" forecast assumes only a small recovery from the present recessionary demand levels and is thus a pessimistic assumption.

7.6.3 Table 7.6.1 sets out the planned scheme evaluation results arising from the "CLRS", "Central" and "Low" employment projections.

Table 7.6.1: Planned Scheme: Alternative Employment Assumptions

No allowance for Union Railways terminal at King's Cross. Costs, benefits and revenue shown as present values, discounted over 30 years at 8%.

	Capital Costs £m	Operating Costs £m	Net Cost £m	Net Revenue £m	Social Benefits £m	**Benefit / Cost Ratio**
Revised Evaluation: CLRS forecast	1431	126	1557	422	2210	**1.69**
"Central" forecast	1431	126	1557	403	1960	**1.52**
"Low" forecast	1431	126	1557	390	1740	**1.37**

7.6.4 The above assume that the full service planned for the CLRS - based "reference year" would be operated. This makes these evaluations pessimistic, as such a service would be excessive in relation to demand and the opportunity would be taken to reduce operating costs. While revenue and social benefits would reduce, the benefit / cost ratio could be expected to improve.

7.7 Financing of Rolling Stock

7.7.1 The above evaluations continue the assumption that some CrossRail rolling stock would be financed from the operators' core budgets, on the basis that new stock, albeit of different types, would be needed elsewhere on the network even if CrossRail did not proceed. With CrossRail, this would be provided by the non-expired stock presently operating the services to be incorporated into the CrossRail network (as it will not be suitable for CrossRail operations). If these assumed "cascades" could not take place, the CrossRail project could have to bear up to £337m more costs (of which £129m is safety-related). The railway operators have reviewed these assumptions and consider that, notwithstanding the uncertainties arising from British Rail privatisation, "cascading" is still a reasonable planning assumption. This is explained further in Appendix 6.

1: Central London Employment Projections for Evaluating CrossRail: H Abrahams (Annex to Strategic Proof of Evidence to the CrossRail Bill Select Committee, December 1993).

7.7.2 As a sensitivity test, table 7.7.1 shows the effect of being obliged to finance all rolling stock. The social benefits are increased in relation to those shown in table 7.6.1 in line with the approach outlined in para 7.2.3 to reflect the benefits of the safety provisions in the additional vehicles financed by the project under this assumption.

Table 7.7.1: Planned Scheme: Alternative Employment Assumptions

No allowance for Union Railways terminal at King's Cross. Costs, benefits and revenue shown as present values, discounted over 30 years at 8%.

	Capital Costs £m	Operating Costs £m	Net Cost £m	Net Revenue £m	Social Benefits £m	**Benefit / Cost Ratio**
Revised Evaluation: CLRS forecast	1670	126	1796	422	2302	**1.52**
"Central" forecast	1670	126	1796	403	2051	**1.37**
"Low" forecast	1670	126	1796	390	1832	**1.24**

7.7.3 The qualification regarding service levels (see para 7.6.4) applies and thus the evaluations here may be regarded as the worst case assumptions.

7.8 Summary

7.8.1 The planned scheme's "best estimate" benefit / cost ratio may now be regarded as 1.52 : 1, falling to 1.37 : 1 with a minimal increase above current recessionary demand levels. The "worst case" assumptions produce a ratio of 1.24 : 1. Further potential benefits have been identified and work will continue on their assessment.

7.8.2 Overall, the planned scheme appears robust to changes in demand and financing assumptions.

8. FINANCIAL APPRAISAL (Contributed by NatWest Markets)

8.1 From the initial analysis we have undertaken using information supplied to us by British Rail and London Transport, the most attractive scheme from a private sector perspective is the Reduced Scheme via the planned alignment.

8.2 We believe there is a high level of conservatism built into our figures due to:

Property recoverables have been excluded (at Stage 1, 50% of the operators' estimate was assumed);

"Central" demand assumptions have been used, but capped to 85% of the level assumed by LT Planning;

No real increase in ticket prices has been assumed after opening;

Revenues from existing Network SouthEast lines have not been included; this structural matter which has a moderately positive effect remains an outstanding issue;

Other possible revenue sources, e.g. advertising, have been excluded;

No account has been taken of any reduction in operating costs due to the project transferring to the private sector; and

Other financing techniques providing cash flow benefits, particularly leasing, have not been taken into account.

8.3 Assumptions

8.3.1 Capital Expenditure: London Transport has provided us with estimates for the original analyses undertaken (amended for minor errors), for the "Realistic" schemes including the "quality" and safeguarding elements and for the King's Cross alignment. As with our original evaluation, we have added a £50m contingency to cover owner's costs. All costs are at March 1990 prices and since the Baxter Index of construction tender prices shows no increase between March 1990 and March 1993, we have only inflated these costs at the general RPI inflation rate from March 1993 onwards to calculate the actual costs incurred. The cost used for the Planned Scheme (base case) totals £2595m at March 1990 prices. As before, we contemplated a £1000m private sector debt contingency facility to meet cost overruns.

8.3.2 Revenues: we have calculated annual revenue streams using the annualised peak passenger kilometre figure provided by London Transport and factoring in the following assumptions:

CrossRail will open in 2001;

No increase in passenger miles;

Gross Revenues have been increased by about 12% reflecting scheme improvements (described in para 7.2.1);

Revenue / passenger mile (17.648p) has been estimated by increasing the actual figure (16.07p) in line with the RPI increases for 1991 (5.9%) and 1992 (3.7%). The resulting total revenue has been decreased in line with LT Planning's "Central" demand forecast produced for this report, but capped at 85% of the LT level. On the current programme this level is achieved in year 2005.

8.3.3 Operating Costs have been provided by Network South East. For the review of the Stage 1 work (Chapter 3), it was not possible to distinguish operating costs between different station combinations although this would be worked on in future evaluations if necessary.

8.3.4 Macroeconomics: we have retained our previous assumptions, i.e. 4% inflation until 1997 and 5% thereafter with real interest rates of 3.5% (i.e. LIBOR 7.5% until 1997 and 8.5% thereafter).

8.3.5 Financing - Base Case Assumptions

Government Contribution:	£1768m (49.48%)
Private Sector Equity:	£ 323m (9.05%)
Bank Debt;	£1482m* 41.47%)

*: Plus standby contingency facility of £1000m.

Government Contribution:

50% drawndown first and then further 50% drawndown pari passu with Bank Debt after Private Sector Equity has been drawn.

Private Sector Equity:

Amount:	£323m
Paid in 1996:	£320m
Paid in 1997:	£3m
Dividends Commence:	2008
IRR (35 years):	17.18%
IRR (30 years):	16.72%

Bank Debt:

Amount Available:	£2482m
Maximum Amount Drawn:	£1482m
Start of Commitment:	1 January 1996
First Drawdown:	2nd half 1997
Final Maturity:	2010
Interest Margin:	1.75% until 2002, 1.5% thereafter
Commitment Fee:	0.75%
Minimum Project Life Cover Ratio:	2.55
Minimum Loan Life Cover Ratio:	1.68
Minimum Annual Debt Service Cover Ratio:	1.31

8.4 Sensitivity Analysis on the Planned Scheme

8.4.1 In view of time constraints, revenue data has been produced only for the planned scheme. In all previous assessments, the Reduced Scheme has produced slightly better results and it is reasonable to assume that this would be the case as far as

the sensitivity analysis is concerned. For the purposes of this report, the results may be considered to be improved for the Reduced Scheme. The results of the following tests are set out in Appendix 8:

1 Senior Bank Debt on commitment from 1994 (versus 1996)

2 Capital expenditure increased by 15%

3 Capital expenditure increased by 25%

4 Capital expenditure increased by 30%

5 Operating costs increased by 50%

6 Inflation reduced to 3% from 2001

7 Revenues decreased by a further 15%

8 Revenues decreased by a further 30%

8.4.2 The results show that the projected revenues provide a satisfactory project for the private sector. Although the return is at the lower end of what would be acceptable, we have used conservative assumptions and believe that a reasonable case can be made for a private sector contribution of the same magnitude as previously discussed. We would draw particular attention here to the absence of any operating cost reduction, which might be expected to occur in transferring the project to the private sector, no real increase in ticket prices over the project's life and no increase in passenger traffic beyond the fifth year of operation.

8.5 Public SectorBenefit / Cost Analysis

8.5.1 This section addresses the issue of the return to the public sector in a joint venture. Prior to the Private Finance Initiative, infrastructure projects were financed either in the public or in the private sector, sometimes with a government contribution by way of, for example, approach roads to bridges, and so benefit / cost issues were comparatively straightforward. The active encouragement of joint ventures by the government raises important new issues for public sector cost : benefit analysis. For a true private / public joint venture project such as CrossRail, the public sector benefit / cost analysis is more complicated because, rather than considering the whole project, the analysis is limited to that proportion of the costs and revenues that are solely attributable to the public sector.

8.5.2 Since just over half of the capital costs and all of the operating costs for the CrossRail Project are borne by the private sector, the public sector capital costs are comparable with the savings in London Underground's and British Rail's operating costs (a result of their loss of passengers to CrossRail). Thus the net public sector costs are negligible. This leads to the possibility of exceedingly high, if not infinite returns for the public sector. We believe that this situation is new, arising from the Private Finance Initiative and this section attempts to demonstrate the very conservative nature of the benefit / cost figures being presented.

8.5.3 Project Related Costs and Benefits

The core project costs are those required whether the project proceeds or not. They are independently justifiable simply to maintain the current network to current standards. Therefore, when performing a cost benefit analysis on a new project, the only costs that should be considered are the non-core costs, i.e. the ring-fenced

costs. Similarly, the only benefits attributable to the project are those that would not otherwise have been obtained.

The following analysis is therefore based on the increase in costs and the increase in benefits which are directly attributable to the public sector from the Crossrail project.

It should be noted that, in the figures supplied to us by LT Planning:

the benefits of upgradeability, safety infrastructure and rolling stock are assumed to be equal to their cost;

mobility impaired access is included as a (ring-fenced) cost but is not included in the benefits;

the cost of safety works at Tottenham Court Road is deducted from the ring-fenced costs because it would still have to be incurred if CrossRail did not proceed;

recoverable property costs are deducted from the ring-fenced costs; and

£17m is added to the ring-fenced costs for the delayed start of construction due to Royal Assent Planning.

8.5.4 The Discount Factor

The discount factor, used to evaluate the net present value of the cost, revenue and benefit flows, significantly influences the result of the cost benefit analysis. A lower discount factor naturally increases the effect of more distant 'fund-flows'. In a classic investment-return scenario, with a lump sum investment up-front followed by returns spread over a number of years, a lower discount factor increases the expected return on the project by increasing the present value of future cash flows.

Theoretically, for every project there is one 'correct' discount factor. However, determining this factor is an inexact science. S.G. Warburg, in their report on the CrossRail Project for the Department of Transport produced earlier this year (Spring 1993), used the average real cost of borrowing in the gilt market (4%). The Monopolies and Mergers Commission's report on gas supply and British Gas (17 August 1993) argues for a discount factor based on index-linked gilts with a risk premium of 2.5-3%. This produces a real cost of capital of 5.8-6.3% (assuming a 3.3% index-linked real gilt rate).

The Technical Guide to Economic Appraisal in Central Government (April 1991 - the 'Green Book') uses the average real cost of borrowing in the gilt market and adds premiums to this for opportunity costs, costs of taxation to fund public expenditure, and market risks. For public sector projects that do not have significant market risks a low risk cost of capital of 6% is assumed. For public sector projects that do have market risks, road and rail projects being specifically identified, a cost of capital of 8% is assumed.

For a public/private sector joint venture where the private sector takes a large proportion, if not all, of the market risks, the Green Book low risk rate of 6% appears to be justifiable, even for a rail project, and it could be argued that an even lower rate was appropriate.

8.5.5 Results

The following is the latest data that have been supplied to us by LT Planning for public sector costs and benefits, based on the Revised Economic Assessment (see Chapter 7). Only data for the Planned Scheme have been received. The data use 1993 prices and discounts 'fund flows' back to 1993 at a real discount factor of 8%.

Table 8.5.1: Public Sector Return in a Joint Venture

Planned Scheme: assumptions consistent with revised economic assessment (Chapter 7); costs and benefits in £m at 1993 prices discounted over 30 years back to 1993.

Employ-ment Case	Discount Factor	Social Benefits	LU/BR Revenue	Net Benefit	Public Capital Exp'ure	LU/BR Costs	Net Costs	Benefit : Cost Ratio
CLRS	8%	2,210	(1,612)	598	701	(373)	328	1.83
Central	8%	1,959	(1,539)	421	701	(373)	328	1.29
Low				251	701	(373)	328	0.76

Source: LT Planning 23/12/93

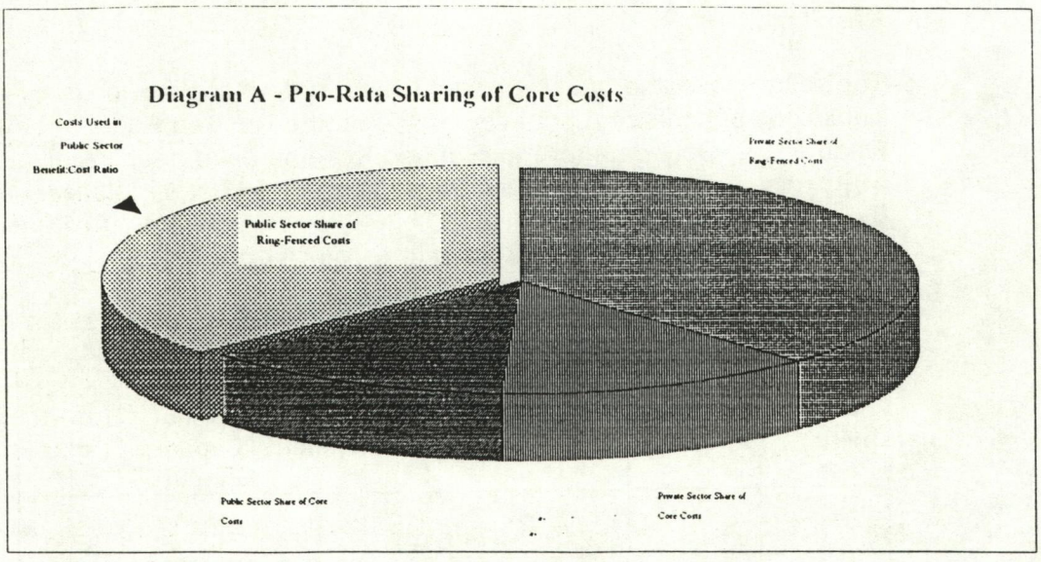
The equation used to calculate the benefit / cost ratios is that used by the Department of Transport[1], comparing the net increase in benefits to 'the Country' which would not otherwise have been accrued, against the net increase in costs to 'the Country'. The benefit / cost ratio for the Central employment case is almost exactly on the London Transport 1.3 : 1 target. The figures, however, are conservative in three respects:

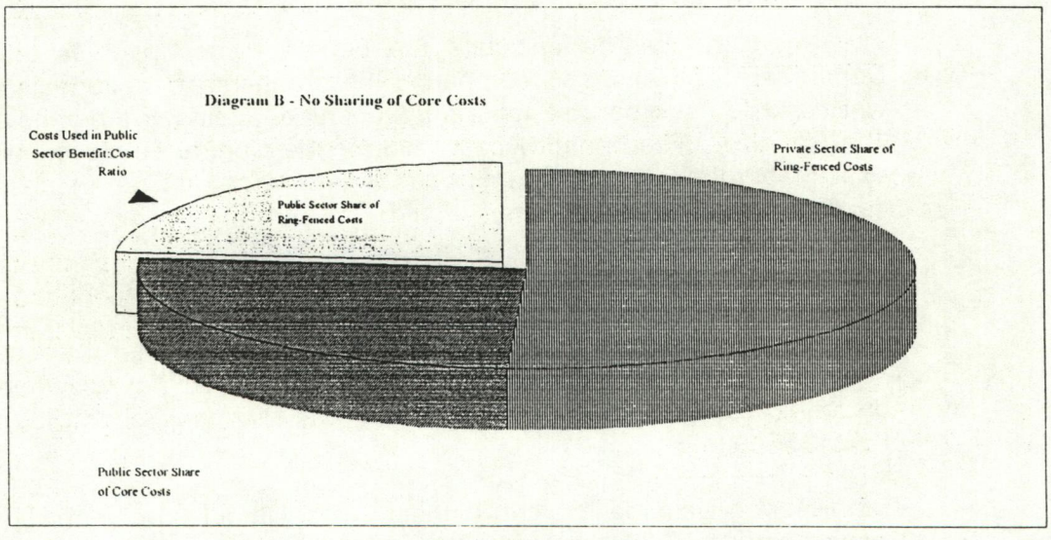
the 8% discount factor used, as discussed in section 7.4.2 above, is highly conservative. If the discount factor is reduced to 6% even the Low Employment Case will probably produce a benefit / cost ratio of greater than 1.3. This can be seen from the Last Complete Data Set table given below, where reducing the discount factor from 8% to 6% increases the Planned Scheme benefit / cost ratio from 1.57 to 8.26;

the Planned Scheme has the highest costs without proportionally higher benefits when compared with the Reduced Scheme. Consequently, the Reduced Scheme intrinsically has a higher benefit / cost ratio; and

the public sector share of the capital expenditure is calculated assuming that the ring-fenced costs are split between private and public sector pro-rata with the split of the total project cost (Diagram A below). This is a conservative assumption because the core costs would have to have been paid for by the public sector alone if the CrossRail project did not go ahead. It can therefore be argued that all of the core costs are attributable solely to the public sector leaving a larger proportion of the ring-fenced costs attributable to the private sector. A lower proportion of the benefit related costs is thus attributable to the public sector (Diagram B below). If, for example, the ring-fenced costs attributable to the public sector are decreased by only 10% to 39%, the low employment case produces a benefit / cost ratio of 1.35 : 1.

1: (Social Benefits + Revenue) divided by (Capital Expenditure + Operating Costs)





8.5.6 We would expect data for the other schemes and discount rates to show that very much higher benefit / cost ratios will be achievable. This statement is based on extrapolating the results from the last complete data set received from LT Planning.. Owing to time constraints, the data is based on slightly different assumptions, excluding the cost and benefit effects of safety infrastructure, upgradeability and mobility impaired access. It also does not take account of the revised economic assessment and is therefore not consistent with other data in this report but is presented for comparison purposes.

Table 8.5.2: Scheme Options: Public Sector Return in a Joint Venture

CLRS Employment assumptions; all costs and benefit figures in £m present values discounted over 30 years.

Scheme	Discount Factor	Social Benefits	LU/BR Revenue	Net Benefit	Public Capital Exp'ure	LU/BR Costs	Net Costs	Benefit : Cost Ratio
Core	4%	1,694	(1,510)	185	398	(571)	(173)	++
Core	6%	1,128	(1,023)	105	356	(390)	(34)	++
Core	8%	775	(714)	61	319	(275)	44	1.39
Reduced	4%	2,857	(2,693)	163	554	(999)	(445)	++
Reduced	6%	1,901	(1,826)	76	495	(683)	(188)	++
Reduced	8%	1,307	(1,275)	33	443	(481)	(38)	++
Planned	4%	3,759	(3,045)	713	824	(999)	(175)	++
Planned	6%	2,502	(2,064)	438	736	(683)	53	8.29
Planned	8%	1,720	(1,441)	280	659	(481)	178	1.57

Source: LT Planning 10/12/93

The infinite (++) returns on the costs attributable to the public sector arise because the capital expenditure attributable to the public sector is less than the reduction in London Underground and British Rail's operating and maintenance costs (caused by the decrease in their passengers). Effectively, a positive social benefit is coupled with a reduction in costs.

All data contained in this report assume that the ring-fenced costs are split between private and public sector pro-rata with the split of the total project cost. As discussed, changes in the split could further increase the benefit / cost ratios.

8.6 Conclusion

The above results show that, from a cost / benefit perspective, both the Planned and Reduced Schemes are justified. The Reduced Scheme produces the largest returns for the public sector. However, the Planned Scheme produces much larger actual net benefits than the Reduced Scheme and its benefit / cost ratio is less sensitive to changes in revenues and costs.

ASSESSMENT OF STAGE 1: CENTRAL AREA STATION OPTIONS

All assessments in this Appendix use CLRS demand forecasts.

1. Core Scheme (Two Central Area Stations)

Table A1.1: Station Location Test Results

Costs and benefits are present values discounted over 30 years at 8%.

Stations		Capital Cost £m	Operating Cost £m	Social Benefits £m	Revenue £m	Benefit / Cost Ratio
Tottenham Court Road	Moorgate	622	21	704	143	1.32 : 1
Bond Street	Moorgate	596	21	687	139	1.34 : 1

Table A1.2: Operations Assessment

Platform usage of CrossRail stations (000s, AM peak three hours)

Stations		Bond Street	Tottenham Court Road	Moorgate	Stratford	Total
Tottenham Court Road	Moorgate	N / A	34	23	29	86
Bond Street	Moorgate	24	N / A	28	31	85
Planned Scheme		24	39	32*	41	179

*: Assumes connection to Liverpool Street BR station

2. Reduced Scheme (Three Central Area Stations)

Table A1.3: Station Location Test Results

Costs and benefits are present values discounted over 30 years at 8%.

Stations			Capital Cost £m	Operating Cost £m	Social Benefits £m	Revenue £m	Benefit / Cost Ratio
Bond Street	Tottenham Court Road	Moorgate	860	64	1216	246	1.58 : 1
Bond Street	Tottenham Court Road	Moorgate / Liverpool Street§	899	64	1237	251	1.55 : 1
Paddington	Tottenham Court Road	Moorgate	826	64	1181	239	1.60 : 1
Bond Street	Holborn	Moorgate	787	64	1195	242	1.69 : 1

§: Test carried out to determine whether significant operational improvements could be achieved at Stratford.

Table A1.4: Operations Assessment

Platform usage of CrossRail stations (000s, AM peak three hours)

Stations	Padding-ton	Bond Street	Tottenham Court Rd	Holborn	Moorgate	Stratford	Total
Bond Street Tottenham Court Road Moorgate	N / A	20	38	N / A	27	29	124
Paddington Tottenham Court Road Moorgate	18	N/ A	47	N / A	30	38	133
Bond Street Holborn Moorgate	N / A	25	N / A	31	28	39	123
Bond Street Tottenham Court Road Moorgate / Liverpool St	N / A	21	39	N / A	35*	36	131
Planned Scheme	20	24	39	24§	32*	41	179

§: Usage of Farringdon station
*: Assumes connection to Liverpool Street BR station

CROSSRAIL COST EFFECTIVENESS STUDY

PHASE II

ENHANCEMENTS TO THE BASIC CORE RAILWAY

The "Basic Core Railway" is rejected as a plausible scheme in the CrossRail Cost Effectiveness Study (October 1993) on the grounds that it would not gain consent to build, permission to operate or attract private finance, due to the omission of "quality" elements. Further, the railway operators were unable to assess the scheme from a safety or operational viewpoint and therefore could not determine whether it would be workable even if the initial obstacles were overcome. It was decided that a "Minimum Realistic Scheme" would be devised, which the operators would be prepared to promote if a financial constraint precluded construction of the full planned scheme.

A "Realistic Scheme" would be produced for two levels, corresponding to the most significant levels identified in the Cost Effectiveness Study, namely:

Level 0: The "Core Railway" - Shenfield - Slough with stations at Moorgate and Tottenham Court Road.

Level 4: The "Reduced Railway" - Shenfield - Reading / Aylesbury, with stations at Moorgate, Tottenham Court Road and Bond Street.

This document sets out a schedule of enhancements to the Basic Core Railway to establish a Realistic Scheme at each of the above levels. It is based on the "CrossRail Basic Core Railway Specification" produced by the CrossRail Project Team, issue dated 21 September 1993. Principal definitions are as follows:

LEVEL 0: REALISTIC CORE SCHEME

CAPITAL COSTS

Quantity: The "Level 0" (i.e. Core) Railway between Shenfield and Slough with central stations at Liverpool Street (Moorgate end) and Tottenham Court Road.

Station tunnels provided at proposed sites for Paddington, Bond Street and Farringdon.

Proposed ticket halls safeguarded[1] at following sites:

Paddington (Extended) Lawn: no physical works needed (maintain Safeguarding Directives). BR InterCity retail proposals will need to take account of its eventual provision.

Western ticket hall: no physical works needed (maintain Safeguarding Directives).

Bond Street: Davies Street; Hanover Square: no physical works needed (maintain Safeguarding Directives).

1: Note: requirements relate only to ticket hall requirements and assume that any safety works (e.g. ventilation) required on the site would be provided as in the planned scheme.

Tottenham Court Rd:	Dean Street: draught relief shaft on SW corner of site, remainder of site to be safeguarded.
Farringdon:	Cowcross Street; no physical works needed unless Thameslink 2000 project precedes CrossRail.
	Lindsey Street; 50%+ of site needed for ventilation shaft, M&E plant and emergency escape. Remainder of site to be safeguarded - ticket hall shell would have to be built as part of any development.
Liverpool Street:	Arcade; no physical works needed, but property redevelopment must allow for ticket hall scheme: Safeguard (under LUL control).
	extended B ticket hall: no physical works needed; maintain safeguarding directives.

Quality: All infrastructure safety provisions;

All rolling stock safety provisions (i.e. fireproof Networker);

All environmental mitigations;

12 - car (23m) platforms at tunnel stations;

Platforms at surface stations as required for 8 car (20m) Networker trains;

All MIP facilities;

(Note: second ticket halls and metro rolling stock not included).

The following further enhancements / changes are required to the Basic Core Railway specification:

Depots and Stabling:

Ilford Depot, Shenfield, Gidea Park: No change from planned scheme.

Old Oak Common: Stabling for 6 x 8 cars required (vice 12 x 8 in planned scheme).

Slough: Stabling for 6 x 8 cars required (vice nil in planned scheme).

CET discharge facilities required at Ilford and Old Oak, as Networkers have CET toilets;

Signalling:

Western section (Royal Oak - Slough) service control: Area Control Centre at Ealing Broadway or within Slough Signalling Centre (assume equivalent cost to Station Supervisory Centres).

Trackwork:

West Ealing: Additional centre reversing siding (space available).

Slough: Additional reversing siding (location not obvious).

Hayes: Additional bay platform or through loop.

Chadwell Heath: Short (8 x 20m) centre reversing siding (space available)

At Grade Works:

Grand Union Flyover: needed in Minimum Realistic Scheme to provide access to Old Oak Common free of main lines (in planned scheme, Aylesbury Line tracks provide this).

Stations:

Slough: Additional footbridge for interchange movements (assumed at London end of station, connecting all platforms).

OPERATING COSTS

The following may be helpful in assessing operating costs for the Minimum Realistic Scheme:

Operational Control: Allow 2/3 staff (24 hour coverage) at the western section Area Control Centre

Allow for platform attendance (Peak periods) at Manor Park, Forest Gate, Maryland, all tunnel stations, Acton Main Line to offset lack of on-train CCTV.

Revenue Control: 55 multi-functional staff needed to protect revenue and provide safety cover at surface stations (vice approximately 180 required for the planned scheme).

Train Services: Additional 4 tph Chadwell Heath - Liverpool Street (high level), operated by existing (Class 315) GE rolling stock - to provide a City only service.

Extend 2 CrossRail tph currently starting at Ealing Broadway to Slough (calling Slough, West Drayton, Hayes, Southall, Ealing Broadway, then as booked).

Note: as CrossRail services on the western section would provide only part of the total suburban service, more interworking with existing services would be needed and this might impose constraints which could only be assessed by a detailed timetabling exercise.

LEVEL 4: REDUCED SCHEME

CAPITAL COSTS

Quantity: The "Level 4" Railway between Shenfield - Reading / Aylesbury with central stations at Liverpool Street (Moorgate end), Tottenham Court Road and Bond Street.

Station tunnels provided at proposed sites for Paddington and Farringdon.

Proposed ticket halls safeguarded at following sites:

Paddington: (Extended) Lawn : no physical works needed (maintain Safeguarding Directives). BR InterCity retail proposals will need to take account of its eventual provision.

Western ticket hall: no physical works needed (maintain Safeguarding Directives).

Bond Street: Hanover Square: no physical works needed (maintain Safeguarding Directives).

Tottenham Court Rd:	Dean Street: draught relief shaft on SW corner of site, remainder of site to be safeguarded.
Farringdon:	Cowcross Street; no physical works needed unless Thameslink 2000 project precedes CrossRail.
	Lindsey Street; 50%+ of site needed for ventilation shaft, M&E plant and emergency escape. Remainder of site to be safeguarded - ticket hall shell would have to be built as part of any development.
Liverpool Street:	Arcade; no physical works needed, but property redevelopment must allow for ticket hall scheme: Safeguard (under LUL control).
	extended B ticket hall: no physical works needed; maintain safeguarding directives.

Quality: All infrastructure safety provisions;

All rolling stock safety provisions (i.e. fireproof Networker);

All environmental mitigations;

12 - car (23m) platforms at tunnel stations;

Platforms at surface stations as required for 8 car (20m) Networker trains;

All MIP facilities;

(Note: second ticket halls and metro rolling stock not included).

CrossRail Client Team
22 November 1993

CROSSRAIL COST EFFECTIVENESS STUDY

PHASE II

KING'S CROSS ALIGNMENT

ENHANCEMENTS TO THE BASIC CORE RAILWAY

This appendix outlines the variations in scheme definition for scheme options on the King's Cross alignment compared to those on the planned alignment and should be read in conjunction with Appendix 2

A "Realistic Scheme" would be produced for two levels, corresponding to the most significant levels identified in the Cost Effectiveness Study, namely:

Level 0: The "Core Railway" - Shenfield - Slough with stations at Moorgate and King's Cross.

Level 4: The "Reduced Railway" - Shenfield - Reading / Aylesbury, with stations at Moorgate, King's Cross and Baker Street.

LEVEL 0: REALISTIC CORE SCHEME

CAPITAL COSTS

Quantity: The "Level 0" (i.e. Core) Railway between Shenfield and Slough with central stations at Liverpool Street (Moorgate end) and King's Cross.

Station tunnels provided at proposed sites for Paddington, Baker Street and Farringdon.

Proposed ticket halls safeguarded[1] at following sites (new Safeguarding Directives required at Paddington, Baker Street, King's Cross and Farringdon):

Paddington:	Ticket hall under the Paddington Basin development site: no physical works needed.
Baker Street:	Baker Street and Marylebone ticket halls: no physical works needed.
King's Cross:	Euston ticket hall: draught relief shaft, remainder of site to be safeguarded.
Farringdon:	Cowcross Street; no physical works needed unless Thameslink 2000 project precedes CrossRail.
	Lindsey Street; 50%+ of site needed for ventilation shaft, M&E plant and emergency escape. Remainder of site to be safeguarded - ticket hall shell would have to be built as part of any development.
Liverpool Street:	Arcade; no physical works needed, but property redevelopment must allow for ticket hall scheme: Safeguard (under LUL control).

1: Note: requirements relate only to ticket hall requirements and assume that any safety works (e.g. ventilation) required on the site would be provided as in the planned scheme.

extended B ticket hall: no physical works needed; maintain safeguarding directives.

Quality, Operational enhancements, operating cost assumptions as planned alignment (see Appendix 2).

LEVEL 4: REDUCED SCHEME

CAPITAL COSTS

Quantity: The "Level 4" Railway between Shenfield - Reading / Aylesbury with central stations (one ticket hall only) at Liverpool Street (Moorgate end), King's Cross and Baker Street.

Station tunnels provided at proposed sites for Paddington and Farringdon.

Proposed ticket halls safeguarded[2] at following sites (new Safeguarding Directives required at Paddington, Baker Street, King's Cross and Farringdon):

Paddington:	Ticket hall under the Paddington Basin development site: no physical works needed.
Baker Street:	Marylebone ticket hall: no physical works needed.
King's Cross:	Euston ticket hall: draught relief shaft, remainder of site to be safeguarded.
Farringdon:	Cowcross Street; no physical works needed unless Thameslink 2000 project precedes CrossRail.
Lindsey Street;	50%+ of site needed for ventilation shaft, M&E plant and emergency escape. Remainder of site to be safeguarded - ticket hall shell would have to be built as part of any development.
Liverpool St:	Arcade; no physical works needed, but property redevelopment must allow for ticket hall scheme: Safeguard (under LUL control).
	extended B ticket hall: no physical works needed; maintain safeguarding directives.

Quality, Operational enhancements, operating cost assumptions as planned alignment (see Appendix 2).

CrossRail Client Team
22 November 1993

2: Note: requirements relate only to ticket hall requirements and assume that any safety works (e.g. ventilation) required on the site would be provided as in the planned scheme.

CROSSRAIL OPTIONS COST ANALYSIS
COMPARISON OF PLANNED AND KING'S CROSS ALIGNMENTS

December 1993 Property Requirements Assessment

All costs in £m at March 1990 prices

Scheme >	Level 0 Core Railway			Level 4 Reduced Scheme			Level 6 Planned Scheme		
	Planned Alignment	KX Alignment	% difference in KX alignment	Planned Alignment	KX Alignment	% difference in KX alignment	Planned Alignment	KX Alignment	% difference in KX alignment
Quantity & Non Discretionary "Quality" items	1279	1395	9%	1554	1662	7%	1747	1932	11%
Rolling Stock (Class 465)	84	84	0%	85	85	0%	135	135	0%
Realistic Scheme	**1363**	**1479**	**9%**	**1639**	**1747**	**7%**	**1882**	**2067**	**10%**
Discretionary "Quality" Items	61	68	11%	91	103	13%	124	141	14%
Metro Rolling Stock	24	24	0%	48	48	0%	53	53	0%
PROJECT EXPENDITURE (Excluding Property Recoverables):_Incremental on Maintaining Existing Network	**1448**	**1571**	**8%**	**1778**	**1898**	**7%**	**2059**	**2261**	**10%**
Property Recoverables	90	42		105	42		128	65	
NET PROJECT COST	**1358**	**1529**	**13%**	**1673**	**1856**	**11%**	**1931**	**2196**	**14%**
Core Budget Expenditure	171	171	0%	486	486	0%	486	486	0%
GROSS CAPITAL EXPENDITURE (Excluding Property Recoverables):	**1619**	**1742**	**8%**	**2264**	**2384**	**5%**	**2545**	**2747**	**8%**

BENEFITS NOT INCLUDED IN PREVIOUS CROSSRAIL EVALUATIONS

A review of previous CrossRail project evaluations has identified some sources of benefit not included in the quantified benefits, which are summarised here. In some cases, an initial approximation of the possible value of the benefits described has been made.

1. Quantifiable Benefits

1.1 The benefits of synergies with Union Railways have not been examined. CrossRail's ability to accept up to 6 commuter trains from the Channel Tunnel Link has been assessed and it was concluded that this is feasible subject to certain relatively minor reservations concerning station capacity and the provision of turnback facilities west of the tunnel section. The Union Railways report of March 1993 estimates synergy benefits at between £300-350 million (Net Present Value). As a conservative estimate, half of this has been treated as a benefit of CrossRail.

EXTRA BENEFIT £150 MILLION NPV

1.2 The LTS model covers South East England, but only sparsely outside London. This means that benefits for journeys wholly outside London are probably underestimated. Increases in long distance trips (e.g. InterCity journeys into Paddington and Liverpool Street) are also probably missing. An estimate of £10m revenue per year to account for passengers not included in the LTS model has been adopted in previous work.

EXTRA BENEFIT £62 MILLION NPV

1.3 In addition to road congestion relief, there are benefits on the highway system of accident and pollution reduction. It is estimated that the reduction in pollution resulting from drivers switching to rail will be about £1m per annum. This figure does not include pollution reduction due to less delays on the road.

EXTRA BENEFIT £8 MILLION NPV

1.4 The proportion of business travellers assumed in previous evaluations was 1.2%. There is strong evidence from NSE Origin-Destination Surveys that, for the Great Eastern and Thames & Chiltern Lines, it is at least 5%. Assuming this proportion raises the overall value of time from £5.085 to £5.513 per hour, an increase of 8.4%. Applying this increase to the quantified passenger benefits increases the present value from £1170m to £1269m.

EXTRA BENEFITS £99 MILLION NPV

1.5 The evaluation assumes a project life of 30 years, which is short given the nature of the investment and could reasonably be extended to 40 or 50 years. The project's overall Net Present Value (November 1991 evaluation) is £427.5m; this increases to £619.6m for a 40 year life and £725.8m for a 50 year life.

EXTRA BENEFIT £182-288 MILLION NPV

1.6 There is a saving in unemployment pay to those who will gain employment from the construction work. It is estimated that 12,000 people will be directly and indirectly employed each year in the construction of CrossRail; assuming that only half of these jobs are newly created, and the other half presently exist, then the project can be considered to generate 6,000 jobs over the four years of construction. Taking as

a conservative estimate that one unemployed person costs £5,000 per year (recent newspaper reports claim the figure is closer to £9,000) then the saving in unemployment pay is calculated to be £30m for each of the 4 years.

EXTRA BENEFIT £79 MILLION NPV

1.7 The total present value of additional benefits is thus estimated at between £580m - £686m. The median figure (£633m) represents a 32% increase in the project's social and revenue benefits[1].

2. Unquantifiable Benefits

2.1 Previous evaluations have assumed that CrossRail has no effect on employment. Two effects are likely:

a) employment will increase as London is made more attractive. Some will be absolute and some diversion. The latter could still be a benefit if for example, employment diverts from M25 ring (saving congestion or highway works) or from abroad.

b) with a given level of employment, there will be a rearrangement along the CrossRail corridor, giving more benefits and attributable revenue. The effect is likely to be stronger with lower overall employment, with differential filling of empty offices etc.

2.2 Present modelling does not fully model Heathrow as a traffic generator for CrossRail. The model uses a small fixed matrix, mainly as an attempt to create more realistic crowding levels, and assumes Heathrow Express. This would give a small time saving benefit, but no revenue for either CrossRail or Heathrow Express. Terminal 5 or a through CrossRail service to Heathrow are not included. A model to evaluate these benefits and revenues has been developed and its use is starting.

2.3 Traffic generated by Thameslink 2000 has not been assumed, as it is not an approved scheme. There would be mutual synergy as the lines will cross at Farrringdon at right angles, with high benefits. The CrossRail station includes sufficient capacity for Thameslink increases, but no sharing of costs is assumed.

2.4 No benefits to the main line stations at Paddington and Liverpool Street are included. Without CrossRail, Paddington may have trouble operating with an increased InterCity and NSE demand, and possibly require works. With CrossRail, a smaller station may be possible, with increased possibilities of development gains (plans exist). There are similar, but probably smaller, opportunities at Liverpool Street.

2.5 There are plans to electrify the Great Western main line (e.g. to Bristol). If CrossRail electrifies to Reading this reduces the cost.

2.6 Although the mechanism is uncertain, road pricing would be expected to increase the use of rail and thus generate additional revenue.

2.7 Relief of crowding on other lines should lead to reliability improvements (e.g. by reducing station dwell times).

1: The planned scheme benefits are estimated at £1646m social benefits and £323m revenue; total £1969m.

2.8 A major feature of CrossRail is reduction in interchange movements, particularly at Paddington and Liverpool Street. The real interchange and wait times are modelled, together with an interchange penalty of 2.5 minutes. However, there is evidence that this value may be low generally, and especially for longer journeys such as those affected by CrossRail. Further, off-peak travel patterns are more generally concentrated in the West End that peak trips, leading to a higher proportion of CrossRail journeys saving interchange in the off-peak, suggesting that off-peak benefits are underestimated.

2.9 The Annualisation Factors used to estimate annual revenues and benefits from peak period forecasts were derived from LUL station counts, which take place in October/November and February/March (for consistency and stability). However, these are times of lowest off-peak travel, and analysis by LUL has given higher Factors which are being investigated. It is reasonable to expect that off-peak traffic will not reduce as much as peak in the lower levels of future demand scenarios being examined.

2.10 The new stations will provide retail space. No estimate has been made yet for the income.

2.11 Assumptions for post-CrossRail services on affected lines have been made for evaluation purposes tests, but these residual services have not been optimised. It is likely that further development would improve the performance of these services and lead to higher revenues. An area of particular potential is the sub-surface services on the north side of the Circle Line.

2.12 Highway congestion relief will increase more than proportionately after 2001, as car ownership and use increase, while highway capacity does not.

3. SUMMARY

The evaluation of CrossRail has not in the past included all of the scheme's likely benefits. The above list of 18 items is an example of some of the benefits which have not been included. Monetary estimates have been put on six, erring on the conservative side and not including further potential benefits due to synergies between the items (such as higher Values of Time and longer project life).

Network SouthEast
21 December 1993

ROLLING STOCK CASCADE ASSUMPTIONS

1. INTRODUCTION

552 new class 341 vehicles will be built to run on the CrossRail service. As CrossRail is replacing a number of existing services, the vehicles currently used on those services will no longer be required. This appendix describes how these vehicles could be utilised by "cascading" them onto other services once CrossRail is implemented, and compares this with the situation without CrossRail.

2. CURRENT BRITISH RAIL FLEET

The fleets on the routes considered here comprise:

BR Great Eastern (GE)

Class Name	312	315	321
Number of Vehicles	112	180	312
Year of Manufacture	1976	1982	1991
Type of Vehicle	AC Overhead Electric : Slam-door	AC Overhead Electric : Sliding-door	AC Overhead Electric : Sliding-door

London Tilbury and Southend (LT&S)

Class Name	302	310	312
Number of Vehicles	112	148	84
Year of Manufacture	1958	1966	1976
Type of Vehicle	AC Overhead Electric : Slam-door	AC Overhead Electric : Slam-door	AC Overhead Electric : Slam-door

2.3 Thames and Chiltern ()

Class Name	165	166
Number of Vehicles	180	63
Year of Manufacture	1992	1993
Type of Vehicle	Diesel : Sliding Door	Diesel : Sliding Door

3. ASSUMPTIONS

This appendix sets out a hypothetical example to show how the cascading approach could work in practice, based on the following assumptions:

(a) A medium demand growth level has been assumed from the year 1993/4 till 2011/12. Beyond 2011/12 no growth has been assumed.

(b) For the purposes of this exercise, the effect of a Thameslink 2000 cascade prior to the introduction of CrossRail has not been included.

(c) BR vehicles are assumed to have a 40 year life in service and are replaced with newly built vehicles.

The assumptions are worked through for "with CrossRail" and "without CrossRail" scenarios.

4. CASCADE WITH CROSSRAIL (OPENING 2001/2)

4.1. Great Eastern and London Tilbury & Southend

In 1996/7, Great Northern Division will receive 100 new class 465 vehicles and will cascade 100 class 317 vehicles to LT&S, displacing 84 class 302 vehicles that will be scrapped. The remaining 28 class 302 vehicles will be required on LT&S for growth.

In 1998/9 8 new vehicles will be built to run in service on GE. This requirement is due to growth.

In 1999/2000, the first 104 Class 341 (CrossRail) vehicles will be built. These will be used in the first instance (i.e. before CrossRail) on GE. 104 class 315 vehicles will be cascaded to LT&S. They will displace the remaining 28 class 302 vehicles and some 80 class 310 vehicles that will be scrapped. In addition, 8 new vehicles will be built to run in service on GE. This requirement is due to growth.

In 2000/1, a further 264 class 341 vehicles will be built. These will also be used in the first instance (i.e. before CrossRail) on GE. The remaining 76 class 315 vehicles will be cascaded to LT&S. They will displace 28 class 310 vehicles which will be scrapped

In 2001/2 the final 144 class 341 vehicles will be delivered. All 552 class 341 vehicles will start service on the newly opened CrossRail service. In addition, 12 new vehicles will be built to run in service on GE. This requirement is due to growth.

4.2. Other British Rail

In 2001/2, 65 class 165 vehicles will no longer be required on Thames and Chiltern as CrossRail replaces the services from Reading. These will be cascaded to replace 14 class 117 vehicles, 3 class 121 vehicles and 35 class 205 vehicles on other NSE services. The class 165's will also replace 13 class 141 vehicles on Regional Railways.

4.3 It should be noted that other options may exist. These could take the form either of an alternative cascade, or a <u>further</u> cascade of the Class 310 units, to replace other units which are genuinely life-expired (for example, in Liverpool or Glasgow). Thus the estimate of £104.9 million should be regarded as a minimum value.

5. CASCADE WITHOUT CROSSRAIL

The following is a hypothetical example of what could happen in the absence of a CrossRail service and allowing for the purchase of new vehicles.

5.1. Great Eastern and London Tilbury & Southend

In 1996/7, Great Northern Division will receive 100 new class 465 vehicles. They will cascade 100 class 317 vehicles to LT&S, displacing 84 class 302 vehicles that will be scrapped. The remaining 28 class 302 vehicles will be required on LT&S for growth.

In 1998/9 48 new vehicles will be built to run in service on GE. This requirement is due to growth.

In 1999/2000, the remaining 28 class 302 vehicles on LT&S will be scrapped. 32 new vehicles will be built for LT&S (4 are for growth). In addition, 8 new vehicles will be built to run in service on GE. This requirement is due to growth.

In 2000/1, 4 new vehicles will be built for GE. This requirement is due to growth. 4 new vehicles will be built for LT&S. This requirement is also due to growth.

In 2001/2, 8 new vehicles will be built for GE. This requirement is due to growth. 4 new vehicles will be built for LT&S. This requirement is also due to growth.

The class 310 will remain in service until 2006/7 after which they will be scrapped. (In the with CrossRail scenario the 310's are scrapped partly in 1995/6 and in 1998/9.)

5.2. Other BR

In 1999/2000, 16 new vehicles will be built for Thames and Chiltern. This requirement is due to growth.

In 2000/1, 2 new vehicles will be built for Thames and Chiltern. This requirement is due to growth.

In 2001/2, 3 new vehicles will be built for Thames and Chiltern. This requirement is due to growth. The following vehicles on NSE services will have reached the end of their life and will be replaced with new vehicles: 14 class 117 vehicles, 3 class 121 vehicles and 35 class 205 vehicles.

The class 141's on Regional Railways will remain in service until 2003/4 after which they will be scrapped. (In the with CrossRail scenario the 141's are scrapped partly in 2000/1 and in 2003/4.)

6 COMPARISON OF NEW VEHICLE REQUIREMENTS

6.1 Sections 4 and 5 showed how the fleets for the routes under consideration would be expected to change (assuming a medium growth in demand) over 40 years, under with and without CrossRail scenarios. The difference in requirement for new rolling stock is illustrated in Figure 1. The total heights of the bars in the graph represent the total number of vehicles required for the services which, without CrossRail, would continue to operate as now, with service levels and fleet requirements adjusting according to demand. These new vehicles would be needed to allow for growth in demand, and to replace life expired stock (e.g. 148 Class 310 vehicles in 2007). The lower (solid) part of the bars represent the number needed by those services in the "with CrossRail" scenario, excluding the CrossRail fleet itself.

6.2 The graph clearly illustrates that non-CrossRail services will require fewer additional vehicles if the CrossRail scheme is implemented and that some rolling stock costs are effectively "saved".

6.3 The assumption made in the April 1993 project cost estimate is that 321 vehicles would effectively be financed by the operators of the services to which stock on the future CrossRail services will be cascaded. However, the financial value of the "saved" requirement will vary according to demand forecasts and fleet plans for the non-CrossRail services. However, the operators believe that the availability of commuter - type rolling stock for similar services in South East England or elsewhere will enable the future operators of those services to replace or upgrade their rolling stock without purchasing new trains.

7 EFFECT OF BRITISH RAIL PRIVATISATION

7.1 Headquarters Function

With the present structure of British Rail, the rolling stock replacement and cascade plans described above would be planned and co-ordinated by a Headquarters function. After April 1994, this function will no longer exist, and the allocation and replacement of rolling stock will be planned by a combination of:

- Train Operating Companies (TOCs), with responsibility for day to day operation of the passenger services,
- Rolling Stock Leasing Companies (LEASCOs), with responsibility for purchasing and leasing passenger rolling stock,
- The Franchising Director (OPRAF), responsible for awarding franchises to TOCs, and specifying various minimum service requirements.

The plans described above should therefore be taken only as an example of what might be possible. As already discussed, other possibilities exist; especially in the Liverpool, or Glasgow areas.

7.2 LEASCOs

Given that it has been shown to be possible to save on rolling stock capital costs with the demand assumptions used here, it is reasonable to assume that the LEASCOs would be aiming to realise this saving. The most cost-effective approach for these companies is likely to remain the same as it has always been, i.e. to retain rolling stock in use until it becomes life-expired, and to scrap it at that stage. It is unlikely that either premature scrapping combined with unnecessary expenditure on new rolling stock, or an attempt to impose undue longevity on existing rolling stock are likely to prove attractive options in financial terms.

It has already been noted that the illustrative cascade described above would release some Class 310 units before they are fully life-expired. These would have additional benefits to the LEASCOs, either for use in a further cascade (as described previously), or to provide additional flexibility (for example to allow TOCs to run additional services).

7.3 TOCs

It has been confirmed that the LEASCOs will be applying "indifference charging" in their leasing costs to the TOCs, which implies that the TOCs should be entirely indifferent to the type of rolling stock that they use on their services - any difference in maintenance costs or attractiveness to the passengers between two potential fleets is exactly balanced by a difference in the rolling stock leasing charge. In principle, a TOC will therefore be content to use any type of rolling stock that the LEASCOs can make available to them, provided it is suitable for operation on the TOC's routes.

The implication of this is that, given a feasible allocation of rolling stock that can be shown to be in the overall "best interest" (such as that described above), the market forces pertaining in the rolling stock leasing industry should work to ensure that the overall "best solution" does actually occur.

7.4 OPRAF

The Franchising Director will be concerned to see that the allocation of rolling stock to TOCs works out in such a way that all of the TOCs are provided with adequate stock in order to operate the requisite services. If necessary, OPRAF has the authority to impose allocations of stock to TOCs to ensure that all of the stock is utilised, and that no TOCs are left unprovided. Thus, if market forces do not contrive to achieve a suitable solution, OPRAF will provide a second line of defence to ensure that a suitable solution is attained. In addition, it is worth noting that OPRAF will be concerned to ensure safe and reliable train operation by the TOCs. In this context, the cascade described above, whereby older slam-door stock is replaced by newer sliding-door stock is likely to find favour.

8 LONDON UNDERGROUND

8.1 CrossRail will take over a part of the Metropolitan Line service, presently operated with the following fleet:

Class Name	A60 / A62
Number of Vehicles	452
Year of Manufacture	1960 / 1962
Type of Vehicle	DC third-rail electric: Sliding-door

The age of the stock indicates that replacement at or near the introduction of CrossRail services is a reasonable assumption, although refurbishment works currently under way could extend life for some ten years.

8.2 In the absence of firm plans to privatise London Underground, the central allocation of rolling stock resources remains a valid planning assumption. A comparison of requirements before and after introduction of CrossRail services indicates that, other things being equal, 13 fewer trains will be required to operate the Metropolitan and East London Line services than at present. Therefore, London Underground effectively "saves" the cost of that number of trains compared to the "without CrossRail" scenario.

8.3 Current London Underground extension proposals entail an increased requirement for A stock or any replacement. In advance of replacement, trains rendered surplus by CrossRail are effectively "free", saving London Underground the cost of

purchase of a small number of trains which would not be standard with the rest of the fleet. If the extensions were to coincide with replacement, London Underground would have to purchase an appropriate extra quantity of new stock but could take advantage of the savings in extending a large production run. In either case, therefore, London Underground could be expected to make some contribution to the CrossRail rolling stock costs in consideration for the reduced replacement requirement compared to the "without CrossRail" scenario.

9 CONCLUSION

9.1 From the above, it can be seen that, although privatisation of BR might change the mechanism whereby a cascade would be implemented (exchanging central planning for market forces), it would not be expected to affect the viability of such a cascade, nor the financial benefits to be derived from it. It is also reasonable to assume that central planning of London Underground rolling stock resources is likely to continue.

9.2 However, the railway operators recognise that attention may need to be given to financial mechanisms to ensure that the undoubted financial benefits of rolling stock cascading accrue to the CrossRail project's financiers and not to intermediaries.

Network South East
23 December 1993

THE CLIENT ROLE IN DEVELOPMENT OF THE CROSSRAIL PROJECT

This is a summary of a paper prepared for the CrossRail Steering Group meeting planned for 26 February 1993.

1. Both London Underground and British Rail recognise a "Client" function which ensures that this major project is business - led and properly controlled. The Client Teams have business - oriented responsibilities, principally to ensure that the project is specified and implemented in accordance with business aims, and have separate direct reporting lines to Network SouthEast and London Underground Boards.

2. The Client channels and formalises communication between the Project Team, with its cost and programme-driven objectives and the parent business(s), with wider financial, business and political goals or constraints. The role is to ensure that all requirements are taken into account in developing and implementing the project, with the overall objective being to secure for the parent business an asset which meets standards and performs such that the benefits which supported the expenditure are achieved. Responsibilities emphasise:

   Achievement of cost - effectiveness and value for money through project specification;

   Achievement of project benefits through tightly defined operational requirements and proven operability;

   Integration of the project with the sponsoring organisations' wider strategic and business aims;

   Strategic control of the project during the design and implementation stages.

3. The role evolves with the Project along the following lines:

3.1 During the feasibility stage, the Client determines objectives and evaluates a wide range of options at a strategic level, leading ultimately to recommendation of a preferred option. For CrossRail, this was the CLRS phase and the follow-up work which led to CrossRail's selection as the first CLRS scheme to proceed.

3.2 The Client exercises a leading role during project development. Overall performance requirements are established and as design develops into progressively greater detail, options are identified for appraisal en route to determining the implementation requirement. In CrossRail's development, this stage may be divided into two - *outline design*, the preparatory work up to Bill deposit in November 1991, followed by *scheme design* where the scope and content of each major element is defined for the purpose of a *design freeze*, which will be reached during 1993. *Detailed design* will follow in 1993/4.

3.3 During tender and construction stages, the Client monitors progress and expenditure to ensure on behalf of the parent Board(s) that the project is properly controlled. If required by external changes or events associated with a major project (e.g. tender price increases and site problems), the Client appraises changes to the project scope or definition.

4. The Client function employs objective - led appraisal methods, utilising quantitative techniques where possible, with the aim always to identify options at the margin and to establish that project specification decisions are taken on a structured basis and properly recorded.

5. Client requirements are developed iteratively with the Project Team through a structured hierarchy of meetings and articulated through a Client Brief which is evolving under controlled arrangements as project knowledge increases.

6. The Client role is critical:

   - To ensure that the right project is implemented at both strategic and detailed levels

   - To carry other parties within British Rail / London Underground along with the development of the Project

   - To act as guardian of the scope of the project, without being under overriding pressures to meet time and cost targets.

7. The Project Director's role is critical to ensure that the design and construction processes deliver the project to time and budget and that the Client's requirements for quality and performance are met.

CrossRail Client Teams,
London Underground Limited / Network South East,
16 February 1993

FINANCIAL APPRAISAL: SENSITIVITY TESTS

Tests undertaken by NatWest Markets (all are relative to the Base case described in Chapter 8)

1 Senior Bank Debt on commitment from 1994 (versus 1996)

2 Capital expenditure increased by 15%

3 Capital expenditure increased by 25%

4 Capital expenditure increased by 30%

5 Operating costs increased by 50%

6 Inflation reduced to 3% from 2001

7 Revenues decreased by a further 15%

8 Revenues decreased by a further 30%

	Base Case	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
Government Contribution (£000)	1,768,249	1,795,639	2,016,835	2,182,623	2,265,517	1,768,137	1,761,399	1,768,249	1,774,053
Private Sector Equity (£000)	323,411	328,421	368,837	399,176	414,353	323,489	322,187	323,411	324,447
Bank Debt Drawn (£000)	1,481,780	1,504,959	1,690,389	1,829,323	1,898,782	1,481,812	1,476,494	1,481,780	1,447,032
Total (£000)	3,573,440	3,629,019	4,076,061	4,411,122	4,578,652	3,537,438	3,560,080	3,573,440	3,572,532
35-year IRR (%)	17.18	16.94	15.32	14.26	13.77	14.88	14.61	14.11	10.12
30-year IRR (%)	16.72	16.47	14.71	13.53	12.98	14.23	14.10	13.39	8.68
Minimum Debt Service Cover Ratio	1.31	1.28	1.12	1.03	0.98	1.08	1.24	1.02	0.73

CHART 1

Central Area Stations
Level 0 - Realistic Core Scheme

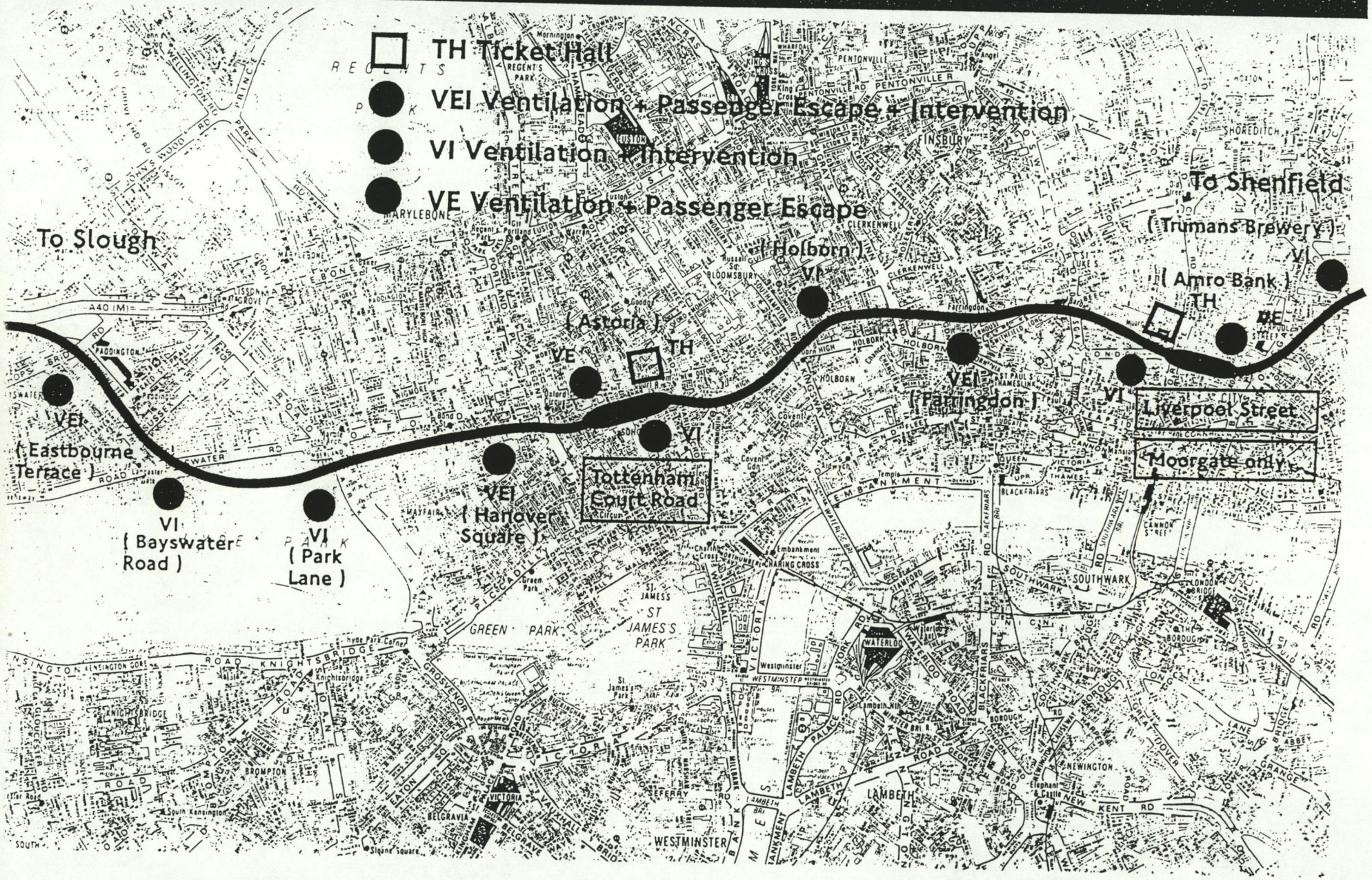


CHART 2

Central Area Stations
Level 4 - Realistic Reduced Scheme

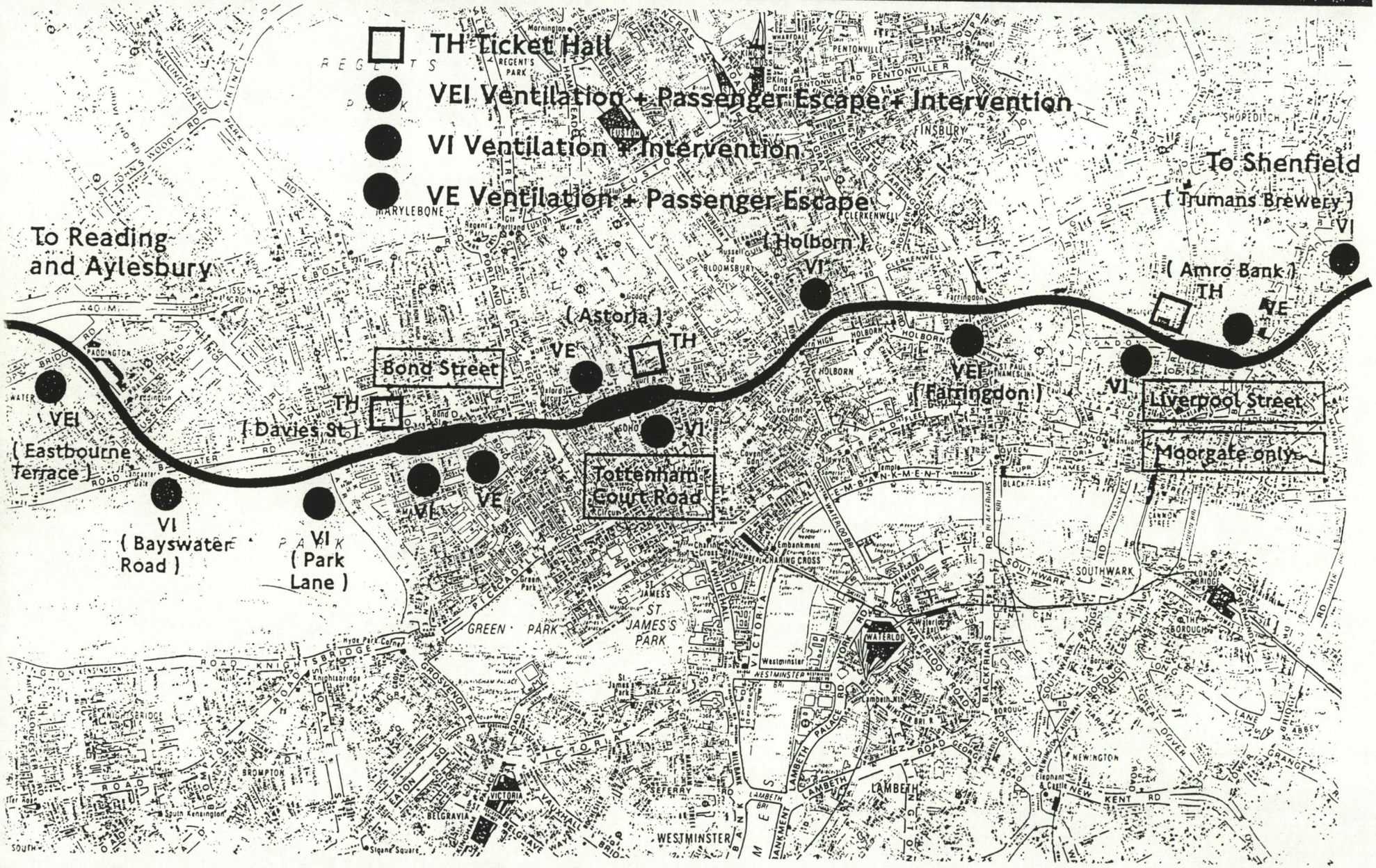


CHART 3

Central Area Stations
Level 6 - Planned Scheme

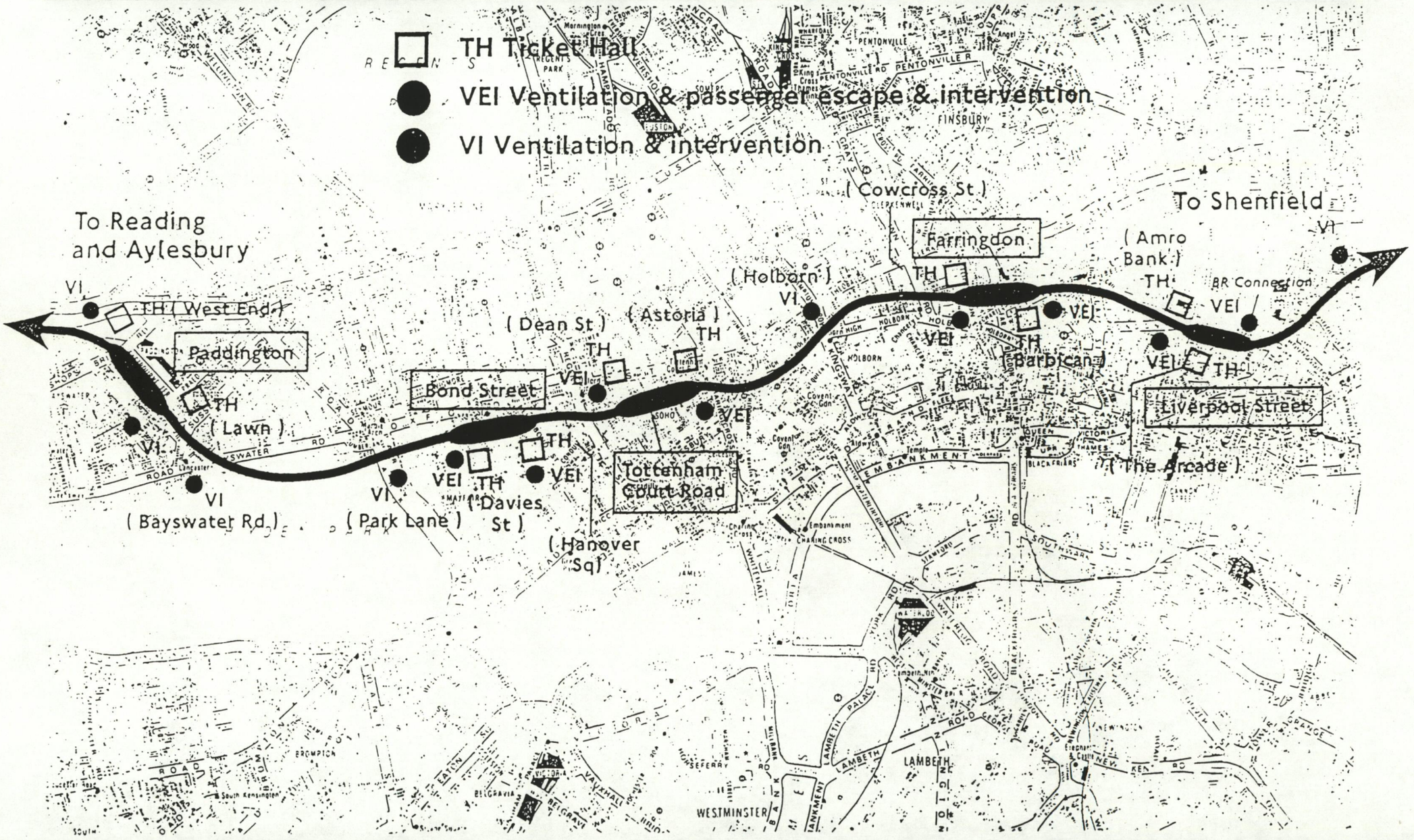
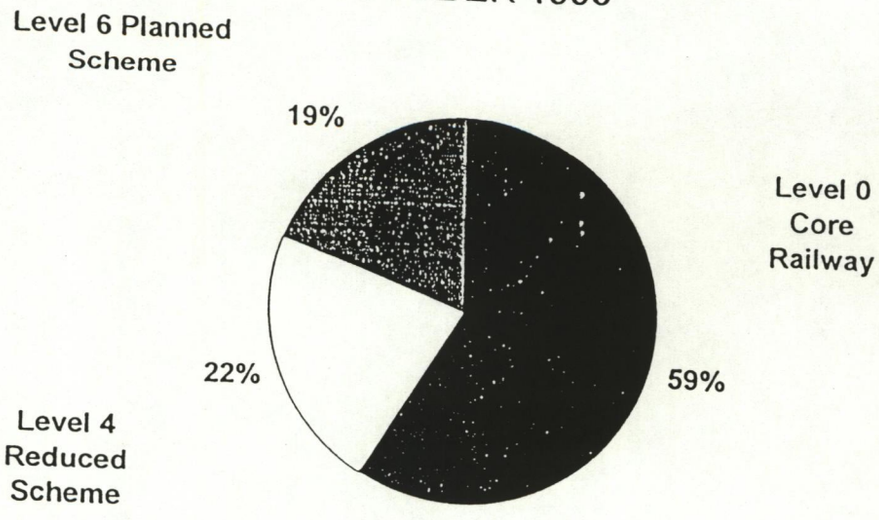


CHART 4

CrossRail Options Cost Analysis
OCTOBER 1993



CrossRail Options Cost Analysis
DECEMBER 1993

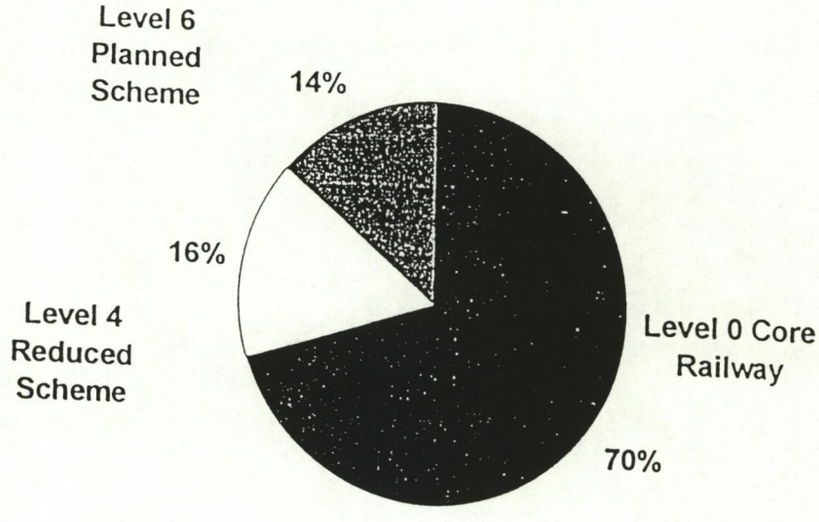


CHART 5

Central Area Stations - Kings Cross Alignment
Level 0 - Realistic Core Scheme

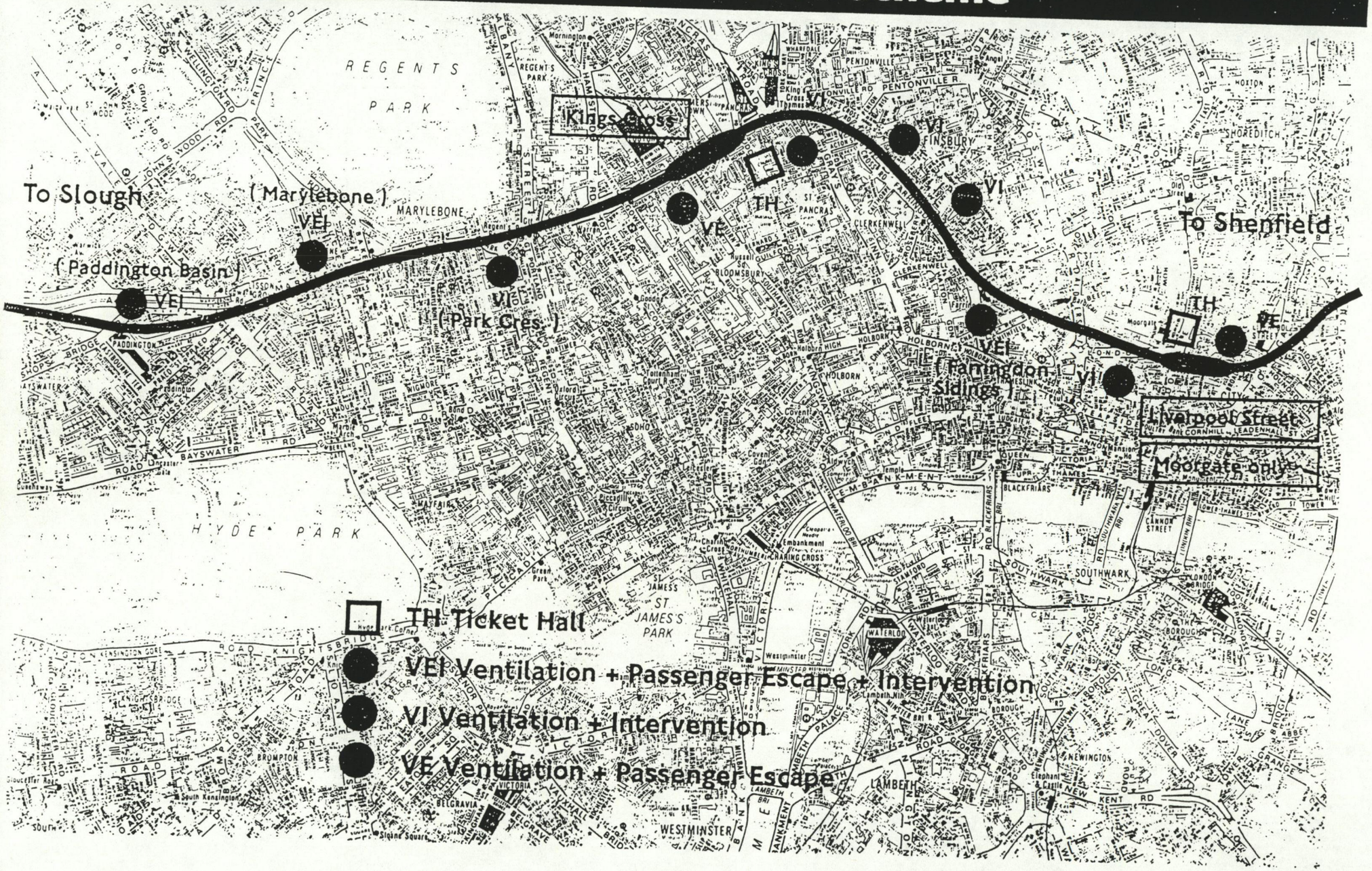


CHART 6

Central Area Stations - Kings Cross Alignment
Level 4 - Realistic Reduced Scheme

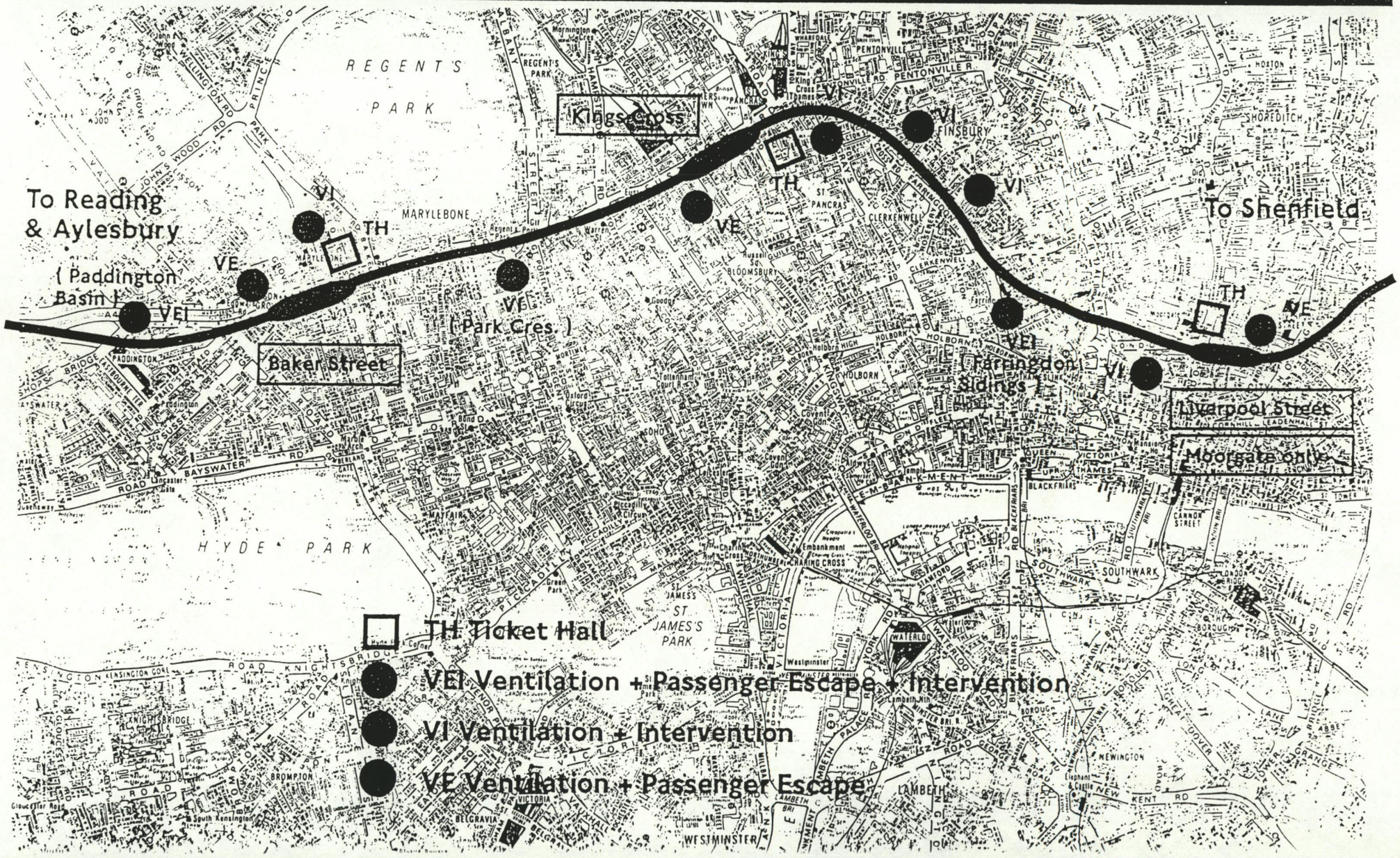


Chart 7 - Zones Where Planned CrossRail Alignment Gives Faster Times to Central London than the Kings Cross Alignment

emme/2

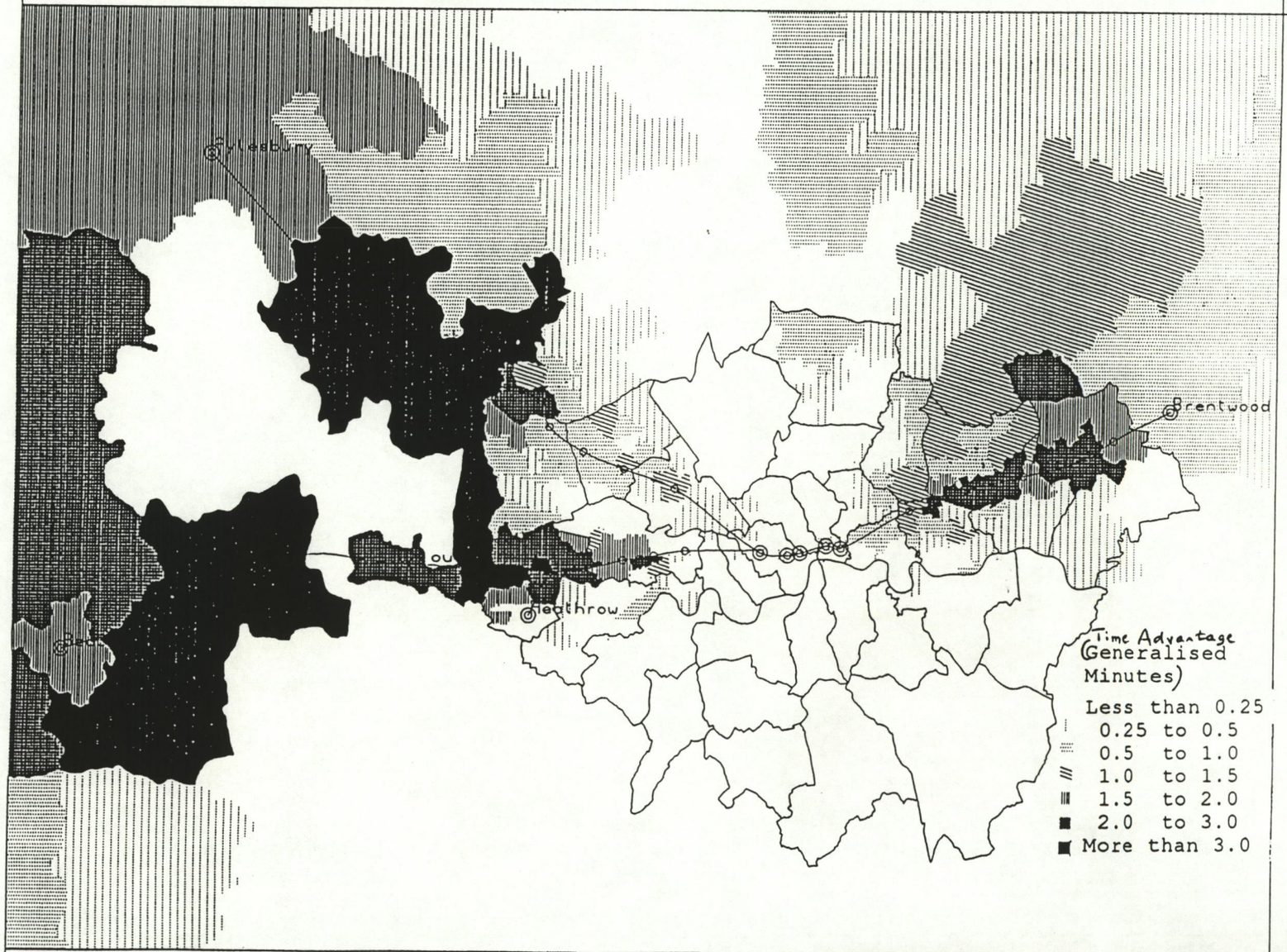


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Chart 8 - Zones Where Kings Cross CrossRail Alignment Gives Faster Times to Central London than the Planned Alignment

emme/2

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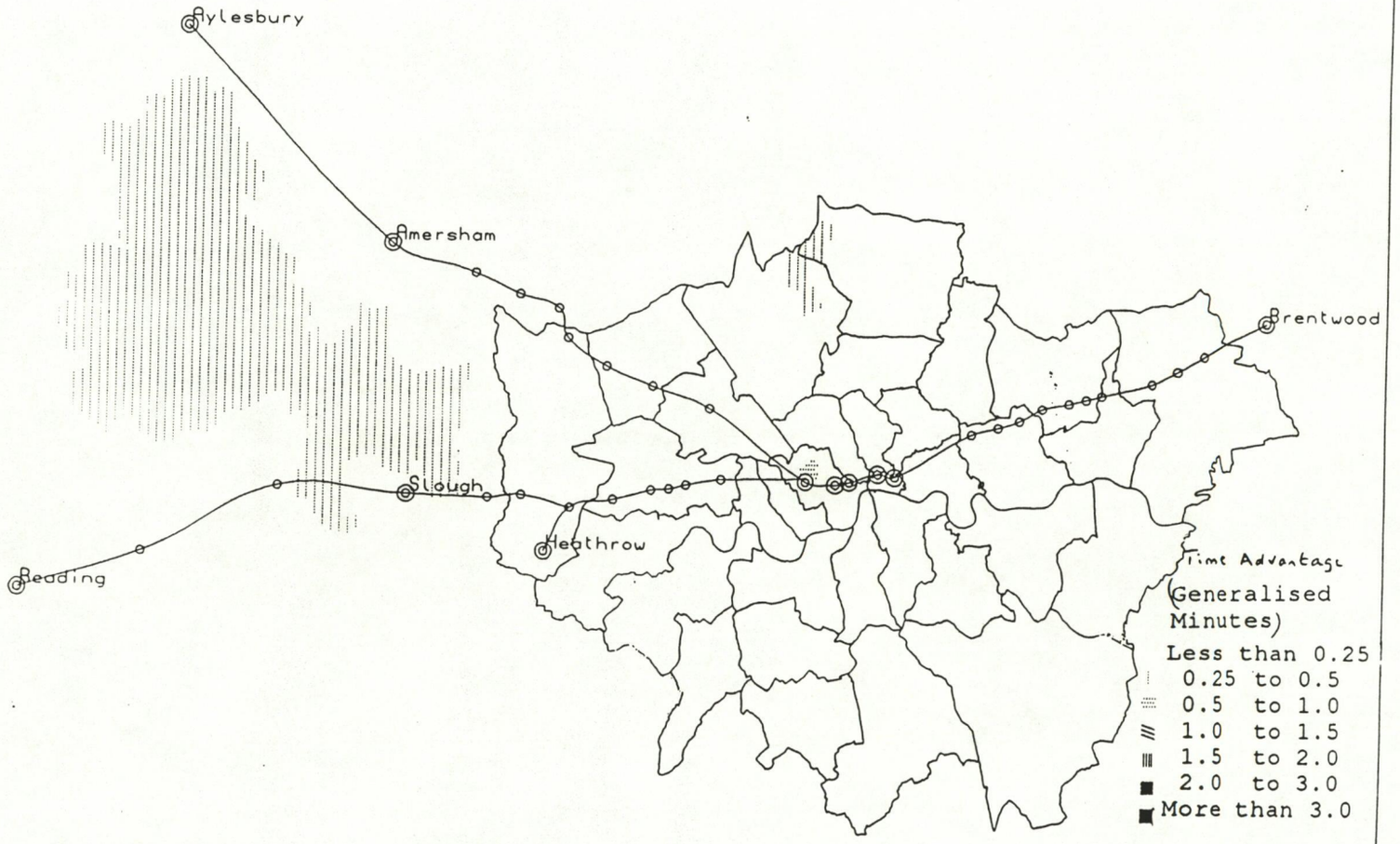

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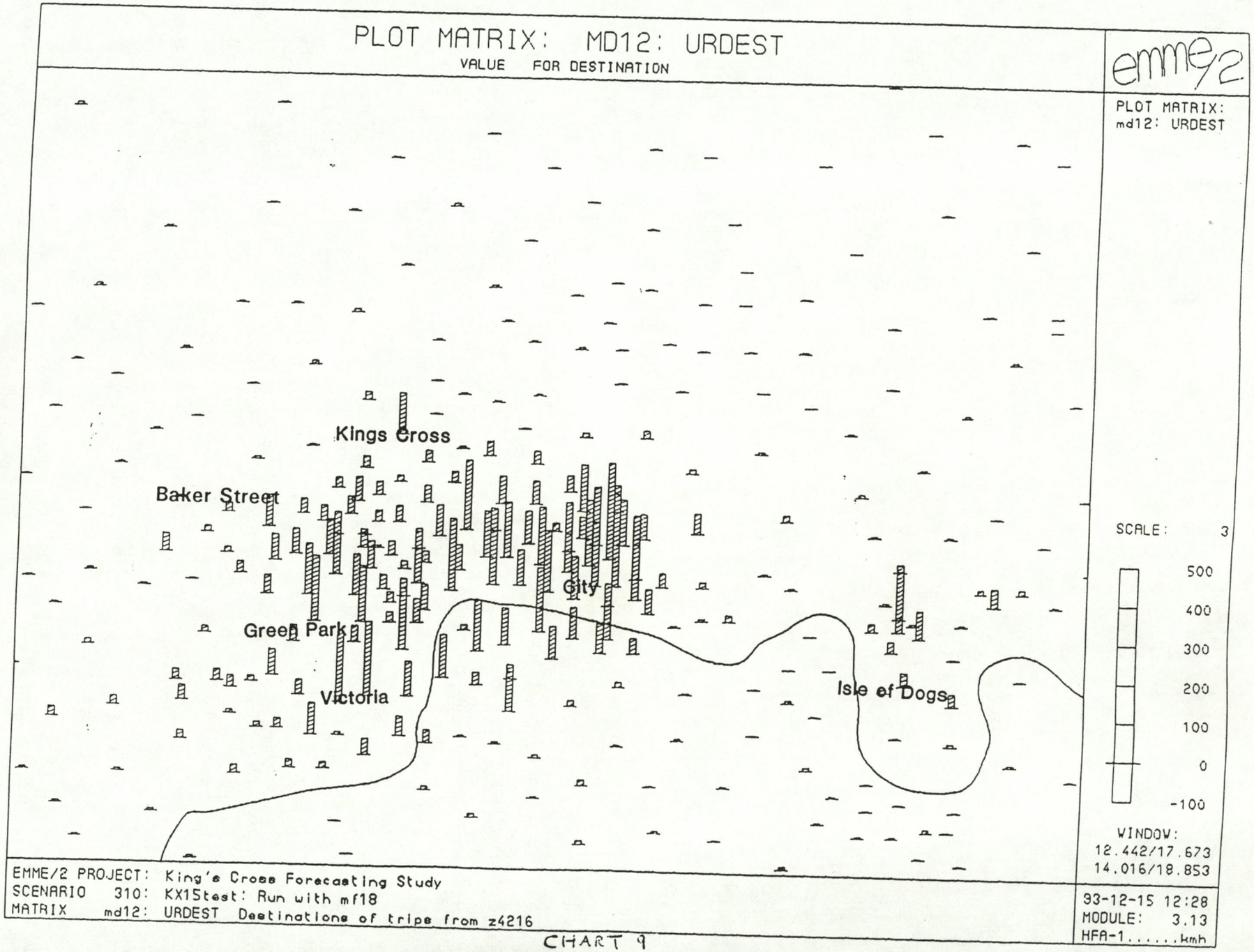
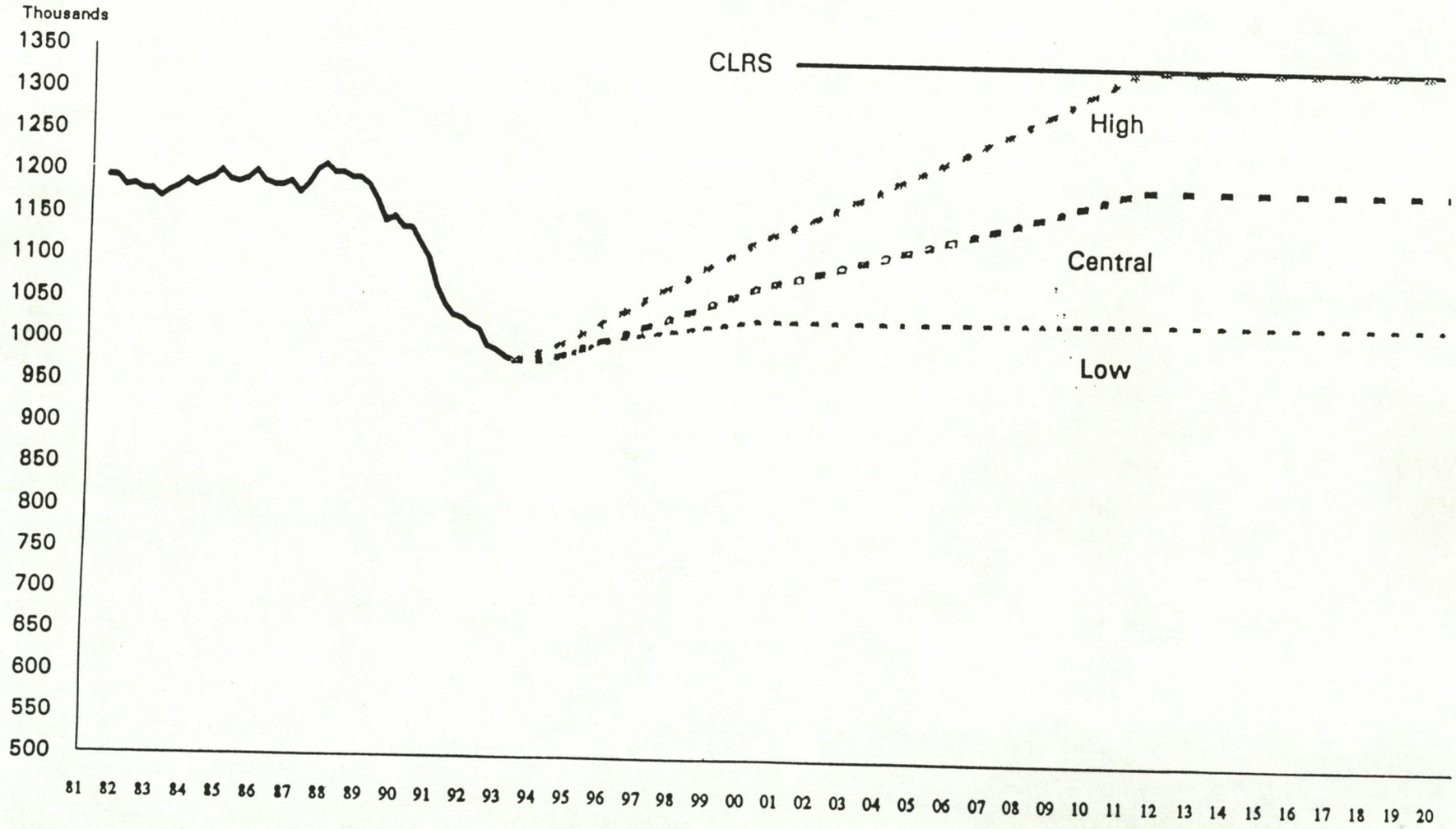


CHART 9

Forecast Destinations of Union Rail

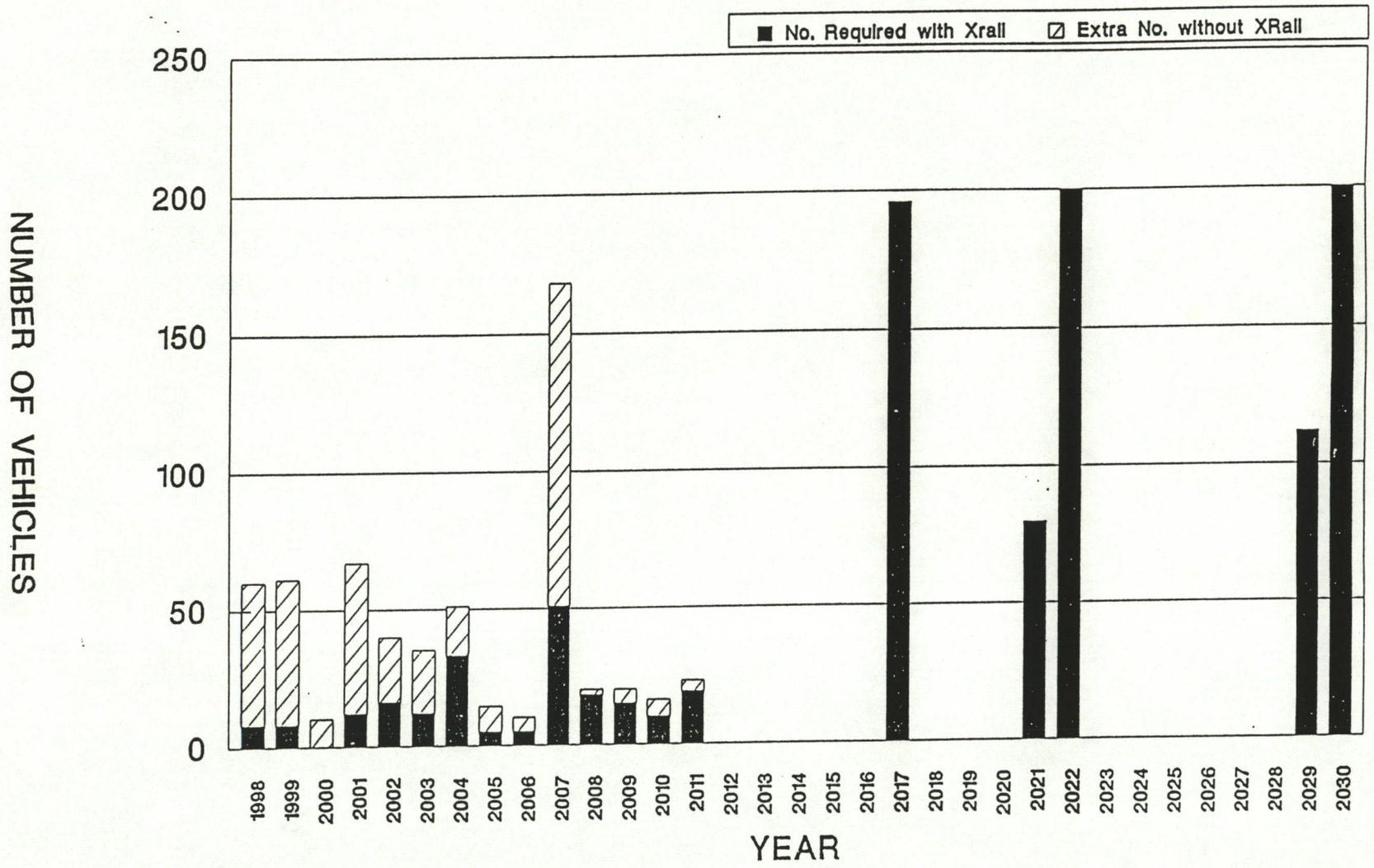
CHART 10

Central London Employment



NON-CROSSRAIL FLEET PURCHASE PROGRAM

Medium Growth



London Transport

10 January, 1994

Sir Wilfrid Newton, CBE
Chairman

55 Broadway
London SW1H 0BD
Telephone 071 918 3157
Fax 071 918 3458
Telex 893633 LRT BDY

The Rt. Hon. John MacGregor, OBE, MP
Secretary of State for Transport
Department of Transport
2 Marsham Street
London SW1P 3EB

Dear Secretary of State.

CROSSRAIL COST EFFECTIVENESS STUDY: BOVIS / GIBB REPORT

We are writing to make a formal response to the report delivered by the Study Team led by Bovis/Gibb on Friday 7 January. The document on which the enclosed response is based did not include certain appendices listed in the table of contents but we consider that their omission does not materially affect consideration of the strategic issues.

Firstly, we are gratified that the Study Team, like its predecessors, has concluded that the planned scheme is soundly based in both planning and engineering terms. We are also pleased to see recognition of the special potential surrounding Paddington and Farringdon stations. We accept that some aspects bear re-examination, such as tunnel diameter and rolling stock specification, and are happy to assure you that these will be reviewed before making construction or purchase commitments. The principal issues raised by the report concern strategy regarding timing and ultimate capacity and it is on these that our response is focused.

The report could be interpreted as suggesting that powers are being sought prematurely; there are two principal reasons why we would not agree with such a suggestion.

Firstly, the report appears to concentrate excessively on Central London employment forecasts, not recognising the scheme's role as a regional service which is less sensitive to economic activity in Central London. It also appears to ignore the benefits to existing rail network users; over 70% of the "design year" demand is using the system now and benefits of £230m p.a. could be captured immediately. The analysis in our own Cost Effectiveness Study (Stage 2 report) shows that, even at a "low" demand forecast which implies little recovery from the present recession-induced demand, the project achieves well above a 1:1 benefit/cost ratio. The debate over timing centres on less than a quarter of the demand and we believe overlooks the fact that the scheme's benefits derive from time savings and diversion from the highway system and that it is not solely a congestion relief measure.

Secondly, the report appears not to recognise the London commuting market's volatility and the time scale of infrastructure-led response. Subject to Royal Assent, the opportunity to exercise the Powers will be available for at least 5 years. Within that period, there can, and no doubt will, be significant change in market conditions, on which a firm decision about the project's scope and timing would be based. While accepting that congestion, which generates some of the benefits, has reduced in the current recession, it could return within the implementation time of either the planned scheme or any reduced-scope alternative, particularly if a fresh consent process were required. We believe that the capability to respond to market developments should be retained and that consent to the planned scheme is the best way of doing this in both planning and practical terms.

The issue of ultimate capacity is addressed in the planned scheme by providing capability to increase train length to 12 cars, while planning train services, tunnel station and outer area infrastructure for a 8-car operation. We consider that the Study Team's 6-car operation concept uneconomic and inadequate; in the short term, this would reduce capacity on the Liverpool Street - Shenfield service unless frequency were increased to the limits of the signalling system in compensation. In the longer term, the capacity would be fully utilised at our "central" demand forecast (broadly equivalent to the Study Team's demand assumption), leaving no room for growth induced by economic conditions or availability of a new regional service. The report's concentration on Central London prospects again seems to have led to CrossRail's potential for outer London and regional regeneration being overlooked, with the implications for ultimate capacity requirements.

We consider that 8-car operation is the minimum acceptable scheme concept, while accepting the Study Team's comment that no economic justification has been provided for the 12-car capability; this is because there is no forecasting technique by which the timing for the requirement can be predicted. However, we both have experience of schemes where demand has far outstripped forecasts - the Victoria Line is now carrying more than double the 1969 forecast and cross-London journeys on Thameslink are more than twice that which would have been forecast by the normal methods. Further details are being provided separately to officials. Our own work (Cost Effectiveness Study Stage 1) has shown that the 12-car capability's initial cost is very small (£6m) and we believe it is justified as insurance policy against the much greater costs of providing additional capacity in the future. The report does not appear to recognise the scope for adjusting costs through train service plans, which offer greater potential savings in capital and operating costs without the long term risks associated with infrastructure decisions.

The report suggests some alternative possibilities, although our recollection is that these were put forward in the Study Team's pre-Christmas presentations as avenues that might be explored if it were decided that the CrossRail project should be abandoned or indefinitely deferred. You are aware of our view that most are fundamentally flawed and we have been unable to find data to support the report's assertions on their performance in social benefit and benefit/cost terms. We do not believe that they, individually or collectively, achieve any worthwhile proportion of the benefits available from CrossRail, or that the effects on the existing network have been properly considered, and therefore feel that there is nothing to be gained by pursuing them.

Continued.....

Looking at the report in the context of the decision on whether to proceed with the CrossRail Bill Committee stage, we see nothing in it to persuade you or colleagues that the full Bill should not proceed. We believe that the issues of final project scope and financing can best be addressed on the basis of an approved scheme with doubt attaching to the consent processes eliminated. The project has been reviewed from several perspectives - engineering, financing and planning - by four independent consortia and twice by ourselves, and each time the overall strategy has been validated. We hope that Government will reach a similar conclusion and meanwhile continue to prepare for substantive Committee proceedings to begin on January 25.

Yours sincerely,

Wilfrid Newton
Chairman
London Transport

Sir Bob Reid
Chairman
British Railways Board

CROSSRAIL

COST EFFECTIVENESS STUDY

RESPONSE TO THE BOVIS GIBB REPORT

1 INTRODUCTION

1.1 The Bovis Gibb Joint Venture submitted their report on Cost Effectiveness of CrossRail to the Department of Transport on 7 January 1994. This response is based on the report as received, notwithstanding that certain appendices were marked as to follow or that time precluded discussion and agreement of the cost information quoted in the report with the Consultants. However, the operators do not consider the outstanding material as lilkely to affect the strategic issues relevant to proceeding with the Crossrail Bill before the House of Commons Select Committee when they meet on 25 January 1994. The report raises other issues, not pertinent to the progress of the Bill, which the operators may wish to discuss with the Government at the appropriate time.

2 PROJECT STRATEGY

2.1 CrossRail Route

2.1.1 The operators welcome the endorsement of the proposed route for the CrossRail and the rejection of the Kings Cross alternative contained in sections 3.2.2 and 3.2.5 of the report. This concurs with the conclusions of their own work and the views expressed in the report produced for the Department of Transport by S G Warburg. Bovis Gibb suggest in Section 3.2.3 of their report that the route proposals on the surface should be re-examined because they are unchanged since the publication of the Central London Rail Study. The operators have undertaken 6 studies over the period since the deposit of the Crossrail Bill in 1991 and will continue to consider whether additions to the scheme could be justified on a marginal basis. However, any proposal must not diminish the performance of the railway in safety and operating terms or compromise the economic and financial justification of the core scheme between Shenfield and Reading/Aylesbury.

2.1.2 The operators welcome the comments of Bovis Gibb regarding the choice of Central Area station locations, particuarly the recognition that special considerations attach to Paddington and Farringdon. The report identifies the case for each of the six station locations provided for in the current tunnel alignment and the operators agree with the statement in section 3.2.4 that "positive net benefits will only materialise upon the opening of the main cross London services." They believe it is necessary to confirm the principles of the scheme through enactment of the Crossrail Bill, enabling the scope of the project to be finalised in the light of market conditions prior to the commencement of construction.

2.1.3 The Bovis Gibb report refers to the possible station at Holborn and suggests that further evaluation should be undertaken. The operators intend to undertake this work, which requires further development of the scheme design,

but if they decided to proceed they would not use an amendment of the Crossrail Bill to provide any necessary powers. They consider that an Order under the Transport and Works Act would be a more appropriate route in this situation.

2.2 Alignment

2.2.1 The Operators welcome the endorsement of the Central Area alignment contained in the report (section 1.2). The CrossRail alignment has been developed over a period of five years and has been progressively adjusted during that period to take account of research into not only underground structures but also relevant information about the surface sites affected by the railway. This has allowed the progressive reduction of the number of buildings, and particularly Listed Buildings, affected by the scheme although many have been referenced to facilitate any work necessary to protect them against the potential effects of settlement.

2.2.2 The current CrossRail alignment is protected by a Safeguarding Directive issued under planning legislation. If the Bill were withdrawn, the alignment would continue to be protected by this means but in the event of a long or indefinite delay to the scheme there would be considerable pressure to rescind the Directive. The attached Appendix 1 shows a number of sites along the route where proposed development has already been impeded by the CrossRail proposals. If the safeguarding were removed, some or all or some of these developments would proceed and Planning Consent be sought for others. There are a number of critical areas where the alignment would be permanently blocked if further development with deep piled foundations took place. It would not then be possible to construct an east west railway along the Oxford Street corridor without major work to buildings. This would probably require a significant number of relatively modern buildings to be demolished and rebuilt in a manner compatible with the railway works thereby considerably increasing project costs and environmental impacts. The planned scheme is the results of several years' development, which has included mitigation of environmental impacts. A relaunched scheme would have difficulty in containing those effects if it had lost the benefit of earlier safeguarding.

3 ECONOMIC EVALUATION

3.1 Long Term Trends

3.1.1 The operators' Cost Effectiveness Study Stage 2 report refers to work[1] which offers a more optimistic long term view of demand than that taken by Bovis Gibb. In principle Bovis Gibb argue that there is a long term decline in peak hour demand for travel by all modes into Central London which, while reversed during the period 1983 - 1988, has reasserted itself in the subsequent recession. The operators' view is that demand was constrained between 1960 and 1980 by Government planning policy expressed in actions such as restrictions on the scale of development, outright bans on new office

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1: Central London Employment Projections for Evaluating CrossRail: LT Planning (H Abrahams) - Annex to Strategic Proof of Evidence to the CrossRail Bill Select Committee. (Supplied to Department of Transport officials.)

construction and direction of offices elsewhere by the Location of Offices Bureau.

3.1.2 Figure 1.2 of the Bovis Gibb report shows the number of people arriving in Central London by all transport modes in the peak period and the attached Appendix 2 presents the same data in the conventional statistical format. This demonstrates that rail demand did not fall significantly between 1960 and 1980 but was stagnant or falling slightly. Following this Central London rail traffic rose to an historic maximum in 1988/89. The 1990 - 92 recession appears to be a short term reaction to an exceptional period of growth on a long term rising market and the graph implies that the upward trend will be resumed as economic activity increases to reach, and probably exceed, 1988 levels.

3.1.3 The work referred to above points to evidence of growing activity in Central London and the ready availability of office accommodation at historically low cost as an indication of the potential for rapid increases in railway traffic within the decade or more necessary to plan and construct a new line. The operators' Cost Effectiveness Study Stage 2 Report shows that CrossRail generates benefits in all employment scenarios: if growth in employment occurs, then the benefits increase more rapidly.

3.1.4 The Bovis Gibb report comments (section 3.7.4) that CrossRail does not unlock major redevelopment areas. Whilst this is generally true in Central and Inner London, Bovis Gibb recognise the opportunities at Farringdon and Paddington. Elsewhere CrossRail will provide accessibility to development areas at Park Royal and Stockley Park to the west of London, contribute to the regeneration of the Stratford area and provide access to Docklands via Stratford. In addition, significant CrossRail demand will originate outside Greater London where there is potential for a high quality service to generate more rapid growth in demand.

3.2 Immediate CrossRail Benefits

3.2.1 The Bovis Gibb report suggests that CrossRail might be delayed until demand grows sufficiently to improve interest from the private sector. The operators consider that such growth would occur whilst commercial arrangements were being completed and during the maximum 5 years of the powers contained in the Bill. Any delay once demand levels had begun to rise would mean that London has to wait a further 5 or 10 years before gaining the benefits of the project. These accrue to existing passengers who will transfer to CrossRail, to the users of other lines who enjoy a quicker and less crowded journey and to road users who have either transferred to rail or benefited from those who have.

3.2.2 CrossRail is not dependent for its success on a growth in Central London employment as it brings major benefits to existing passengers. Most importantly :

1. It dramatically improves access to key areas of London - 13 minutes saving on a 57 minute journey from Reading to Tottenham Court Road, 14 minutes saving on a 25 minute journey from Stratford to Tottenham Court Road. These benefits are worth around £80m pa.

2. It reduces demand and thus relieves congestion on a number of key overcrowded railway lines, particularly on the Central Line, bringing travelling conditions into the acceptable range from the unacceptable. These benefits are worth around £60m pa.

3. The demand for CrossRail will undoubtedly grow above today's level, even without any growth in Central Area economy. CrossRail will bring a new quality to public transport in London and many people will choose to make a journey by rail rather road; make their journey to London rather than elsewhere or; decide to make an entirely new journey, because of CrossRail. These benefits are worth around £45m pa.

4. CrossRail will bring significant benefits in terms of highway congestion relief as a result of the switch from car to rail. These benefits are worth around £45m pa.

All these benefits will occur without any growth in Central Area employment and together they are worth around £230m pa. If the project were delayed from 2001 until 2011, London would forego benefits totalling nearly £800m NPV. The loss of benefits would not be distributed evenly throughout the capital, the City and West End would suffer most: the very locations where it is essential to attract new businesses for London to prosper. If the modest 'central growth' employment assumptions now being used in the review of CrossRail occur then the benefits foregone would increase significantly.

3.3 Benefit/Cost Ratios

3.3.1 The Bovis Gibb report concludes that "the project benefit:cost ratio would appear to be too marginal to support public-private sector funding with an acceptable transfer of risk". In the absence of the relevant appendices and time to review the assumptions contained in them it is impossible to determine whether this conflicts with the conclusions of the operators' studies. The operators' re-evaluation of the Project contained in their Stage 2 report shows that development of the scheme has significantly enhanced its performance and casts doubt on whether the statement in section 3.10.3 of the Bovis Gibb report that "the project is marginal as a public sector development" remains valid.

3.3.2 The report does comment (in 3.8.1) that "whilst it would be wrong to build CrossRail with to little capacity, it would be equally wrong to build it with too much". The report does not define "too much or too little", but the operators consider that provision for 12 car trains at a marginal cost of £6 million is not "too much" in the context of the full scheme. The CrossRail tunnel will have a design life of 120 years and probably will serve much longer: sufficient to give a reasonable prospect that enhanced capacity will be required. The operators also consider that ability to provide all the planned stations by at least construction of the station tunnels would be prudent. The project as promoted in Parliament is intended to provide the framework within which an appropriately scaled project can be built within a reasonable time.

3.3.3 The Bovis Gibb report expresses concern (section 3.9.1(iv)) about the assumptions of the operators regarding core funding of rolling stock and its

cascade to other services. The operators note that cascade strategies feature in some of the other infrastructure proposals contained in section 4 of the Bovis Gibb report and consider that the assumptions made in the Project Evaluation and their Cost Effectiveness Study, which have been previously reported to Government, are reasonable.

4 MINIMUM CORE RAILWAY

4.1 General

4.1.1 The Bovis Gibb report proposes the reduction of the scale of the CrossRail project from the basic 8 car railway of the operators' scheme to one of 6 car trains with no provision for upgrading other than variation in the frequency of the service. The maximum capacity of a 6 car railway can never be as large as that of an 8 car service. On the Shenfield line 6 car operation would represent a reduction in the present capacity of the trains, although this could be offset by an increase in frequency that would absorb the full capacity of the signalling system, precluding further expansion without major expenditure on a signalling system that is currently being installed. On this section an 8 car service is required to provide the existing service and allow capacity to meet the increasing demand to Docklands via Stratford.

4.1.2 Bovis Gibb suggest a service of 30 trains per hour at 85% of CrossRail Reference Year demand which could occur in 2002 on the "central" demand scenario and beyond which growth continues. At this level a 6 car service would have reduced the quality of service experienced by the passenger in order to increase capacity. The view of the local authorities, and especially the Cities of London and Westminster is that CrossRail should meet current and future quality expectations for speed, reliability, comfort and safety and that the infrastructure should be large enough to do so, even if demand forecasts were exceeded, without further disruption of the urban fabric.

4.2 Characteristics of 6 Car Railway

4.2.1 A 6 car railway has significantly higher costs than an 8 car railway of similar passenger capacity in terms of both fixed equipment and manpower. The higher service frequencies require more sophisticated signalling, more manpower and a more complex ventilation regime which may require additional shafts to the surface. Additional staff are required; for example, the planned CrossRail driving staff of 220 would be increased to 290 to provide the same capacity (and generate similar revenue). Overall, direct operational costs will be around 30% more for a 6 car railway than an 8 car service.

4.2.2 The larger volume of equipment required for the 6 car railway generates more maintenance at greater cost and a proportionately higher risk of breakdown. There is also a larger requirement for maintenance facilities and siding capacity because of the larger number of trains in service. A line designed for higher service frequencies also requires more terminal points to accommodate the larger number of trains in the service. Typically maintenance costs will be 25% higher for a 6 car railway than for an 8 car one of the same capacity.

4.2.3 The Bovis Gibb report envisages not only 6 car operation but also reducing the train specification from the 3 door car design to a 2 door design. This has

major implications for station dwell times, limiting the actual frequency with which trains can be operated. This is amplified by a fragmented service pattern which causes uneven loading between trains, longer journey times, unpunctuality and overcrowding.

4.2.4 The initial view of the operators is that a 6 car service would be fully stretched to accommodate the demand contained in their "central" estimate for 2011 and which could occur sooner if exogenous factors stimulate growth. The information contained in Table 3.4 of the Bovis Gibb report suggests that the infrastructure costs of a 6 car railway are substantially the same as those of an 8 car railway (£1810 million compared with £1820 million). In this event an 8 car railway would represent a better investment because of its lower operating costs and greater revenue potential. The relationship between infrastructure capacity and demand is not absolute; decisions on infrastructure are only taken once in the lifetime of an asset whereas the level of service can be varied infinitely and at relatively short notice to respond to changes in demand.

5 OTHER INFRASTRUCTURE PROPOSALS

5.1 The Bovis Gibb report considers six less capital intensive projects which were offered at presentations as ideas to be pursued in the absence of CrossRail. They are intended to address what it calls "CrossRail type objectives" which the study brief describes as:

> "1.1 To provide direct access to Central London, saving journey time and removing the need for passengers to change.
>
> 1.2 To alleviate road and rail transport congestion in and around London"

5.2 The six schemes have been considered in a separate report accompanying the Stage 2 Cost Effectiveness Study[2]. Three are routed via Kings Cross, an alignment dismissed elsewhere in the report, and the remainder have little apparent relationship to CrossRail. In the absence of engineering feasibility drawings of the schemes and details of the costs and evaluation it is difficult to comment further on these suggestions.

5.3 The Bovis Gibb report asserts that the schemes could attract private sector finance but in the absence of supporting information this cannot be judged. The proposals' implications appear not to be appreciated; they would require regrouping of the Railways Act franchises which are only just being established. Section 4.5 of the report goes beyond present Government policy by suggesting ways in which these projects might be undertaken as part of the franchising of London Underground.

5.4 None of the options considered as Other Infrastructure Proposals replicate the benefits of attributable to CrossRail.

6 COMMENTS OF THE PRIVATE SECTOR (Provided by NatWest Markets)

6.1 We have reviewed the Bovis Gibb report without the benefit of having seen the appendices relating to the economic and financing aspects. Our comments

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2: CrossRail Cost Effectiveness Study - Preliminary Response to Bovis Gibb options - London Underground, December 1993.

are made in the light of a general agreement between NatWest Markets and Schroders set out in a letter from Schroders to the Department of Transport on 23 December 1993.

6.2 Economic Evaluation

6.2.1 We have shown in the supplement issued with the Cost Effectiveness Study Stage 2 report that, on a conservative basis, using an 8% discount rate and taking the full scheme with London Transport "central" demand assumptions based on a pro rata allocation of Core Budget items between public and private sectors, the benefit:cost ratio equates to 1.05 or 1.28 depending upon the method of calculation. Even the lower figure shows the project to be justifiable.

6.3 Financing Structure

6.3.1 In our financing structure we have contemplated financing sources of only debt and equity although we acknowledge that there are various options for "layers" of finance highlighted in the Bovis Gibb report.

6.3.2 Whilst future due diligence will be required at the time of raising the finance for the project and on the basis of the numbers presented to us, we believe that whilst it is at the lower end of what would be acceptable, there is sufficient financial attractiveness for CrossRail to expect reasonably that the proposed levels of finance could be raised.

7 CONCLUSIONS

7.1 The Bovis Gibb report indicates a number of additional studies which might be undertaken, none of which would compromise the continued progress of the CrossRail Bill through Parliament. However, such progress is in the sole gift of Government and would be seen as giving renewed credibility to the scheme which will stimulate private sector interest and participation.

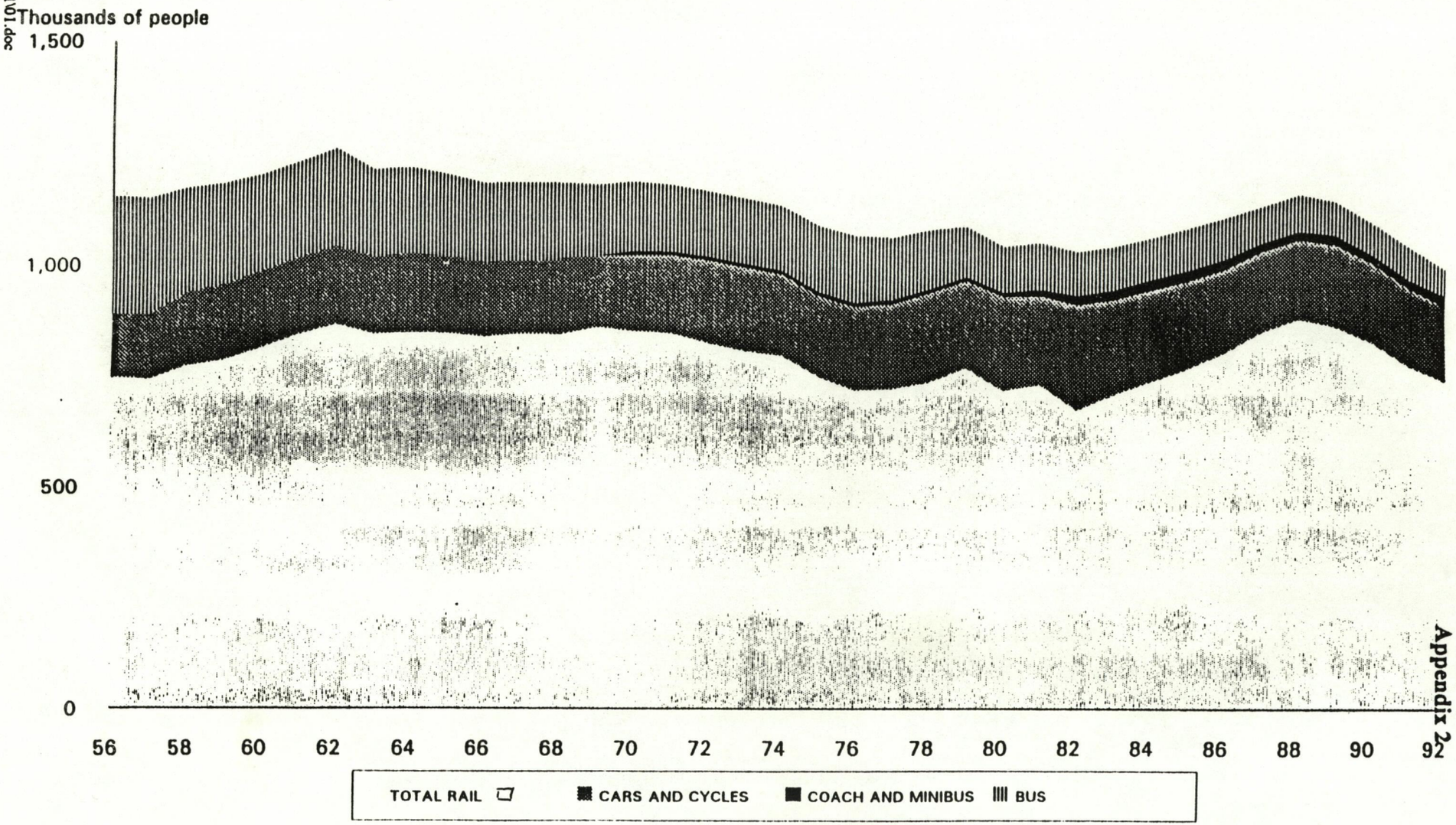
CrossRail Client Team (London Underground, London Transport, Network SouthEast),
10 January 1994

PROPERTY DEVELOPMENTS & CROSSRAIL ALIGNMENT

P/Pa.009/01/JG/aa/0106

Appendix 1

Trends in Central Area Peak Count
(07:00 to 10:00)



Appendix 2