Hyder

London Borough of Greenwich

DLR Extension Silvertown - Falconwood

Pre-Feasibility Study

Elevated Alignment on A2 - BTSA Centre Line

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Elevated Alignment on A2 - BTSA Centre Line

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1 Executive Summary

1.1 An extension of the DLR from Silvertown to Falconwood, generally following line of the A2 Rochester Way Relief Road and the A102 Blackwall Tunnel Southern Approach (A2 – BTSA), potentially offers considerable benefits to residents and businesses in L B Greenwich. It would vastly improve north-south public transport links and connect large swathes of the Borough with existing fixed-track services to/from Central London and other parts of the Capital.

1.2 The construction of an elevated DLR extension along the centre line of the A2 - BTSA, undoubtedly would provide a very visible, high profile facility along a recognised transport corridor with good legibility and minimum land-take.

1.3 The multi-modal use of transport corridors in this way can be advantageous if the provisions can be designed collectively as part of an integrated land-use/transportation masterplan for a major settlement. But attempting to retro-fit a proposed fixed rail facility into an existing principal road corridor requires a flexible design approach to overcome the inevitable constraints and achieve the optimum solution.

1.4 Rigid application of an elevated DLR concept along the centre line of the A2 – BTSA could result in disproportionate costs being incurred along some sections of the route. It is important, therefore, also to consider alternative alignments. An elevated DLR construction would be particularly expensive to achieve at the Woolwich Road crossing, Westthorn Avenue and the Eltham Tunnel, for which locations bespoke structural solutions would need to be identified and costed.

1.5 Also for the purpose of mitigating additional noise nuisance and visual intrusion, a tunnelling option may be more appropriate in other locations that would otherwise require the construction of high-level flyovers of existing over-bridges, such as The Sun in the Sands.

1.6 The business case for any proposed DLR extension would be highly dependent on high levels of passenger demand and accessibility to secure maximum patronage and fare revenues. In this regard an elevated construction along the A2 – BTSA centre line would need to be evaluated against other alignment options.

2 Introduction

2.1 Hyder Consulting was commissioned by the London Borough of Greenwich to conduct a preliminary assessment of the feasibility of constructing an extension to the Docklands Light Railway (DLR) between Silvertown and Falconwood.

2.2 Hyder was asked to explore how a DLR extension between Silvertown and Falconwood could keep strictly to the A2 - BTSA alignment throughout, with a view to minimising property impact and avoiding disruptive tunnelling. We were asked to consider the construction of a viaduct following the centre line of the central reserve, but also to discuss the relative merits of other options at specific sections.

2.3 In producing this report, therefore, Hyder has also considered various route options at problematic locations and has suggested an alignment that could be constructed largely outside the limits of the carriageway to avoid significant impact on the operation of the existing road.

3 DLR Elevated Construction

3.1 The building of an elevated DLR extension between the Greenwich Peninsula and Falconwood along the A2 - BTSA would require a suitable form of construction likely to minimise the disruption during construction and the area required at ground level. The A2 – BTSA is a strategic road on the Transport for London Road Network (TLRN) and reduced capacity on this road is unlikely to be acceptable. Therefore, an elevated DLR alignment would need to fit the existing road geometry as far as possible.

3.2 Much of the existing DLR is constructed on viaduct. The core network was opened in 1987 and used two of the four railway tracks between Tower Gateway and Limehouse, it also re-used the former railway viaduct between Limehouse and Westferry. New viaduct was constructed at Poplar junctions and south through Canary Wharf to just north of Crossharbour. All of this new construction and most of the elevated sections of DLR's extensions are constructed with reinforced concrete beams under each track supported by a separate column for each track. The principle of an elevating the DLR above existing road level therefore is well established.

3.3 The elevated section between Canning Town and London City Airport, however, is constructed along the south side of Silvertown Way and North Woolwich Road with single columns supporting double track. This provides a suitable precedent for elevated construction along the A2 - BTSA. In a short study of this kind, it was not possible to obtain information from TfL/DLR on the precise dimensions and form of construction but we measured the columns and have used our judgment, based on the design of similar structures, to indicate the likely form of construction.

3.4 **Figure 1** shows single pier elevated sections of the DLR employed on the City Airport extension. The columns are octagonal in plan with four longer sides on the main axes. They are about 1.70m wide and support spans of lengths that vary between 30 and 50 metres. Track is supported by a reinforced concrete box beam and there are two tracks, conductor rails, emergency/maintenance walkways and fences. The overall width of a double track DLR viaduct is about 8.5 metres.

Figure 1: DLR City Airport Extension – Single Pier Elevated Construction

4 The A2 - BTSA Highway through Greenwich

4.1 The A2 - BTSA is mostly constructed as dual two and three lane with a relatively narrow central reserve. The road is dual two lane between Kidbrooke and Falconwood and mostly dual three between the Sun in the Sands and the Greenwich Peninsula. There are slip roads at the junctions with Blackwall Lane, Woolwich Road, Shooters Hill Road (the "Sun in the Sands" where the A2 turns westwards), Rochester Way, Kidbrooke Park Road and at Westhorne Avenue.

4.2 Consequently there are several stretches which are wider than dual two or three lanes, but generally there is very little room for widening the road without affecting property. There is some scope for widening between the Sun in the Sands and Kidbrooke without property demolition but elsewhere houses are close to the road, or the road is in relatively deep cutting. The A2 is in cutting between Eltham and Falconwood, as is the BTSA between Bramshot Avenue (north of Charlton Road) and the Sun in the Sands.

4.3 The road is constructed to current acceptable design standards but with a central reserve of about 2.5 metres - wide enough to accommodate the existing crash barriers. There is a narrow hard shoulder along most of the south/east bound carriageway but most of the other carriageway has a narrow raised verge about 1 meter wide. On both carriageways there are lay-bys at intervals.

4.4 The A2 - BTSA is constructed as a flyover at Blackwall Lane and Woolwich Road but, south of this point, it is in cutting with 14 over-bridges, and three under-bridges between Kidbrooke and Westhorne Avenue. The over-bridges include railway bridges at Westcombe Park and at Eltham, and five footbridges. None of the over-bridges are high enough to permit a DLR extension constructed above the road to pass under them.

4.5 The fitting of a DLR Extension into this narrow corridor, if at all possible, would have an advantage over other possible alignments insofar as it would take no land from adjacent properties. It would also provide a very visible, high profile facility along a recognised transport corridor with good legibility. Whether or not it offers the best solution in terms of optimising patronage is uncertain, but few potential passengers would have difficulty locating the service or orientating it to their surroundings.

5 Elevated DLR over the A2 - BTSA

5.1 General DLR Requirements

5.1.1 It is assumed that a double track DLR extension would be required. Short sections of single track may be contemplated, but long sections affect DLR network operations by constraining headways and magnifying the effects of service delays, so are to be avoided. The longitudinal span length between the piers would vary between 30 and 50 metres depending on local conditions, so the average span would be about 40m.

5.1.2 An elevated DLR alignment above the A2 would require either a viaduct supported by central piers or a portal frame with supports beside the road. The artist's impression below (**Figure 2**) gives some idea how a central piers concept might look from a motorist's perspective.

Figure 2: Artist's impression – DLR Central Reserve Elevated Alignment Concept

5.1.3 However constructed, a wide structure over the existing carriageway would interfere with the existing street lighting. As an integral part of the project, this would have to be substantially revised over the entire length of the A2 – BTSA from Woolwich Road to Falconwood.

5.2 Central Pier Construction

5.2.1 For central pier support, there would need to be enough room to locate the piers on the central reserve. At present there is insufficient room for most of the length of the road between Greenwich Peninsula and Falconwood. Piers of 1.7m width would require a central reserve of at least 3.5 metres to allow for crash barriers with adequate clearance and headroom to the underside of the piers. Since much of the road is constrained by cuttings and/or adjacent development, widening the road corridor would probably affect on some property along the route.

5.2.2 Alternatively it may be possible for traffic lanes to encroach on to the hard shoulder but this would have to be agreed with TfL. This is likely to be unacceptable if deemed to affect the network resilience of the route. The third (and most probable) option may be to secure the required width of central reserve through agreed minor adjustments to the width of the traffic lanes. **Figure 3** shows a typical cross section of the A2 through the Eltham – Falconwood retained cutting. This exemplifies the minimum land-take required for a central pier construction and how this might impact on the width of the carriageway if the existing hard shoulders and margins were retained.

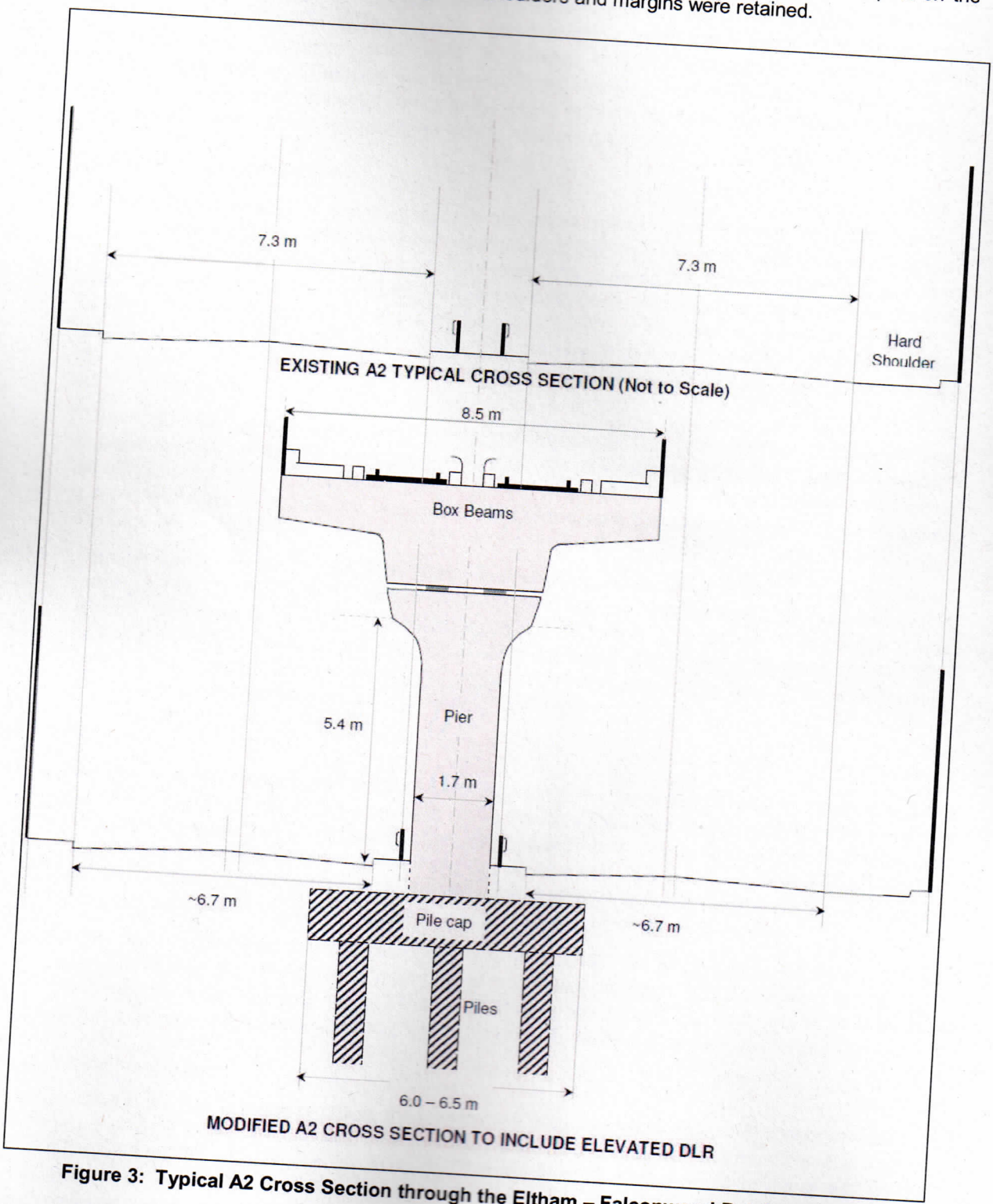

Figure 3: Typical A2 Cross Section through the Eltham – Falconwood Retained Cutting

5.2.3 An elevated alignment supported by central piers would pose temporary difficulties during construction. Foundations design would depend on ground conditions but piled foundations for the piers would probably be needed. The pile cap would extend laterally under each pier with an overall width likely to be about 6 – 6.5 metres. Such would require a construction area encroaching on the existing traffic lanes adjacent to the central reserve, so lane closures would be necessary.

5.2.4 Construction could proceed in stages affecting a limited stretch of road at any one time. For the most part, it may be possible to retain three reduced-width running lanes utilising the existing hard shoulder. Traffic disruption could then be partially mitigated through tidal contra-flow traffic management that would provide two lanes for traffic travelling northbound and southbound during the morning and evening peak hours respectively. It is likely, however, that significant traffic delays would still be incurred with some impact on the adjacent road network.

5.3 Portal Frame Construction

5.3.1 The alternative method of construction is to use portal frames – that is arches spanning the road. Where sufficient space exists, columns constructed at the roadside would support cross beams on which the DLR tracks would be located. The longer the cross-spans, the larger the piers and cross beams would need to be. Therefore, it would be much cheaper to locate these structures over one carriageway rather than centre them across the full width of the road. It would be necessary to identify space to locate piers, which is less of a problem at the side of the A2 – BTSA (other than through the retain cuttings). But the pier on the central reserve would probably still require the latter to be widened.

5.3.2 Therefore, similar issues arise in portal frame construction as for central pier construction although the columns for portal frames would probably be slimmer with more modest foundations, which would reduce the space needed for construction. A potential problem with portal frames is that the piers constructed on the drivers' nearside could interfere with the visibility of road signs so careful attention would be needed to relocate signs as necessary to achieve satisfactory sight lines.

5.3.3 Through careful planning and attentive traffic management, it may be possible to retain four narrow running lanes adjacent to the construction of a portal frame structure, so traffic disruption would be minimal, but construction costs could be appreciably more than for a central pier construction. It may be that a combination of structural methods is needed to balance the costs of construction and traffic delays, having regard to the availability of space at different parts of the road. This would require more detailed consideration outside the scope of this study.

5.4 Headroom

5.4.1 The DLR extension would need to be constructed to provide the minimum required headroom over the A2 - BTSA. This means pier crosshead soffits having a clearance of at least 5.4m over the road surface (see **Figure 3**). But the design of an elevated DLR extension would also be affected by the over-bridges. Unless road lanes were closed and replaced by DLR tracks under the existing over-bridges, an elevated DLR extension would also need to clear over-bridges by the design minimum of 5.4m above the surface of the carriageway, and about 3.5m above the footbridges.

5.4.2 While this appears feasible the environmental impact could be problematic. Adjacent to most residential areas, the visual intrusion and noise problems associated with the existing A2 - BTSA have partly been mitigated by constructing the road in cutting. Clearly this would not be possible for a DLR extension with elevated construction above grade separated interchanges and over-bridges.

5.5 Visual Intrusion

5.5.1 Looking in a south westerly direction, the following artist's impression (**Figure 4**) shows how a DLR crossing might look at this location from the perspective of a motorist on the roundabout in front of the Sun in the Sands public house. Assuming that the required station would be out of shot (to the north), this gives some idea of the visual intrusion on adjacent residential premises of a high-level elevated DLR construction.

5.5.2 The visual impact of an elevated DLR extension is bound to be significant throughout much of the route. Under normal circumstances structures of about 8 - 9 metres total height would be needed over the A2 - BTSA, but these would rise to 14 -15 metres where the DLR tracks needed to cross above existing over-bridges, and at stations.

Figure 4: Artist's impression – Sun in the Sands, Elevated DLR Concept

5.6 Noise Intrusion

5.6.1 Noise on concrete structures is mitigated by various design measures, including damping of vibration by resilient track design and sound baffles. However the noise of DLR trains on sections where higher speeds are likely could still be problematic particularly where the DLR structure rises to clear existing over-bridges. Even the deeper road cuttings would generally offer little noise mitigation of an elevated DLR constructed above the A2 – BTSA.

5.6.2 In other places, the traffic noise of the road is high at most times of the day so, in measureable terms, the DLR may not add to this significantly. However, it is likely to be perceived as an additional source of noise which, together with the visual intrusion, would almost certainly give rise to objections from residents living at close quarters.

6 Elevated DLR Extension - Greenwich Peninsula - Falconwood

6.1 A New DLR River Crossing

6.1.2 A DLR extension can be envisaged from a junction south of Canning Town ramping down to cross under the Thames, rising south of North Greenwich station. This idea has been considered by TfL investigating options for road and rail crossings and feasibility studies are in hand. Tunnel design options are being considered, concentrating on a road tunnel.

6.1.2 A DLR link can be envisaged beside the road tunnel. This could serve the North Greenwich Peninsula but, because of constraints on the cross river alignment, could not easily also serve North Greenwich station and interchange. It should not, however, conflict with the proposed River Thames Cable Car that would terminate some distance to the north of the river crossing portal, **see Figure 5.**

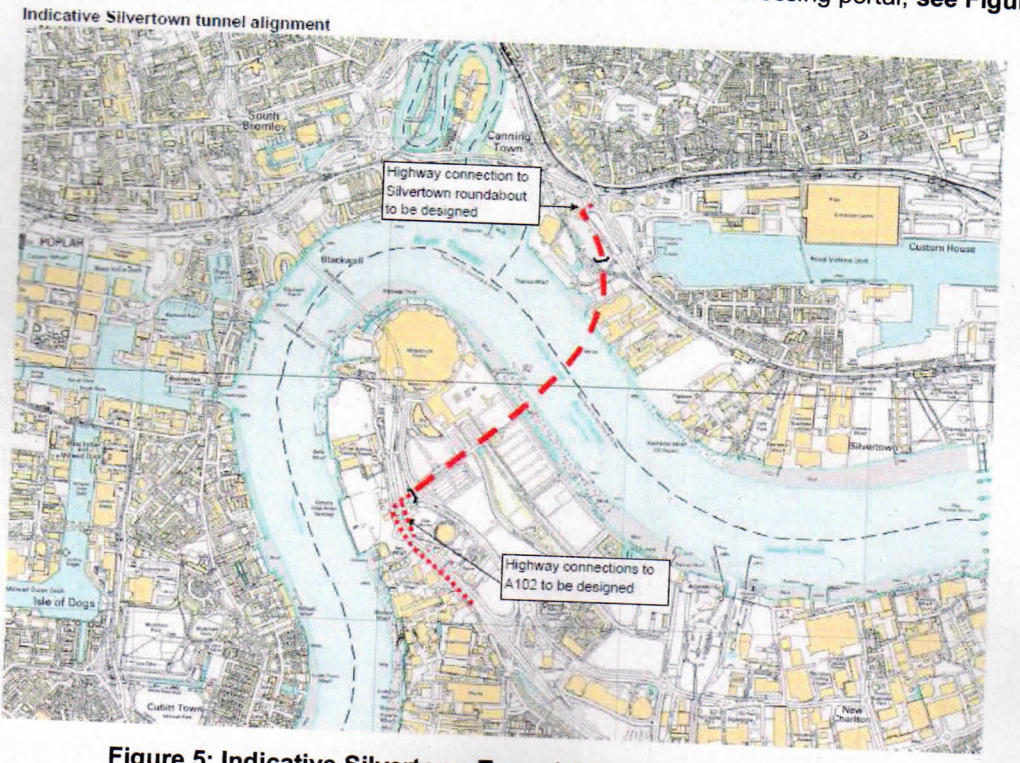

Figure 5: Indicative Silvertown Tunnel Alignment. Courtesy TfL

6.1.3 The Silvertown Link proposal is not the only river crossing opportunity. However, the alignment would need to meet several requirements. We understand from TfL and from information on hydrographic surveys by the Port of London Authority, that the river depth in the Bugsby's Reach area is about 10m under datum and that the roof of the proposed Silvertown Link tunnel would be about 15m-18m under the river bed to keep below mud and gravel. The banks of the Thames are constructed to provide ground at about 6m above datum. This implies that a DLR ramp from ground level to pass under the Thames would need to drop through about 21m.

6.1.4 The DLR can accommodate gradients of 6% which implies that the ramp from elevated alignment with track level at 6m above ground level to pass under the Thames at 15m below datum would need to be a minimum of 450m long plus vertical curves. A ramp from a surface alignment would be shorter, perhaps some 300m. However, the Thames is about 350m wide and while some of the ramp could be under the Thames a crossing still requires at least 1km of tunnel.

6.1.5 The following paragraphs that describe the route from the envisage Thames Tunnel portal to Falconwood should be read in conjunction with route plans included as Appendix B to this report.

6.2 Routeing on the Peninsula

6.2.1 If a DLR river crossing in the Silvertown area is achievable, the issue of routeing on the Greenwich Peninsula then arises. Emerging from the portal at the existing Edmund Halley Way, an elevated DLR could follow the road link to join the BTSA almost immediately. Such a route however would offer poor service to Millennium Village residents and commercial premises on the Peninsula.

6.2.2 *Alternative Alignment: A better option may be to turn south beside or above Millennium Way to serve the Peninsula retail/leisure area, possibly over the large car park. Alternatively the DLR extension could run along the east side of the BTSA with relatively modest impact on existing infrastructure; there are no houses here. This would not serve the retail area quite as well but it appears possible to construct this alignment partly at grade, so it should be cheaper.*

6.3 Crossing Woolwich Road

6.3.1 The above alignment options would come together just north of Woolwich Road. Houses and shops press close to the junction and approach roads so there is insufficient room for a surface DLR alignment alongside the BTSA at this location. It is appropriate, therefore, to consider crossing Woolwich Road by elevating the DLR extension above the existing BTSA viaduct. Minimum clearance above the BTSA flyover would put the DLR about 15m above the level of Woolwich Road.

6.3.2 This may be possible by providing support piers along the central reserve with associated alterations to the road layout on the flyover. However the existing highway viaduct is not designed to support the additional weight of the DLR, so these loads would have to be brought to ground. The feasibility of strengthening the existing viaduct and its foundations would require a specialist structural assessment that is outside the scope of this report, but is likely to be an expensive undertaking.

6.3.3 Assuming the latter was feasible, it may be possible to construct some of the piers without closing traffic lanes on the flyover but this is seems unavoidable on the approaches to the flyover. To accommodate a central DLR alignment, therefore, it appears necessary to widen the BTSA and move one or more slip roads, which would be likely to require property demolition.

6.3.4 *Alternative Alignment: To avoid all property impacts the only feasible alternative is a tunnel between the vicinity of Pear Tree Way under the BTSA as far as Angerstein Works (some 650m). Even if the structural issues could be resolved, the elevated crossing of Woolwich Road may be no cheaper than this tunnel alternative.*

6.4 Woolwich Road – Old Dover Road (Sun in the Sands)

6.4.1 Assuming the elevated crossing of Woolwich Road can be achieved, the DRL extension could continue southwards on a central pier. Being a dual 3-lanes carriageway (with a hard shoulder), there are fewer space constraints to this form of construction along this section. One or two traffic lanes would be affected during construction, and the elevated tracks would need to rise to pass above Charlton Road, Old Dover Road and Shooters Hill Road **(see Figure 4).** A station in this area would require additional piers, lift and stair towers.

6.4.2 *Alternative Alignment: The headroom and environmental ramifications of high level elevation are outlined in 5.4 – 5.6 above. These could be mitigated by an alternative parallel alignment with tunnelling. South of Angerstein Works, the DLR extension could continue beside, and east of, the BTSA via the fairly wide embankment of the BTSA cutting. There appears to be space for the DLR to pass under Charlton Road and enter a short tunnel (about 550m long) under the "Sun in the Sands" roundabout (Shooters Hill Road) to emerge south of Hervey Road.*

6.5 Old Dover Road - Kidbrooke

6.5.1 South of the Sun in the Sands the BTSA links with the A2 and becomes a dual two lane road, whence the space constraints again become more limiting. To retain the existing traffic lane widths, an elevated alignment would require some road widening. Otherwise the construction may be achieved without property impacts if the hard shoulder on the eastern side of the A2 were sacrificed, or if narrower traffic lanes (as indicated in **Figure 3**) were deemed acceptable. Any such variation to the road geometry could affect the network resilience of a TfL road, so would require the approval of TfL Network Management.

6.5.2 The DLR extension would probably need to stay at high level (12-15m above A2 road level) to clear two footbridges and the Rochester Way bridge. If the elevated tracks stayed in the centre of the A2 the DLR would pass some distance north of Kidbrooke Station, so interchange with rail and bus services here would be less than seamless.

6.5.2 *Alternative Alignment: To avoid traffic disruption the DLR could continue at or near grade on the east side of the A2, tunnelling under Rochester Way before rising to cross the A2 at Kidbrook to reach the existing station. An elevated DLR station appears feasible on the north side of the railway station, for good interchange with rail and bus services. From here it could continue along the southwest side of the A2 towards Eltham.*

6.6 Kidbrooke - Eltham

6.6.1 From Kidbrooke, a DLR extension constructed above the A2 could continue with piers in a wider central reserve and would avoid taking property if the hard shoulder on the northeast side were sacrificed, or if the traffic lanes were narrowed (subject to TfL Network Management approval). But supporting the DLR on Westhorne Avenue bridge presents similar structural issues to that of the Woolwich Road crossing.

6.6.2 *Alternative alignment*: We would suggest continuing the alternative alignment from Kidbrooke along the narrow strip of land between the railway and the A2. This would avoid traffic disruption and has the further advantage that the DLR would be less intrusive to neighbouring properties, all of which are already beset by the noise of the A2 and the visual intrusion of the road and the railway.

6.7 Eltham Tunnel

6.7.1 Crossing the A2 Eltham Tunnel and interfacing with rail and bus services at the existing station poses more design challenges than any other part of the route. It is not possible to identify the most appropriate alignment across Eltham without more detailed work. The alignment issues are complicated by the existing railway crossing while the A2 is in retained deep cut and bounded closely by residential property.

6.7.2 Elevating the DLR extension to fly high over the tunnel and station may seem the simplest solution conceptually but would be extremely difficult to implement in practice. As with the Woolwich Road viaduct, the Eltham Tunnel structure is not designed to withstand the additional loads of the DLR, all of which would have to be brought to ground. The feasibility of strengthening the existing superstructure, its piers and its foundations would require a specialist structural assessment that is outside the scope of this report, but is likely to be an expensive undertaking.

6.8 Eltham - Falconwood

6.8.1 Subject to TfL Network Management approval a centreline elevated DLR alignment along the A2 could be constructed by widening the central reserve either by sacrificing the hard shoulder on the northeast side or narrowing the traffic lanes (see **Figure 3**). However, as outlined above, traffic lanes would probably need to close during construction.

6.8.2 The elevated route would be partly hidden in the deep retained cutting containing the road but would probably need to rise to cross above Westmount Road and Glenesk Road. It might be possible to alter the footbridge linking Eltham Park North and South to pass above the DLR extension. East of

this point the DLR would need to swing to the north of the A2 to terminate at Falconwood station, preferably at ground level.

6.8.3 *Alternative alignment: From Eltham interchange the DLR could run between the railway and the A2, ramping down to pass under Westmount Road. From here it would cross to the north of the railway to run along the railway embankment. Shortly before Falconwood Station, it would cross back to the south side of the railway where the line could terminate at a single platform. This alignment beside the A2 avoids traffic disruption and property demolition. It should also be less intrusive than an elevated alignment along the centre of the road.*

6.9 Conclusions

6.9.1 The use of a transport corridor to accommodate the needs of two or more different modes is a sound principle that can work very well when facilities are designed to complement each other as part of an integrated land-use/transportation strategy. In such circumstance the environmental impacts can be assessed and mitigated collectively to provide sustainable solutions and seamless interface with other public transport infrastructure.

6.9.2 These DLR extension proposals, however, are not part of a masterplan for a major 'green field' development but are attempting to retro-fit a proposed fixed rail facility into an existing principal road corridor along which there are constraints in terms of space, environment and structural feasibility. Such conditions do not favour 'off-the-peg' standardised solutions but demand a flexible approach to cost effective bespoke design.

6.9.3 Also to stand any chance of being funded, a robust business case would have to be made that demonstrates a favourable costs:benefit ratio over the lifetime of the scheme. Such an analysis would include an assessment of patronage and potential revenue, so any DLR extension must demonstrate good pedestrian accessibility and a capability to attract high passenger demand.

6.9.4 In this regard, an elevated DLR constructed along the centre line of the A2 – BTSA would need to be evaluated against other possible alignment options. Any feasible solution would also need to resolve the difficult structural issues at Woolwich Road and Eltham Tunnel within reasonable cost limitations, while more work would be needed along the entire route to determine the most cost effective alignment with the least environmental impact.

7 Stations

7.1 Elevated DLR stations above the A2 - BTSA would cover an area comprising tracks and platform(s) together with access stair/escalator and lift towers linked to both sides of the road. Assuming a mezzanine level was not required a design similar to West Silvertown and Pontoon Dock would be appropriate, as shown in the photograph below (**Figure 5**).

Figure 5: West Silvertown Elevated DLR Station

7.2 However, with an alignment directly over the A2 - BTSA this is probably not practicable since it will be necessary for passengers to cross the road to reach both platforms so footbridges would be needed. This implies that a mezzanine level is probably unavoidable which will increase the cost of the stations and require a higher DLR track level to provide the clearance. To cover this requirement we have added a notional £2m to the unit cost of an elevated station.

7.3 Stations with side platforms have an overall width of about 16 metres (assuming the platforms are not staggered. An alternative design would be to use an island platform to reduce the overall footprint. The overall width of the station with a single, island platform would be about 13 metres. This would permit a single stairway/escalator tower and a single lift tower but would require pedestrian access from both sides of the road, implying footbridges over the road and a higher track level. It would also have implications for the viaduct design since the tracks need to diverge to flank the platform. This makes the viaduct wider or requires separate viaducts for each track which poses a major problem of where to place the piers without major alterations to the road.

7.4 For the proposed DLR Extension, stations are envisaged at:

- North Greenwich (Edmund Halley Way),
- Millennium Village (John Harrison Way),

- Peninsula Park (Peartree Way),
- Westcombe Park (Farmdale Road),
- Charlton Road, Sun in the Sands (Shooters Hill Road),
- Dursley Road,
- Kidbrooke (interfacing with Network Rail),
- Eltham (interfacing with Network Rail),
- Eltham Park (Westmount Road) and
- Falconwood (interfacing with Network Rail).

7.5 An alignment elevated over the BTSA/A2 implies that several of the stations would not be best located for the best possible interchange or easiest pedestrian access. There would be particular issues at Kidbrooke and north of Woolwich Road if the Peninsula shopping/leisure area is to be served. On the positive side, however, the proposals may afford an opportunity to deal with some of the community severance issues caused by the A2 – BTSA.

8 Costs

8.1 Design Criteria

8.1.1 Extensions to the DLR need to be compatible with the alignment design standards adopted for the network and with the signalling and train control systems used. The main standards are summarised in Table 8.1. The overriding requirement in DLR extension design is that the DLR employs automatic operation which means that street running is not possible and all alignments must be segregated from other traffic and designed to prevent access by pedestrians.

8.1.2 Partly because DLR alignments are segregated, the network employs third rail current collection. The third rail is protected and conductor shoes run under the rail but, despite this protection, it would not be safe on unsegregated alignment. It is conceivable that DLR extensions could be constructed with overhead current collection and manual control. This would need a different car design which is likely to be feasible. However, it would be an expensive option and would complicate operations. Therefore, we assume that DLR extensions would have automatic operation fully compatible with the existing system.

Items	**Values**
Minimum curve radius	40m
Maximum gradient	6% (1 in 16.7)
Tunnels - diameter of single track tunnel	5m to include walkway
Stations – platforms 3 car length approx -width[side platforms] -fully accessible with lifts	90m 8m [18m] Up to 24m
Traction supply	750vDC under-running third rail
Cars - length - width - height - weight	28m 2.65m 3.4m 39t
Capacity/car	84 seated 210 total

Table 8.1: Main DLR Alignment Standards

8.2 Capital Unit Costs

8.2.1 In 2010, as part of preliminary work for LB Greenwich, TfL/DLR were asked for recent capital cost data as a basis for assessing the indicative scale of costs for extensions. They kindly supplied a copy of the SKM report on the DLR **Dagenham Dock Extension Appraisal** completed in 2008. This extension would run from Gallions Reach to Dagenham Dock station on the Tilbury Loop and is shelved at the moment awaiting funds. This report gives a summary table of capital cost used in the appraisal which is reproduced as Table A1 in Appendix A. However, the build-up of costs is not in the public domain and we have, therefore, deduced unit costs from the overall totals: see Appendix A, Table A2.

8.2.2 The **Woolwich Arsenal extension** from King George V opened in January 2009. It is reported to have cost £180m for 2.5km of double track mostly in tunnel. It was constructed for Woolwich Arsenal Rail Enterprise Ltd, a joint venture PFI concessionaire formed by Land Securities Trillium and RBS. The cost was financed by RBS and the European Investment Bank.

8.2.3 The extension includes two 1.8km bored tunnels of 6 metres external diameter. There is one station constructed as cut and cover at Woolwich Arsenal partly under the Network Rail station, and providing interchange with heavy rail services.

8.2.4 The **Stratford International** extension is under construction and is due to open in 2011. This 5km line replaces the former heavy rail service between Canning Town and Stratford (regional) and extends to Stratford International. It includes the refurbishing of three existing stations and adding four new stations. The cost of the extension was recently put at £238m (DLR website) implying average construction costs of £47.6m/km. This route is mostly surface construction with minimum need for land acquisition or statutory undertakers' works. Therefore, the construction costs can be expected to be relatively low and to serve as a minimum cost benchmark. This was used as a cost for surface alignment even though it is inflated by station costs.

8.2.5 DLR extensions may trigger the need for additional depot capacity. Present depot provision is the original DLR depot at Poplar and a depot at Gallions Reach on the Beckton extension. In 2010, the DLR fleet is planned to reach 149 cars, all of which need to be stabled and maintained at these two depots. We understand that there is sufficient space at Beckton depot for the additional cars that would be needed for the Dagenham Dock extension, although it may be necessary to lay some extra sidings. Therefore, should a DLR extension in the Borough of Greenwich get priority, we expect depot capital costs to be minimal providing the total of new cars required are similar to the Dagenham Dock proposal.

8.2.6 The average costs of construction per route kilometre and per item (often called unit construction costs) are discussed in Appendix A drawing on the evidence summarised above. They are contained in Table A2 which summarises the unit construction costs used in this work. Although based on several sources, the unit costs may be assumed to be at 2009 prices.

8.3 Operating and Maintenance (O&M) Costs

8.3.1 DLR supplied updated costs which incorporate the impact of a high proportion of three car operation and latest values for staff and other costs. These are shown in Appendix A, Table A3 and can be assumed to apply to DLR extensions. These unit costs imply the annual O&M costs per DLR station as shown in Table 8.2.

8.3.2 Our preliminary assessment of costs is based on the unit costs of construction summarised in Appendix A, Table A2. The Silvertown - Falconwood extension would be 9.75 kms long including the Thames Tunnel. Although there are several alternative alignment options, we give costs for the A2 – BTSA Centre Line Elevated Construction only. All costs are subject to confirmation in full feasibility work and are at 2010 prices.

Item	Underground Station	Surface/elevated Stn
Staff	50,000x2= 100,000	50,000
General maintenance	70,000	70,000
Lift maintenance	3,800x1.8= 6,840	3,800x1.8= 6,840
Escalator Maintenance	5,000x3.3= 16,500	0
Ticket Machine maintenance	3,500x3.3= 11,550	3,500x3.3= 11,550
Totals	**204,890**	**138,390**

Table 8.2: Annual O&M Costs for DLR Stations (£ @ 2009 prices).

8.3.3 An alignment constructed wholly above the A2 - BTSA works out at about £824 million, but with increased costs per station (see 7.2 above). In addition, a DLR service of 3 car trains operating every 10 minutes would require 15 additional cars costing £30.7 million. (Any spare cars would be additional to this.) These costs exclude land, preliminaries and utilities works. They also exclude any costs for road realignment, traffic management, street lighting changes, and the special structural works that would be required at Woolwich Road and Eltham. All told therefore it seems unlikely that the elevated DLR extension alignment described in this report could be delivered for less than £1 billion and could possibly cost much more.

8.3.4 Bespoke solutions would be needed for Woolwich Road and Eltham with costs that are likely to be appreciable. Modifying the BTSA flyover at Woolwich Road would likely have to include for a partial (or complete) reconstruction of the existing highway viaduct. At Eltham the entire tunnel and interchange may have to be reconstructed from the ground up.

Appendix A

DLR Capital and Operating Costs

Dagenham Dock Extension

The capital cost projection for the Dagenham Dock extension was kindly provided by DLR in the consultants' report of 2008 and is shown in table A1. There is no available build-up of the construction costs of recent DLR extensions which give outturn costs. However, the scale of the cost for the Woolwich Arsenal extension is known although no detailed breakdown was available. Therefore, without a full costing exercise calibrated on outturn costs, capital costs must be based on these projections.

Table A1: Dagenham Dock Extension - Capital Cost (Q1 2007 prices)

Purpose	Amount (£ 000)
A. GENERAL	
1. Surveying, drilling and soil sampling.	410
2. Acquisition of land and rights over land.	19,850
3. Earthworks (including land reclamation and landscaping).	5,887
4. Fees of professional and other advisers, in connection with the implementation of the project once authorised.	9,100
B. TRANSPORT SYSTEMS	
1. Tunnels, bridges and other transport system structures.	234,159
2. Highway works, excluding alterations to and relocation of existing services and statutory undertakers' apparatus. See B9.	10,739
3. Permanent way or other supporting/guiding structures	26,313
4. Workshops, depots, stations and other buildings.	70,313
5. Electrical plant and equipment.	16,097
6. Signalling and communications.	23,468
7. Vehicles.	42,000
8. Alteration, modification and removal of existing works.	21,626
9. Modifications to statutory undertakers' apparatus.	17,108
TOTAL	**497,070**

Taking the figures in table A1 for the 6km extension, average construction costs per km are given by taking vehicles cost (£42m for 20 additional cars) out of the total. This yields £455 m/6 kms = £75.83m /route km for a double track extension which would be mainly elevated alignment but including a section of tunnel under the River Roding and would have five new stations. This total includes the cost of land and stations

which can vary considerably depending on the locations involved. For the Dagenham Dock extension, the depot costs are thought to be minimal and are associated with extending the stabling capacity of Beckton depot. Therefore, most of the costs under item B4 are probably for stations i.e. £70m for 5 stations or £14m per station, all of which are surface or elevated.

If station and land costs are removed from the construction costs in table A1, we have £455m - £70m - £20m = £365m which implies a construction cost per route km of £60.83m. This unit cost figure includes a range of items that are likely to be incurred for any DLR extension although the components of the cost are bound to depend on the location and detail of extensions. However, it also includes a tunnel under the River Roding but no information was available on its length or cost. The rest of the proposed route is understood to be surface/elevated construction. The tunnels are probably not more than 1 km of the 2.3km between Beckton Riverside and Creekmouth. Assuming construction cost for this tunnel £80m/km, as implied by the Woolwich Arsenal extension costs, the average cost of construction of the remainder of the extension becomes [(£365m – £80m)/5km] = £57m/route km. The unit construction costs deduced from the available sources, as described above, are summarised in table A2.

Woolwich Arsenal Extension

The outturn costs of the Woolwich Arsenal extension are reported to be £180m for 2.5km of double track, some 1.8km of which are in bored tunnels, and one underground station. It is understood that no additional cars were procured for this extension and that there were, therefore, no associated depot costs. This implies an average construction cost of £180m/2.5km = £72m/double track route km. However, the unit cost of the bored tunnel sections is likely to be higher with 0.7km of track in cutting on the tunnel approach and in the cut and cover section at Woolwich Arsenal. Therefore, a unit cost of about £80m/ double track km seems more appropriate.

We reviewed other DLR information in the public domain on the costs of the Stratford International extension now under construction and other information. This indicates that the cost for constructing surface double track is at least £40m/km without stations, land costs and other location-specific items.

Optimism Bias

Following Treasury and DfT guidance, cost forecasts for transport schemes should have uplift to costs to allow for the optimism in scheme promotion. The TfL Business Case Development Manual specifies the addition of 44% to capital costs for optimism bias. In this very preliminary study the costs are extremely uncertain but are tied to an outturn costing (Woolwich Arsenal) and a forecast which already includes Optimism Bias (Dagenham Dock). Therefore, there is a strong risk of "pessimism bias" so we have not factored costs for Optimism Bias.

Table A2: Indicative Unit Costs of DLR Construction (No Optimism Bias)

Item	Unit Cost
Elevated alignment	£57m/double track km
Bored Tunnel	£80m/double track km
Surface alignment	£47.6m/double track km
Elevated Station	£14m
Underground station	£25m
Light Rail Vehicle	£2.1m

Operating and Maintenance Costs

The term S12 station refers to underground stations at which two staff are required during traffic hours.

Table A3: DLR Operating and Maintenance Costs

Category/Item	Values
Cost per train kilometre	£1.10 per km
Salary cost per driver	£51,000 per annum
Annual maintenance cost as proportion of capital investment	0.5%
Lifts per station	1.8
Escalators per S12 station	3.3
Ticket machines per station	3.3
Number of staff per S12 station	2
Station staff cost	£50,000 per annum
Station maintenance cost	£70,000 per annum
Lift maintenance cost	£3,800 per annum
Escalator maintenance cost	£5,000 per annum
Ticket machine maintenance cost	£3,500 per annum

Appendix B

Route Plans

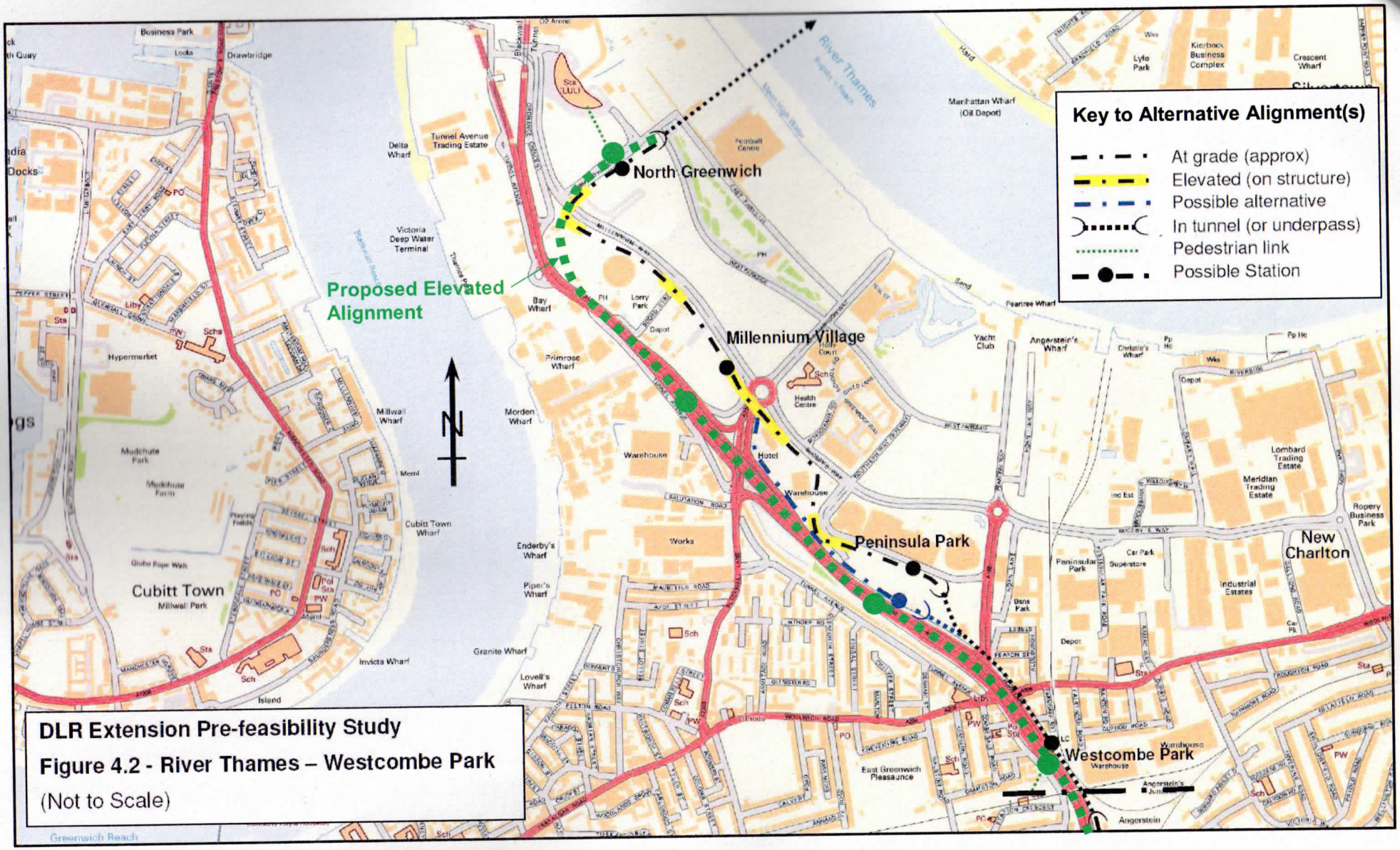
Key to Alternative Alignment(s)
At grade (approx)
Elevated (on structure)
Possible alternative
In tunnel (or underpass)
Pedestrian link
Possible Station
Proposed Elevated Alignment
North Greenwich
Millennium Village
Peninsula Park
Westcombe Park
Cubitt Town
New Charlton
River Thames
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Figure 4.2 - River Thames – Westcombe Park
(Not to Scale)

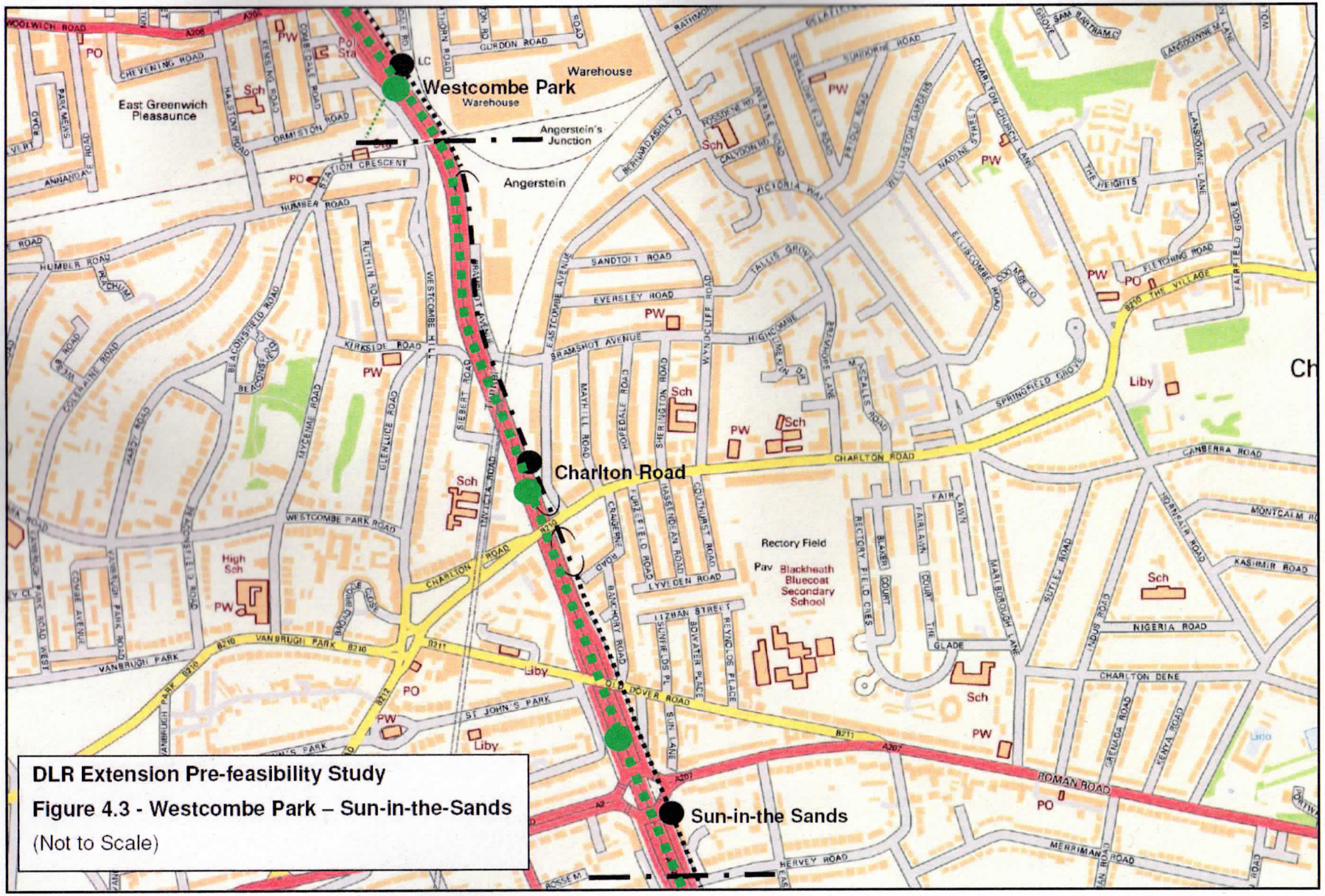

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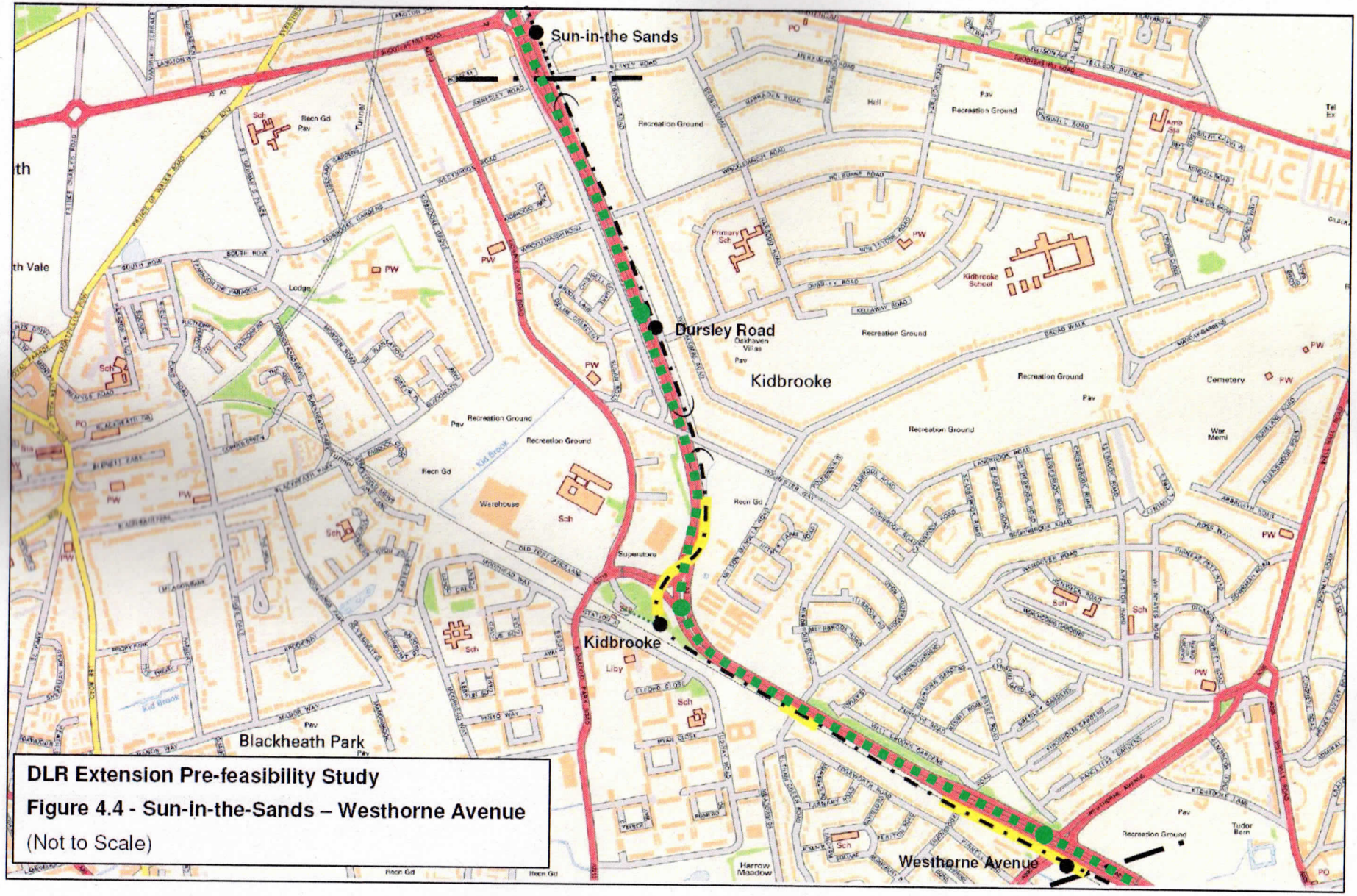
Figure 4.3 - Westcombe Park – Sun-in-the-Sands

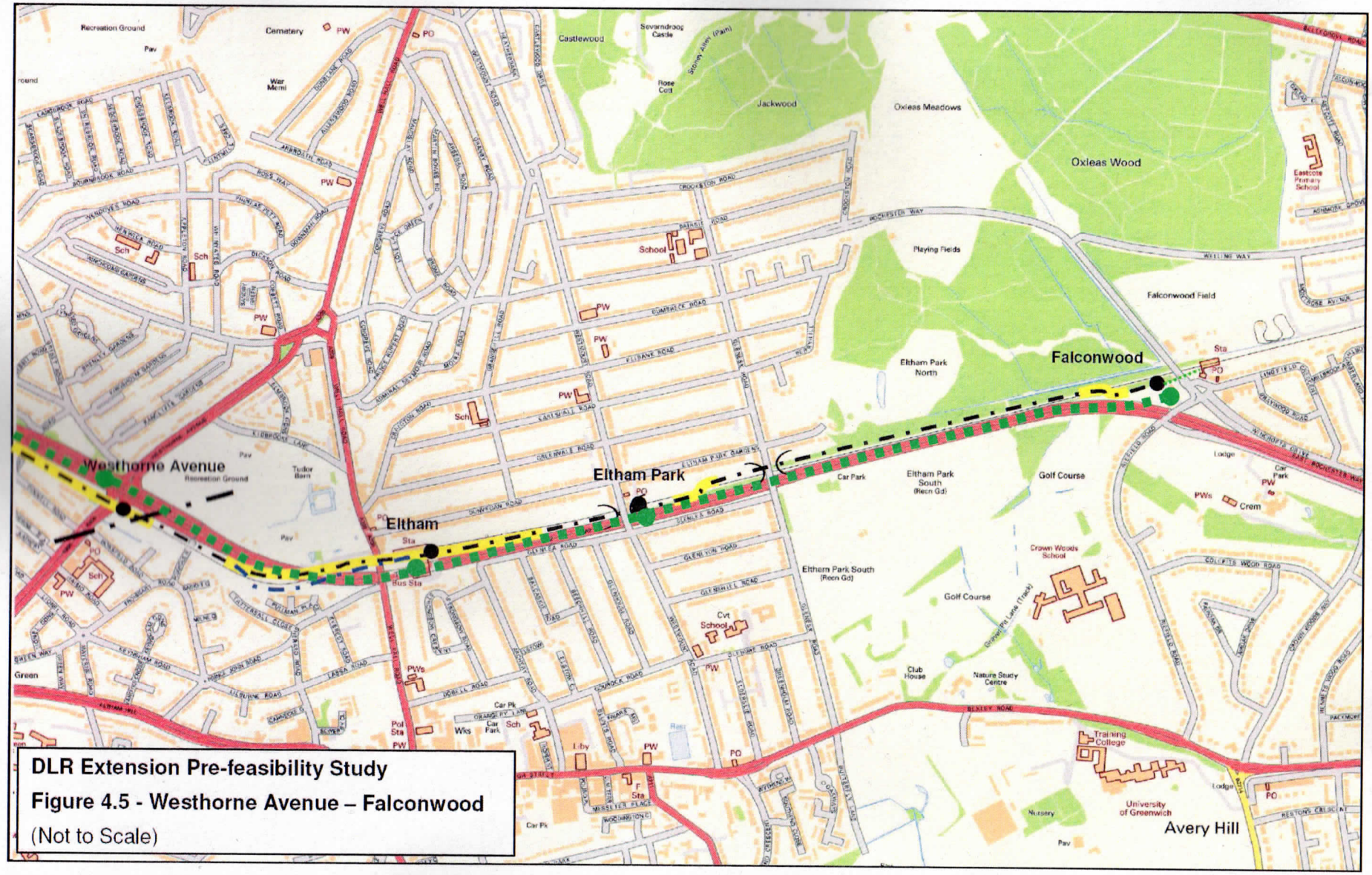
(Not to Scale)



DLR Extension Pre-feasibility Study

Figure 4.4 - Sun-in-the-Sands – Westhorne Avenue

(Not to Scale)



DLR Extension Pre-feasibility Study

Figure 4.5 - Westhorne Avenue – Falconwood

(Not to Scale)