

# New Metro North

Green Line Metro Upgrade – Line B

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## Document Control Information

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## Glossary of Terms/Acronyms

<b>Term</b>	<b>Definition</b>
Bored tunnel	Underground tunnel, excavated by a Tunnel Boring Machine.
Cut and cover tunnel/box	A tunnel or box structure where a trench is excavated to the required dimensions and is roofed over with an overhead support system, strong enough to carry the load of what is to be built above.
Engineering link	A non-service track connection between two rail systems to allow movement of vehicles between them for maintenance or for stabling in a depot.
Track inter-axis	Where tracks are side-by-side, the track inter-axis is the distance between the centre points of each track. The wider the distance, the more space there is between passing vehicles.
Tunnel portal	The entrance or exit to a tunnel. The interface point between the underground tunnel and the ground level.
Segregation	Metro tracks are fully separated from other traffic and from pedestrians. It is an essential requirement for the running of high frequency metro vehicles.
<b>Acronym</b>	<b>Definition</b>
AVLS	Automatic Vehicle Location System
DCC	Dublin City Council
DKE	Dynamic Kinetic Envelope
GLCE	(Luas) Green Line Capacity Enhancement
GLIU	(Luas) Green Line Infrastructure Upgrade
HFV	High Floor Vehicle
LFV	Low Floor Vehicle
MS	Metro South
NMN	New Metro North
NTA	National Transport Authority
PPHPD	Passengers per hour, per direction
PSGs	Platform Safety Gates
TBM	Tunnel Boring Machine
TPH	Trains per hour
TII	Transport Infrastructure Ireland

## 1 EXECUTIVE SUMMARY

The extent of upgrades required on the Luas Green Line is wholly dependent on the type of system proposed for New Metro North (NMN); however, at the time of this study, no decision on the type of vehicle or the mode of operation has been made. Therefore, the objective of this Green Line Metro Upgrade study is to estimate the costs and identify the extent of work required to upgrade Line B from Ranelagh to Sandyford for three potential metro operating scenarios, namely:

1. Scenario 1: 60m long low-floor vehicles, operating similar to the current Luas system with minimal additional segregation with the exception of road junctions.
2. Scenario 2: 60m long high-floor vehicles, operating fully automatic and requiring significant infrastructure segregation from road junctions, other vehicles, passengers and pedestrians.
3. Scenario 3: 90m long low-floor vehicles, operating similar to the current Luas system with minimal additional segregation with the exception of road junctions.

Figure 1 provides the estimated costs for converting the line section from Ranelagh and Sandyford to a metro standard to the extent required by each of the scenarios. In the event that it is deemed that road segregation is not a requirement for Scenario 1 or 3, estimated costs for each scenario reduce by €20 million. As Scenario 2 involves a fully automated rail system, full segregation from roads and other points of interface with pedestrians and vehicles is an absolute requirement.

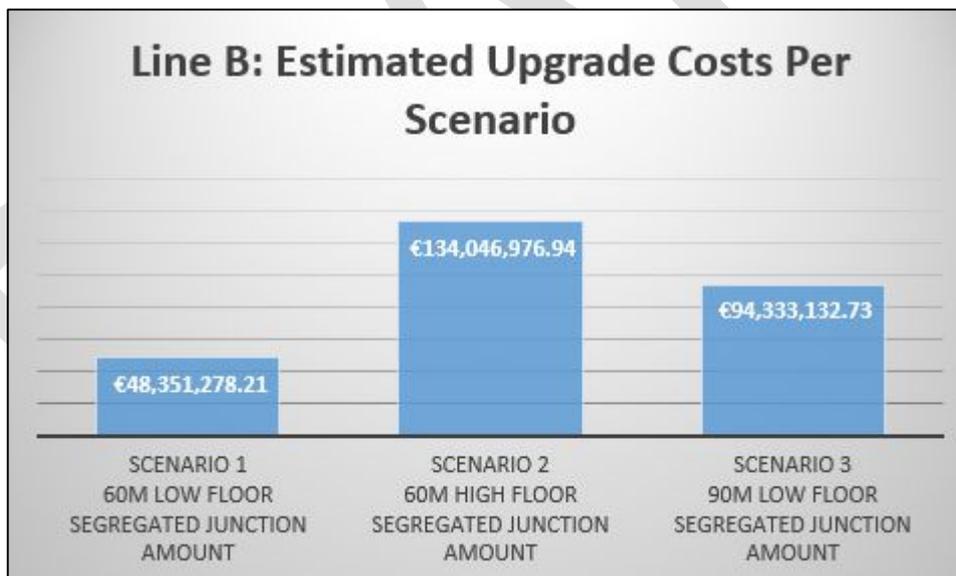


Figure 1: Overall cost estimates for Line B for all scenarios

A large proportion of the additional costs for Scenario 2 arise from the work to extend the platform to 60m, raise the platform heights, install safety gates at platforms and modify access routes to each platform, including foot bridges and additional lifts (as the track cannot be crossed).

## 2 INTRODUCTION

The National Transport Authority's (NTA) Fingal/North Dublin Study (June 2015), recommended an optimised Metro North scheme as the preferred public transport solution to service the passenger demand along the corridor between Dublin City Centre, Dublin Airport and Swords.

The Government's seven year investment plan titled "Building on Recovery: Infrastructure and Capital Investment 2016–2021" (October 2015) endorsed this recommendation and included for a new metro project for Dublin, referred to as "New Metro North" (NMN).

The NTA's Transport Strategy for the Greater Dublin Area, 2016–2035 (The Strategy) provides a framework for the planning and delivery of transport infrastructure and services in the Greater Dublin Area (GDA) over the next two decades. It has built on the work undertaken in the Fingal/North Dublin Study and undertaken similar studies for all other corridors. In this regard, it provides the context for the integrated transport network within which NMN will operate.

The Strategy defines NMN as a high speed, high capacity, high frequency public transport link from the city centre to Dublin Airport and Swords. The city centre section will be underground. As described in the Strategy, it is anticipated that NMN will ultimately tie into Dublin's existing Luas Green Line light rail system, enabling through running of metro trams from Swords to Bride's Glen.

The Project Objective for NMN as agreed with the NTA is as follows:

*"To provide a safe, high frequency, high capacity, fast, efficient, fully segregated and sustainable public transport light rail service from the city centre to Dublin Airport and Swords."*

*In delivering this objective, NMN will:*

- *Cater for existing and future public transport travel demand along this corridor;*
- *Be modern, attractive and accessible to all users;*
- *Be designed to integrate appropriately into the existing public realm;*
- *Be segregated from other transport modes between Dublin Airport and the City Centre;*
- *Contribute to a reduction in urban congestion and the enhancement of the environmental sustainability of the region;*
- *Support the continued economic development of the Dublin area and the wider State.*
- *Deliver a high quality service with journey-time reliability along the corridor;*
- *Be planned, constructed and operated in an environmentally sustainable manner;*
- *Support public transport network integration by providing high quality passenger interchange points, which facilitate convenient transfer between public transport services at key locations;*
- *Facilitate connection to key trip attractors; and*
- *Support the strategy for a strategic Park & Ride*

## 2.1 Study Scope and Objective

The objective of the Luas Green Line Metro Upgrade study is to carry out an engineering feasibility and costing assessment on upgrading the existing Luas Green Line to a metro standard to facilitate the through running of metro services from Swords to Bride's Glen as envisioned in the Strategy.

Within the Strategy (Section 5.5.3), Metro South (MS) is described as an upgrading of the existing Luas Green Line to metro standard through the extension of NMN southwards, via a tunnel, to join the Luas Green Line in the Ranelagh area, enabling through running of metro trams from Swords to Bride's Glen. The upgrading of the Luas Green Line to metro standard will ensure that growth along this corridor can be accommodated and, in combination with NMN to Swords, will provide Dublin with a high capacity, high frequency cross-city rail corridor, serving critical destinations at Dublin Airport, Dublin City University, Dublin City Centre and Sandyford directly.

The extent of the infrastructure works required to upgrade the current Luas Green Line to a metro standard, wholly depends on the type of metro system proposed to operate on NMN. At the time of this study, no decision on the operating characteristics of NMN has been made; therefore, three likely operating scenarios have been considered for analysis in this study and these are described in detail in Section 3.2. The existing Luas Green Line can be divided into two sections: Line B which runs from Ranelagh to Sandyford and Line B1 which runs from Sandyford to Bride's Glen. The sections differ considerably in terms of their operating environment. Line B runs within the old railway cutting and is largely segregated from its surrounds, other than at three locations (Dunville Avenue / Beechwood Road at Beechwood Stop, access to Alexandra College from Richmond Avenue South at Milltown Stop and St. Raphaela's Road at Stillorgan Stop) where there are at-grade crossings. Line B1 has a far higher level of at-grade running at locations such as Blackthorn Avenue, Ballyogan Road and between Carrickmines and Cherrywood stations; this section of the Luas Green Line will be analysed for impacts in the next revision of this document.

The scope of this study includes infrastructure and cost estimates for Line B, but does not cover potential environmental impacts, effects on Luas Green Line services during construction, transport modelling of any scenario, or architectural considerations of proposed solutions.

## 2.2 Luas Green Line Tie-in Study

In January 2016, Transport Infrastructure Ireland (TII) commenced work on the "Luas Green Line Tie-in Study". The objective of the study was to identify the preferred location and configuration for a tie-in between NMN and the existing Luas Green Line, which would ultimately enable through running of metro vehicles from Swords to Bride's Glen. The study was completed in January 2017 and concluded that "Option 4(B) - Ranelagh In-line" is the preferred tie-in option for NMN.

Option 4(B) - Ranelagh In-line is illustrated in Figure 2. The site is located to the rear of No. 2 Grand Parade, Dublin 6. From the north, NMN tunnels will be bored under No. 2 Grand Parade which is a Protected Structure to the vacant lot to the rear of the building where a new metro stop will be located. The tracks will then rise in a cut and cover section, passing under Dartmouth Road and Northbrook Road. Immediately south of Northbrook Road, the track will continue to rise in a retained

cut along the line of the existing Luas Green Line embankment and then onto a ramp structure to its eventual tie-in point, north of Ranelagh Stop. The final operating configuration will result in the severance of the existing Luas Green Line at Charlemont with future metro vehicles operating exclusively south of the tie-in point in order to enable through metro services from Swords to Bride's Glen. Luas Green Line services will operate between Charlemont Stop and Broombridge Stop.



Figure 2: NMN tie-in point at Ranelagh

### 3 EXISTING INFRASTRUCTURE

The types of metro operations under consideration for NMN will have a varying degree of impact on the infrastructural changes required to upgrade the Luas Green Line to a metro standard. In addition, the differing characteristics of Line B and Line B1 introduce both opportunities and challenges, depending on the type of operations applied. Consequently, Line B and Line B1 are assessed separately. The illustration in Figure 3 provides a context for the location of the tie-in point on the Luas Green Line, and the two line sections that are the subject of this study. An overview of the characteristics of each line section is provided in Sections 3.1 and 3.2.



Figure 3: NMN tie-in in context with Luas Green Line

#### 3.1 Line B (Ranelagh to Sandyford)

Significant sections of Line B were constructed within the route of the old Harcourt railway line and as a result, large sections are contained within the original railway cuttings. The infrastructure itself was designed and constructed for possible later conversion to metro rail operations from Ranelagh to Sandyford, including an increased track interaxis, increased separation distances from trackside structures (to accommodate wider bodied trainsets), and additional space capacity within the substations to allow for future power upgrades. The line runs within the old railway cutting and is largely segregated from its surrounds, other than at three locations (Dunville Avenue / Beechwood Road at Beechwood Stop, access to Alexandra College from Richmond Avenue South at Milltown Stop and St. Raphaela's Road at Stillorgan Stop) where there are at-grade crossings.

#### 3.2 Line B1 (Sandyford to Bride's Glen)

Line B1 from Sandyford to Bride's Glen runs through a mixture of environments, from business parks to housing estates to rural South Dublin. Passenger demand on this line section will increase in the future due to the development of Cherrywood town centre, located adjacent to the current line terminus at Bride's Glen.

Unlike a majority of the Line B alignment, there are a number of sharp bends on the alignment, along with significant interfaces with roads, residential areas, and a future town centre as previously stated. Line B1 has a far higher level of at-grade running at locations such as Blackthorn Avenue, Ballyogan Road and between Carrickmines and Cherrywood stations.

## 4 METRO OPERATING SCENARIOS

With the connection of NMN to the Luas Green Line at Ranelagh, interoperability between the two systems is a necessity. Evaluating the engineering and cost impacts of upgrading the Luas Green Line to achieve a seamless metro operation from Swords to Bride's Glen requires details on the type of metro operations proposed on NMN.

At the time of compiling this report, an Alignment Options Study to deliver an emerging preferred route and a concept design of the same is underway. As the preferred route for NMN has not yet been established, the level of segregation for the new line cannot be defined and as such, a decision on the type of metro operations or vehicle type cannot yet be made. Therefore, both low floor vehicles (LFVs) similar to the current Luas fleet and high floor vehicles (HFVs) similar to those found on international metros (e.g. Copenhagen) require consideration in this study. In addition, without a decision on the type of vehicle to operate on NMN, the operational characteristics (driver-controlled vs fully automatic) are similarly undefined.

The length of the vehicles that will operate on NMN and MS is at present unknown and will be decided upon once the required demand and capacity analysis has been completed. For the purpose of this study, it is assumed that vehicles will be initially 60m long and that the line may eventually require 90m long vehicles to allow for future capacity increases.

In order to assess the infrastructure and cost impacts on the Luas Green Line of upgrading to a metro standard, where that standard has not yet been defined, three separate operating scenarios will be used to cover the potential options open for NMN.

### 4.1 Scenario 1: 60m LFV – Driver Controlled

Scenario 1 envisages NMN will operate similar to the current Luas system with driver-controlled LFVs. Vehicles sets are 2.65m wide,<sup>1</sup> low floor and 60m long, operating at a peak of 30 trains per hour (TPH). For this level of service, segregation of all road junctions along the route is required and is considered as part of this scenario.

Using passenger capacity figures received from vehicle manufacturers as part of the TII NMN Vehicle Configuration study, a sample 2.65m wide, 64m long low-floor vehicle has a capacity of approx. 440 passengers (at 4 passengers per m<sup>2</sup>). Adjusted for 60m, this figure reduces to 413 and at 30 TPH, this provides an estimated system capacity of 12,390 passengers per direction per hour (PPDPH).

### 4.2 Scenario 2: 60m HFV – Fully Automatic

Scenario 2 envisages NMN operating as a fully automatic metro system, similar to the Copenhagen, Barcelona or Brescia metro systems. Vehicles are 2.65m wide, high floor and 60m long and the system can operate at a peak of 40 TPH. For this level of service, segregation of all road junctions along the route is required and is considered as part of this scenario.

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<sup>1</sup> Existing Luas fleet is 2.4m wide

Using the Copenhagen trainsets as an example, a 60m cabinless vehicle has a capacity of approx. 450 passengers (at 4 passengers per m<sup>2</sup>). At 40 TPH, this provides an estimated system capacity of 18,000 PDPH.

### **4.3 Scenario 3: 90m LFV – Driver Controlled**

Scenario 3 envisages that NMN will operate similar to the current Luas system with driver-controlled vehicles. Train sets are 2.65m wide, low floor and 90m long (which would represent the maximum extension length), operating at a peak of 30 TPH. For this level of service, segregation of all road junctions along the route is required and is considered as part of this scenario.

Using passenger capacity figures as derived for the original Metro North project by Jacobs, a 2.4m wide, 90m long low-floor vehicle has a capacity of approx. 674 passengers (at 4 passengers per m<sup>2</sup>). A change in vehicle width to 2.65m was estimated to provide an increase in capacity of approx. 10.4%, resulting in a figure of 744 passengers. At 30 TPH, this provides an estimated system capacity of 22,320 PDPH.

## **5 INFRASTRUCTURE ASSESSMENT**

The infrastructure impact assessment has been carried out in two stages. Stage 1 considers an upgrade to metro services for Line B (Ranelagh to Sandyford), whilst stage 2 builds on this work and provides an assessment of Line B1 (Sandyford to Bride's Glen). In carrying out the assessments, the following high-level assumptions have been made:

- Metro services operate exclusively from Swords to Sandyford and Bride's Glen;
- New stop furniture assumed for all metro scenarios;
- No safety or evacuation issues associated with reduced platform widths arising from the installation of platform screen doors and platform end gates;
- Green Line Capacity Enhancement (GLCE) works are complete and all existing platforms have been lengthened to 53m;
- Priority given to minimise the amount of works, limiting extensions over horizontal or vertical track curvature, limiting impact on existing features (e.g. manholes or ducts, roads, walls, retaining structures in general); and
- Sandyford Depot to be upgraded to suit (where required).

### **5.1 Line B (Ranelagh to Sandyford)/Segregation**

The existing Luas Green Line is limited to running a maximum of 24 TPH. This limitation is driven by the non-segregated nature of the line and in particular the need for vehicles to stop at at-grade crossings at Dunville Avenue and St Raphaela's Road.

In order to achieve the increased frequency of services to 30/40 TPH required for Scenarios 1, 2 and 3, it will be necessary to completely segregate the line from any interface with road and pedestrian traffic. This will involve taking steps to remove the at-grade crossings and, in addition, closing an existing signalised junction at the access to Alexandra College.

Figure 4 shows a street view of Dunville Avenue, which is located just north of Beechwood Luas Stop. To achieve segregation, it will necessary to permanently close this junction to all traffic.



*Figure 4: Dunville Avenue*

Figure 5 shows the signalised junction at the access to Alexandra College. This junction provides pedestrian and vehicular access to the college. Luas currently has priority at this junction; however, in order to achieve full segregated running, it will be necessary to close this junction and provide an alternative access from Milltown Road to the college.



*Figure 5: Access to Alexandra College*

Figure 6 shows the existing signalised junction at St Raphael's road, which is located just north of Stillorgan Luas Stop. This is a much larger junction and an important connection between Sandyford Industrial Park and Stillorgan Village.



*Figure 6: St Raphael's Road junction with Luas at Stillorgan*

As this road cannot be permanently closed, grade separation would be required to achieve segregation for the upgraded metro line. There is insufficient distance between the track and Blackthorn Avenue (which runs in parallel) to create an underpass beneath the rail or alternatively elevate the road above. As a result, a bridge structure is proposed to raise the track above the road at this location and therefore, Stillorgan Luas Stop would be positioned on the elevated structure (approx. 4.8m above the current level of the platform). Figure 7 illustrates the proposed structure in section and the extent of the structure compared to the current alignment in plan.

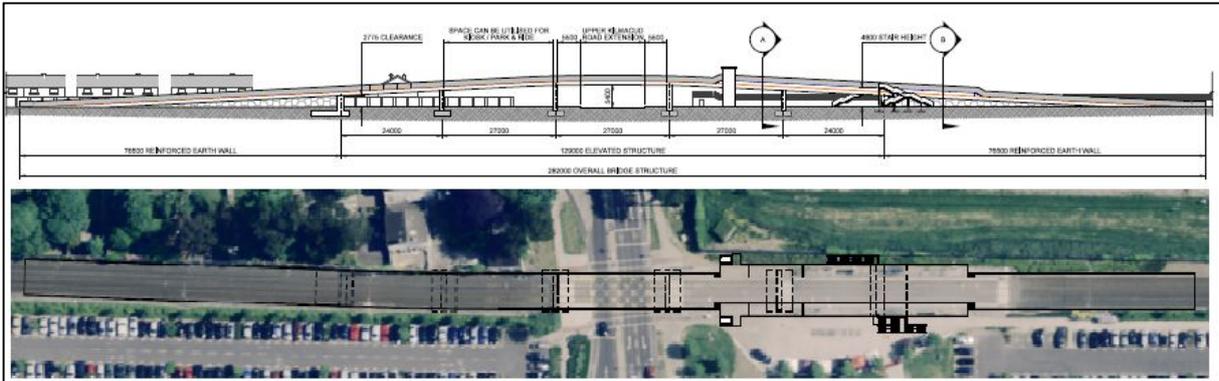


Figure 7: Proposed overpass and elevated stop at Stillorgan

To ensure service continuity for Luas Green Line services while the elevated structure is being constructed, it is proposed that a temporary track is installed through the current Park & Ride, bypassing the Stillorgan Luas Stop. This arrangement is illustrated in Figure 8. It would also be possible to construct a temporary stop in this location if deemed necessary.

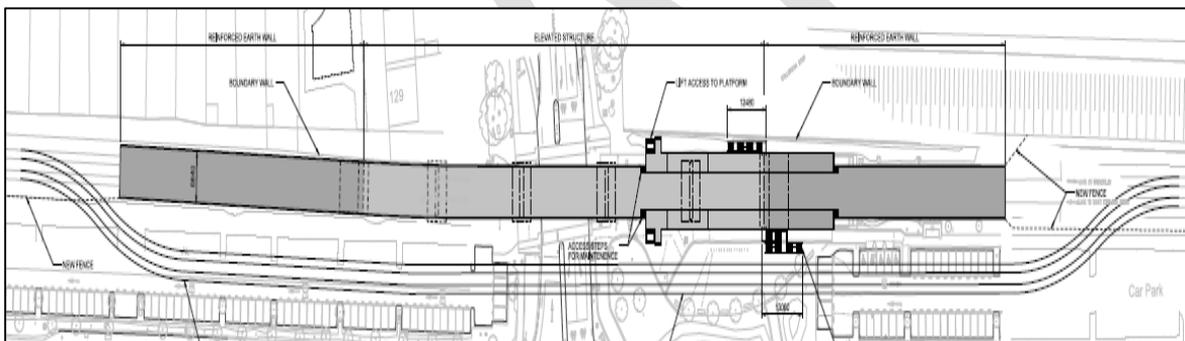


Figure 8: Proposed temporary track for maintaining Luas operations during bridge construction

### 5.1.1 Green Line Power & Systems (P&S) Upgrade

With the completion of the Luas Green Line Infrastructure Upgrade (GLIU), the existing traction power system is being upgraded to accommodate the additional weight of the longer (54.7m) vehicles and to provide sufficient capacity for an expected maximum frequency of 24 TPH.

The Luas Green Line substation structures were designed to be “metro upgradable”, with the space capacity to accommodate either additional or physically larger traction power equipment. As such, no structural modifications of the existing substation buildings would be required for the proposed upgrade to metro services as described in Scenarios 1, 2 and 3. Additional equipment requirements at

Milltown, Dundrum, Balally and Sandyford substations (traction transformers and switch gear) to deliver the extra power required for metro operations make up the majority of the P&S costs.

For the purposes of this report, it is assumed that each scenario will require an upgrade of the power system, with Scenarios 2 and 3 demanding a more significant traction power upgrade than Scenario 1.

### **5.1.2 Signalling Upgrade**

The current Luas system on the Green Line operates using “line of sight”, where the driver is responsible for ensuring a safe distance from the vehicle in front is maintained. For the purpose of this study, each metro scenario assumes a full signalling system is installed to provide for increased safety with high service frequencies between stops. This would involve additional signalling equipment both within the track area and within the technical rooms along the line.

### **5.1.3 Line Segregation Works**

In addition to signalling, the line must be secured against trespass and passengers and other members of the public prevented or actively discouraged from encroaching on the tracks. This would require additional fencing to be installed along the alignment where such fencing is not yet in place or the replacement of existing fencing with a more secure design. For Scenarios 1 and 3, additional fencing is provided for within the cost of upgrading the stops. For Scenario 2, as it would be a fully automatic line, additional costs for barriers to ensure the line is fully segregated are included in Section 5.

## **5.2 Luas Stop/Platform Modifications**

The implementation of all three proposed metro operating scenarios will require significant upgrades and modifications to all of the existing Luas platforms. The following sections detail the type and nature of the modifications that will be required.

### **5.2.1 Scenario 1: 60m LFV – Driver Controlled**

The physical characteristics of the low floor metro vehicles operating in this scenario are 60m in length and 2.65m in width. As such, while platform heights would not require modification, an extension of 7m and trimming back of the edges would be required for each platform. For the majority of stops within the study area, a high-level analysis did not reveal any major impacts for extending the platforms to 60m length, with the level of work required comparable to the current GLIU project.

To allow the operation of larger vehicles (2.65m) through the existing stops, all existing platforms will have to be trimmed (including the ramps on the non-extended side), thereby setting the coping edge back by approx. 150mm as illustrated in Figure 9. This dimension would depend on type of rolling stock and dynamic kinetic envelope (DKE), along with the body shape at the door thresholds.

To facilitate the platform trimming works, each stop undergoing upgrading works would require closure for service but could reopen to standard Luas operations with the adoption of a platform-to-tram platform filler (subject to further investigation). This filler would be in use for the time between platform works and full NMN tie-in works. The fillers would be removed once the wider metro vehicles are put in service. The scenario is more complicated where a chamber is located within the zone of

the tactile paving or where the platform structure is combined with a bridge deck structure (such as Ranelagh). In the latter situation, additional time would be required to re-instate reinforcement between the bridge deck and the remaining part of the platform slab. Table 1 provides a high-level summary.



Figure 9: Approx. platform edge area to be removed and photo of platform edge

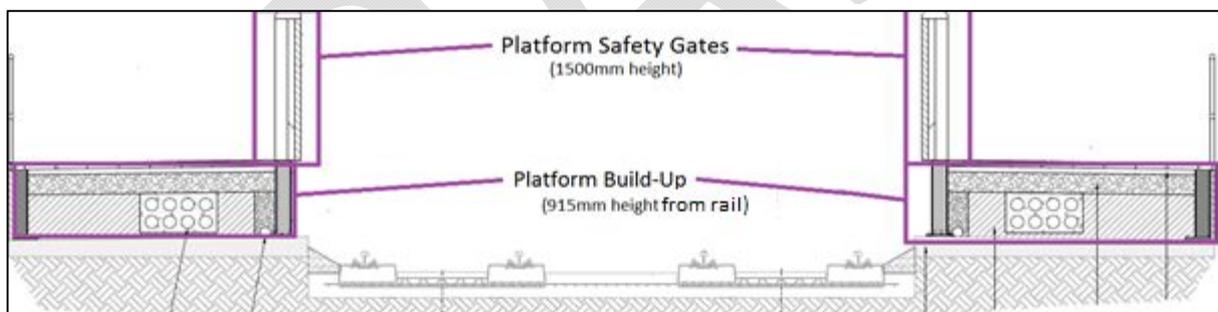
Stop Name	Construction	Land Take	Main Impacts
RANELAGH	EASY	NO	Equivalent to GLIU works scope
BEECHWOOD	EASY	NO	Equivalent to GLIU works scope
COWPER	EASY	NO	Equivalent to GLIU works scope
MILLTOWN	EASY	NO	Equivalent to GLIU works scope
WINDY ARBOUR	EASY	NO	Equivalent to GLIU works scope
DUNDRUM	EASY	NO	Equivalent to GLIU works scope
BALALLY	EASY	NO	Equivalent to GLIU works scope
KILMACUD	EASY	NO	Equivalent to GLIU works scope
STILLORGAN	EASY	NO	Non-segregated- Equivalent to GLIU works scope
SANDYFORD	EASY	NO	Equivalent to GLIU works scope

*Table 1: Line B Study Area - Scenario 1 Summary*

### 5.2.2 Scenario 2: 60m HFV – Fully Automatic

The physical characteristics of the high floor metro vehicles operating in this scenario are 60m in length, 2.65m in width and with an internal floor height of approx. 915mm from the top of rail (TOR). As a result, the height of the platforms would increase by approx. 630mm over the existing platform levels and the length of the platforms would extend by an additional 7m. As the platform end ramps would no longer be required, these would form part of the extension (while those not included within the new platform area would be demolished).

In addition, the vehicles operating in this scenario are fully automated with no driver supervision and as such, maintaining safety at the platforms is paramount. To ensure passengers do not enter the track area (either accidentally through falls or trips or deliberately through trespassing), Platform Safety Gates (PSGs) with an approx. height of 1,500mm would be required at each platform edge, with the vehicle doors fully aligned with the gates when stopped at the platforms and both sets of doors opening and closing in sync. A cross-section through a typical platform is illustrated in Figure 10. Figure 11 shows an over-ground platform on Copenhagen’s metro system before and after the installation of PSGs. Full enclosure of the platform boundary would be achieved via barriers installed at the platform ends in addition to removal of the ramps and the existing pedestrian crossings between each side.

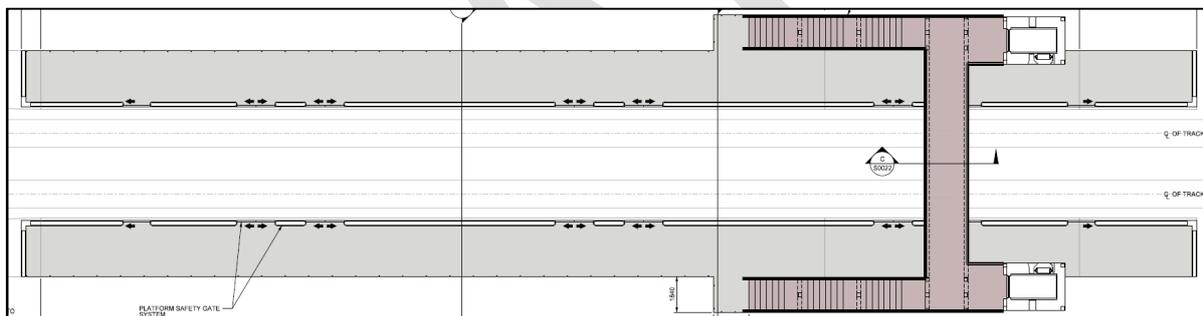


*Figure 10: Cross-section through typical upgraded stop (Scenario 2)*



*Figure 11: High-floor Copenhagen metro - before and after installation of PSGs*

As passengers could no longer cross over to the opposite platform at track level, access arrangements to either platform would require significant reconfiguration, including the addition of footbridges and lifts (or modification of the same where already existing) at each stop. Figure 12 illustrates a standard platform detail with a footbridge and lift access, and fully enclosed platform edges with access gates.



*Figure 12: Typical arrangement at upgraded stop (Scenario 2)*

This standard arrangement of footbridge and lifts was applied to each stop separately and modified to suit the local conditions. It was concluded that while raising the platform level by over 600mm and providing access to each platform without passengers crossing the track area is technically feasible (while requiring significant works) for all stops within the Line B study area, the works at Ranelagh, Dundrum, Stillorgan and Sandyford would prove challenging for differing reasons outlined in the following paragraphs.

At Ranelagh, as the stop is located on a bridge structure, the increase in height of the platform, surrounding balustrade and the lift structure would potentially result in a negative visual impact and additional strengthening of the bridge structure would be required. Landtake of approx. 125m<sup>2</sup> would be necessary to provide space for a new lift and stairs on the south-west of the bridge to access the inbound platform along with adjustments to the stair and lift heights on the outbound side (see Figure 13)



in Figure 15). Additional fencing would be required along the inbound track to prevent access to the track area and this would continue either side of the track area along Blackthorn Avenue.

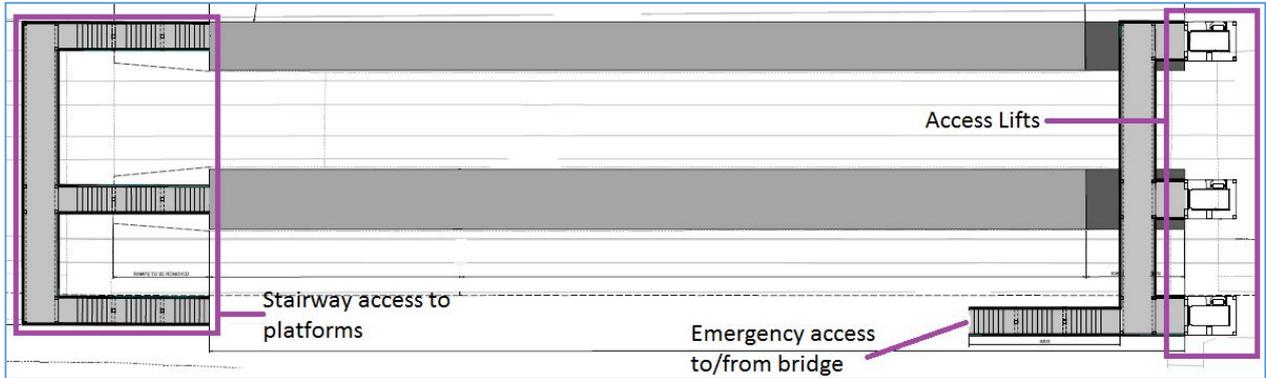


Figure 15: Sandyford Stop following upgrade (Scenario 2)

A full set of drawings showing the extent of work proposed at each stop under this scenario is included in Appendix 3. Table 2 provides a high-level summary.

Stop Name	Construction	Land Take	Main Impacts
RANELAGH	DIFFICULT	YES	Visual impact on bridge with rise in platform height, bridge strengthening required. Additional access on inbound side requiring landtake.
BEECHWOOD	MEDIUM	NO	Closure of Dunville Avenue, north of stop – pedestrians to use stop stair/lift and footbridge for access.
COWPER	MEDIUM	NO	Crossing south of stop closed – pedestrians to use stairs/lift and footbridge for access.
MILLTOWN	MEDIUM	YES	Both vehicular and pedestrian access to Alexandra College from Richmond Avenue South is closed – pedestrians to use stop stair/lift and footbridge for access.
WINDY ARBOUR	MEDIUM	NO	Crossing on north of stop closed for through foot traffic – pedestrians to use stop stair/lift and footbridge for access.
DUNDRUM	DIFFICULT	NO	Strengthening of existing stone retaining wall on inbound side required. Below ground works required for lift access from underpass to street and platform level. Visual impact on Dundrum Station House.
BALALLY	EASY	NO	Requires opening in bridge parapet for new lift access on outbound side. Existing access from retail unit maintained.

Stop Name	Construction	Land Take	Main Impacts
KILMACUD	MEDIUM	NO	Existing access arrangements maintained with additional stair and lift access created on inbound side.
STILLORGAN	DIFFICULT	NO	Stop located on new overpass for grade separation of track with Upper Kilmacud Road Extension. Temporary track installation through existing Park & Ride.
SANDYFORD	DIFFICULT	NO	Outbound side stone wall requires strengthening. One set of additional stairs and lift required for access to island platform.

*Table 2: Line B Study Area - Scenario 2 Summary*

### 5.2.3 Scenario 3: 90m LRV – Driver Controlled

The platform lengths on the Luas Green Line, following the GLIU works, will be 53m, requiring an additional 37m to accommodate a 90m light rail vehicle as used within this scenario. Following an internal TII engineering assessment, it was concluded that while platform extensions to 90m are technically feasible for all stops within the Line B study area, the extension of Ranelagh, Cowper, Windy Arbour and Sandyford would prove challenging for differing reasons outlined in the following paragraphs.

To ensure sufficient space is provided to facilitate the nearby NMN tie-in, the Ranelagh platform would require extension towards the Sandyford direction. Consequently, there would be a significant impact on the existing passenger access buildings (refer to Figure 16) located at the southern end of the platforms. The existing stairwell and platform level structure on the outbound side would be demolished while the lift shaft would be retained within a new building. The existing pedestrian underpass would also be retained and extended to provide passenger access to a new staircase and lift to the platform level. The current stairwell structure on the inbound side would be demolished and a new structure provided, set back from the structure, to provide space for the platform. This would require landtake within the green area below the stop.



*Figure 16: Ranelagh passenger access*

At Cowper Luas Stop, the preferred extension side would be northwards, requiring the taking of approx. 2.5m of nine back gardens on the inbound side. However, the gardens in question are already limited in space and removal of a 2.5m strip would remove a significant proportion of the land available to the occupants. For the purpose of this report, the platform is extended south instead, with the key drawback that the pedestrian passage across the tracks would no longer be combined with the stop pedestrian crossing. This could increase the risk of uncontrolled pedestrian crossing in the middle of the platforms and introducing approx. 80m walking detour through the platforms for prams and wheelchair users. This could also potentially add unnecessary congestion to the platforms (refer to Figure 17).



*Figure 17: Cowper pedestrian passage/crossing*

For Windy Arbour Luas Stop, the opposite approach to Cowper is proposed, in that 1.8m of seven relatively large back gardens would be taken to extend the platform southwards in order to maintain the pedestrian route across the northern end of the current stop. Extending northwards would introduce a convoluted pedestrian detour of approx. 80m, and would unnecessarily overload the platforms with pedestrian traffic and increase risk due to pedestrians directly crossing via the two platforms.

Sandyford Luas Stop could only be extended northwards due to complex trackworks and geometries on the south side to allow for the links to Line B1 and the entrance to the depot. The stop is currently designed to cater for a mixed service of passing trams (Bride's Glen to St. Stephen's Green) and turning-back trams (St. Stephen's Green to Sandyford), plus the necessary connections in and out of the depot. For this reason, the stop has three tracks with three platform sides (one lateral and one island) and a series of crossovers plus a simple junction. One consequence of extending the platforms north would be the requirement to relocate one crossover and one turnout further north (refer to Figure 18).

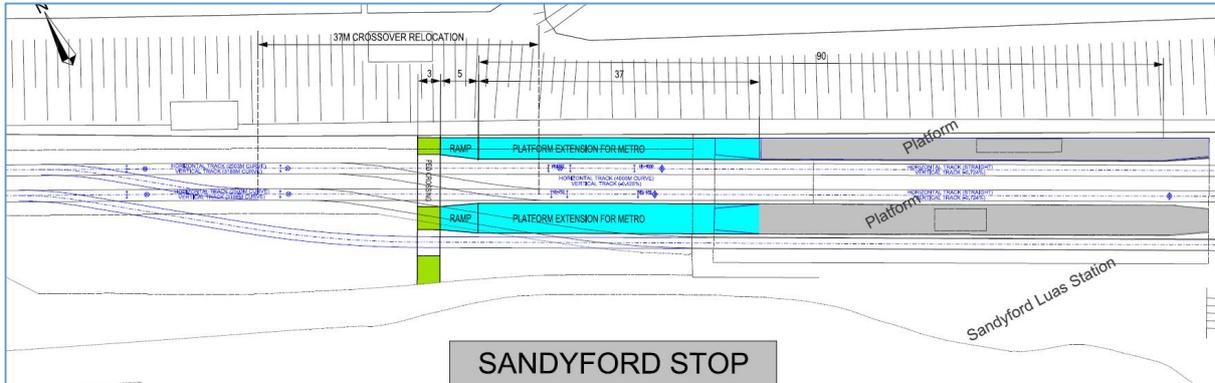


Figure 18: Sandyford Stop extension

Further technical information on each stop is contained within Appendix 1 and Table 3 provides a high-level summary. In addition to the platform extension works and the associated measures required, the track facing edge of each platform would require trimming, as described in Section 4.2.2.1.

An upgrade to Line B (Ranelagh to Sandyford) in isolation of an upgrade to Line B1 (Sandyford to Bride’s Glen) would result in the termination of metro service at Sandyford (thereby retaining a Luas service from Sandyford to Bride’s Glen). In this scenario, a number of factors would require consideration as described in the following section.

Stop Name	Construction	Land Take	Main Impacts
RANELAGH	DIFFICULT	YES	Stairwell buildings on inbound and outbound side to be demolished, outbound lift retained with new stairs, with new lift and stairs on inbound side requiring landtake and new access way from Ranelagh Road.
BEECHWOOD	EASY	NO	Equivalent to GLIU works scope
COWPER	MEDIUM	NO	Crossing centre of stop closed - pedestrians to use crossing at platform for access.
MILLTOWN	EASY	NO	Equivalent to GLIU works scope

Stop Name	Construction	Land Take	Main Impacts
WINDY ARBOUR	MEDIUM	YES	Landtake of 7 No. properties back gardens on the inbound southern side of the platform.
DUNDRUM	MEDIUM	NO	No major impacts
BALALLY	MEDIUM	NO	No major impacts
KILMACUD	MEDIUM	NO	No major impacts
STILLORGAN	EASY	NO	Stop extension at ground level without overpass of road is straightforward. Refer to Scenario 2 for overpass.
SANDYFORD	MEDIUM	NO	Track work required to achieve northwards extension of platforms.

Table 3: Line B Study Area - Scenario 3 Summary

### 5.3 Sandyford Depot Implications

This study provides a high-level cost assessment for the infrastructure modifications that would be required to the Sandyford Depot if it were required to accommodate the stabling of metro trams and be the termination point for metro services. In the event of a decision to terminate the metro service at Sandyford (thereby retaining a Luas service from Sandyford to Bride's Glen), a number of factors would require further consideration as follows:

- Interchange arrangements at Sandyford Stop:** As Sandyford Stop would become a service interchange between the metro and Luas, turn-back arrangements for both metro and Luas would require further study to ensure headways can be maintained. In addition, passenger access arrangements between the two services would also need further study, especially in the event of an automated metro service due to the level of segregation involved.
- The operational status of Sandyford Depot:** In such a scenario, the depot would either be used solely for metro stabling and maintenance (a new depot would be required to support Line B1 operations) or be retained for Luas vehicles only, requiring other arrangements for stabling of metro vehicles for start of service in the mornings and significant track work to create a new entry. Mixed occupation of the depot by both metro and Luas vehicles would result in significant technical and contractual risk and

consequently is unlikely to be considered further. Expansion of the depot is not possible as the site occupies the maximum possible footprint.

- Line B1 isolation from Luas Cross City (LCC)/Line C:** With a metro system operating to Sandyford, Line B1 (and a future Line B2 to Bray) would become isolated from the remainder of the Luas system. In order to facilitate the transfer of trams between LCC/Line C and Line B1, either an engineering link would be provided between the Charlemont terminus and the upgraded metro line, or all vehicle transfers would be carried out using the road network. In the engineering link scenario, this would also require a significant level of interoperability between the metro system running on the former Line B and the Luas vehicles.

The costs estimates provided as part of this report for the Sandyford Depot modifications do not currently account for these factors.

### 5.3.1 Sandyford Depot Modifications - Scenario 1: 60m LFV – Driver Controlled

Following completion of the GLCE works, Sandyford depot will have an ultimate capacity of 30 no. 54.7m long vehicles. Following initial analysis, it has been determined that approx. 26 trams of 60m length can be stabled within the depot using this new configuration (as illustrated in Figure 19).

Space proofing the 60m vehicles within the maintenance shed would require a more detailed analysis to check against the position of objects such as the pits, gantries, doors, etc. but vehicles of this length would appear to fit within the extended depot building without additional major works required.

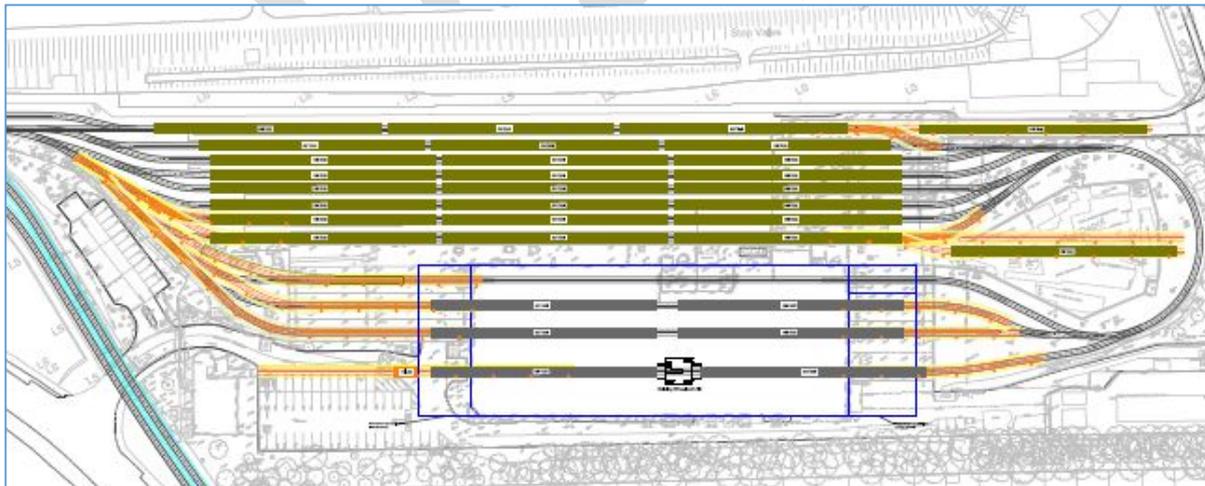


Figure 19: Sandyford Depot capacity and modifications for 60m metro vehicles

### 5.3.2 Sandyford Depot Modifications - Scenario 2: 60m HFV – Fully Automatic

As discussed in Section 5.3.1, initial analysis concludes that up to 26 60m long vehicles could be stabled within the depot (following the current capacity enhancement works) with minimal works required. Further detailed analysis would be required to establish the impact of automated HFVs operating within the depot environment.

### 5.3.3 Sandyford Depot Modifications - Scenario 3: 90m LFV – Driver Controlled

Figure 20 illustrates the Sandyford Depot following the GLCE works completion with 90m long vehicles superimposed in the stabling area and in the maintenance shed (outlined in blue). Following the GLCE works, the maximum stabling capacity for 53m long Luas vehicles will be 26; with a 90m metro vehicle, this figure would drop to 16. Maintenance capacity would be similarly affected; each maintenance track within the shed (as illustrated in Figure 20) could accommodate one vehicle at a time, rather than two.

The sanding plant (top left in the maintenance shed) would require extending as shown hatched in Figure 20, while there would be no impact on the washing plant (top right in the shed) as this is a pass-through system. In addition, a new track extension would be required outside the lower left corner of the maintenance shed (opening a door through the building) to allow wheel-turning activities in the middle of the shed.

The two stabling tracks in the loop and the single dead-end track in the delivery lane (top right in the sketch), both built as part of the GLCE project, would become redundant, as would the use of the two north apron tracks (on the left of the maintenance shed). Some of them could be re-used for maintenance vehicle parking, while the two large areas on either end of the maintenance shed built as extensions for GLCE project in 2017 would become redundant.

The most critical aspect is operational; a vehicle coming off the line and waiting to be sanded would foul the rest of the entrance fan to the depot, blocking most of the other movements in and out.

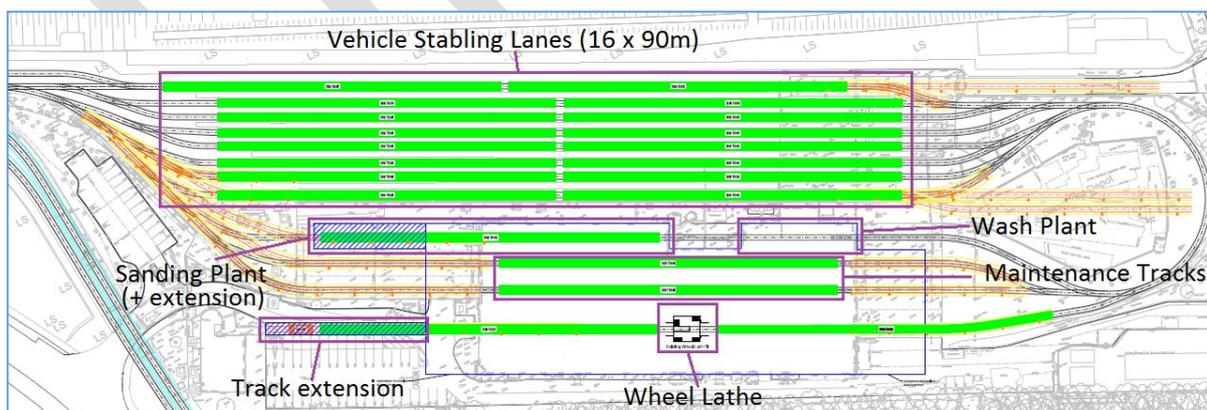


Figure 20: Sandyford Depot capacity and modifications for 90m metro vehicles

## 6 COST IMPACT ESTIMATE LINE B (RANELAGH TO SANDYFORD)

This section includes the cost estimates produced for each operating scenario for upgrading Ranelagh to Sandyford to metro standard, following the engineering analysis. The costings described in this section are indicative, and additional design development and analysis would be required to provide upgrade costs with a greater level of confidence, once the final operating scenario has been chosen for NMN.

### 6.1 Scenario 1: 60m LFV – Driver Controlled

Table 4: Assumptions and Exclusions for Costing Scenario 1

Scenario 1 - Assumptions and Exclusions	
1	<b>All Stops</b>
1.1	Rates for platform extension works, track infill panel works, stop furniture and removal and reinstatement of existing platform surfaces have been obtained from GLIU - Platform Extensions Pricing Document.
1.2	A nominal amount of 30% has been allowed for Preliminaries.
1.3	It has been assumed that 1 No. Automatic Vehicle Location System (AVLS) loop will be required at the end of the new extension.
1.4	It has been assumed that 2 No. Validators will be required at each new platform extension (4 No. per stop).
1.5	The rate for trimming of the platform edge has been generated from current market rates.
1.6	Only new balustrading required for the platform extension has been included.
2	<b>Ranelagh</b>
2.1	Nominal amounts have been allowed for Demolition and Alterations, Property Acquisition based on previous contracts.
2.2	The rate for the lift works has been obtained from building costs undertaken by Linesight.
4	<b>Sandyford</b>
4.2	The island platform rates have been generated from GLIU Contract - Harcourt platform extension.
5	<b>Depot</b>
	The estimated costs for upgrading the depot to suit each scenario will be included within the Line B1 study area costings.

Table 5: Cost Estimate Breakdown – Scenario 1

Item	Description	Scenario 1 60m Low Floor Unsegregated Junction	Scenario 1 60m Low Floor Segregated Junction
1	Ranelagh Stop	€ 899,291.63	€ 899,291.63
2	Beechwood Stop	€ 723,600.63	€ 743,100.63
3	Cowper Stop	€ 531,909.92	€ 531,909.92
4	Milltown Stop	€ 697,815.97	€ 697,815.97
5	Windy Arbour Stop	€ 820,965.21	€ 820,965.21
6	Dundrum Stop	€ 748,614.42	€ 748,614.42
7	Balally Stop	€ 767,014.45	€ 767,014.45
8	Kilmacud Stop	€ 733,523.89	€ 733,523.89
9	Stillorgan Stop	€ 679,558.33	€ 11,365,775.00
10	Sandyford Stop	€ 860,708.39	€ 860,708.39
11	Power & Systems	€ 8,000,000.00	€ 8,000,000.00
	<b>Total</b>	<b>€ 15,463,002.85</b>	<b>€ 26,168,719.52</b>
12	Design - 7.5%	€ 1,159,725.21	€ 1,962,653.96
13	Project Management - 14.5%	€ 2,242,135.41	€ 3,794,464.33
14	TII Insurance and Overheads - 3%	€ 463,890.09	€ 785,061.59
15	Transdev Interface Costs @ 6%	€ 927,780.17	€ 1,570,123.17
16	Construction Risk and Order of Magnitude	€ 5,064,133.43	€ 8,570,255.64
17	Inflation to 2022 @ 2.5%	€ 3,300,000.00	€ 5,500,000.00
	<b>Total</b>	<b>€ 28,620,667.17</b>	<b>€ 48,351,278.21</b>
	<b>Difference</b>		<b>€ 19,730,611.05</b>

## 6.2 Scenario 2: 60m HFV – Fully Automatic

Table 6: Assumptions and Exclusions for Costing Scenario 2

<b>Scenario 2 - Assumptions and Exclusions</b>	
<b>1</b>	<b>All Stops</b>
1.1	The rates for Power & Systems works have been obtained from BXD_450 LCC Variation.
1.2	A nominal amount of 30% has been allowed for Preliminaries.
1.3	It has been assumed that no AVLS loops will be required.
1.4	The replacement of the stop furniture has been excluded as it is assumed that the stop furniture will be replaced to match the NMN stop furniture/branding theme.
1.5	An assumption of €600,000 has been allowed for the platform screen gates - waiting on a rate from a supplier.
1.6	Rates for platform extension works, platform-raising works, stop furniture and removal, and reinstatement of existing platform surfaces have been obtained from GLIU - Platform Extensions Pricing Document.
1.7	It has been assumed that €850,000 will be sufficient per stop for footbridges and lifts.
1.8	Platform raising works has a separate BOQ to provide clarity to the reader.
1.9	The demolition of the existing ramp at each stop - this rate was generated from GLIU Platforms Contract.
1.10	It has been assumed that all material used in the reinstatement of existing platform surfaces is new material and not being re-used.
1.11	It has been assumed that track-infill panels will not be required as the platform is now screened.
<b>2</b>	<b>Beechwood</b>
2.1	It has been assumed that the café at Beechwood Stop is property of TII and no monetary value has been included for Property Acquisition.
2.2	It has been assumed that the closure of Dunville Avenue will cause issues so a monetary value has been added to the budget for this stop.
<b>3</b>	<b>Milltown</b>
3.1	Based on rates from GLIU platform extension, a rate of €600 has been applied for the construction of approx. 19m long stone boundary wall and bulk earth removal.
3.2	It has been assumed that €25,000 will suffice for the Property Acquisition form Alexandra College (area 1.3m x 1.8m).
<b>4</b>	<b>Windy Arbour</b>
4.1	A rate of €250 has been applied for re-grading the existing footpath - based on GLIU rates. In addition, the area has been scaled off the drawings provided by TII.
<b>7</b>	<b>Stillorgan</b>
7.1	The overpass estimate was generated from Carrickmines Bridge, inflated to current prices.

Scenario 2 - Assumptions and Exclusions	
8	<b>Sandyford</b>
8.1	The island platform rate has been generated from GLIU Platform extensions – Harcourt.
9	<b>Depot</b>
	The estimated costs for upgrading the depot to suit each scenario will be included within the Line B1 study area costings.

Table 7: Cost Estimate Breakdown – Scenario 2

Item	Description	Scenario 2 60m High Floor Segregated Junction
1	Ranelagh Stop	€ 3,982,549.83
2	Beechwood Stop	€ 3,262,531.69
3	Cowper Stop	€ 2,967,574.10
4	Milltown Stop	€ 3,339,085.15
5	Windy Arbour Stop	€ 3,270,102.51
6	Dundrum Stop	€ 2,364,373.94
7	Balally Stop	€ 2,280,318.31
8	Kilmacud Stop	€ 3,085,960.56
9	Stillorgan Stop	€ 12,145,775.00
10	Sandyford Stop	€ 4,588,785.44
11	Power & Systems	€ 31,291,250.00
	<b>Total</b>	<b>€ 72,578,306.53</b>
12	Design - 7.5%	€ 5,443,372.99
13	Project Management - 14.5%	€ 10,523,854.45
14	TII Insurance and Overheads - 3%	€ 2,177,349.20
15	Transdev Interface Costs @ 6%	€ 4,354,698.39
16	Construction Risk and Order of Magnitude	€ 23,769,395.39
17	Inflation to 2022 @ 2.5%	€ 15,200,000.00
	<b>Total</b>	<b>€ 134,046,976.94</b>

### 6.3 Scenario 3: 90m LFV – Driver Controlled

Table 8: Assumptions and Exclusions for Costing Scenario 2

Scenario 3 - Assumptions and Exclusions	
1	<b>All Stops</b>
1.1	Rates for platform extension works, track infill panel works, stop furniture and removal, and reinstatement of existing platform surfaces have been obtained from GLIU - Platform Extensions Pricing Document.
1.2	A nominal amount of 30% has been allowed for Preliminaries.
1.3	It has been assumed that 1 No. AVLS loop will be required at the end of the new extension.
1.4	It has been assumed that 2 No. Validators will be required at each new platform extension (4 No. per stop).
1.5	The rate for trimming of the platform edge has been generated from current market rates.
1.6	Only new balustrading required for the platform extension has been included.
2	<b>Ranelagh</b>
2.1	Nominal amounts have been allowed for Demolition and Alterations, Property Acquisition based on previous contracts.
2.2	The rate for the lift works has been obtained from building costs undertaken by Linesight.
3	<b>Windy Arbour</b>
3.1	Property Acquisition - it has been assumed that €30,000 per property will meet the requirements from residents (7 No. properties).
4	<b>Sandyford</b>
4.1	It has been assumed that no Track Infill panels are required at Sandyford as the track will be replaced due to the relocation of the specialist track equipment - crossover and turnout.
4.2	The island platform rates have been generated from GLIU Contract - Harcourt platform extension.
5	<b>Depot</b>
	The estimated costs for upgrading the depot to suit each scenario will be included within the Line B1 study area costings.

Table 9: Cost Estimate Breakdown – Scenario 3

Item	Description	Scenario 3 90m Low Floor Not Segregated Junction	Scenario 3 90m Low Floor Segregated Junction
1	Ranelagh Stop	€ 3,218,523.59	€ 3,218,523.59
2	Beechwood Stop	€ 1,475,883.57	€ 1,495,383.57
3	Cowper Stop	€ 1,185,923.47	€ 1,185,923.47
4	Milltown Stop	€ 1,597,823.91	€ 1,597,823.91
5	Windy Arbour Stop	€ 1,798,003.33	€ 1,798,003.33
6	Dundrum Stop	€ 1,464,535.48	€ 1,464,535.48
7	Balally Stop	€ 1,542,522.22	€ 1,542,522.22
8	Kilmacud Stop	€ 1,620,066.46	€ 1,620,066.46
9	Stillorgan Stop	€ 1,313,271.85	€ 12,535,775.00
10	Sandyford Stop	€ 1,323,861.80	€ 1,323,861.80
11	Power & Systems	€ 23,291,250.00	€ 23,291,250.00
	<b>Total</b>	<b>€ 39,831,665.69</b>	<b>€ 51,073,668.84</b>
12	Design - 7.5%	€ 2,987,374.93	€ 3,830,525.16
13	Project Management - 14.5%	€ 5,775,591.52	€ 7,405,681.98
14	TII Insurance and Overheads - 3%	€ 1,194,949.97	€ 1,532,210.07
15	Transdev Interface Costs @ 6%	€ 2,389,899.94	€ 3,064,420.13
16	Construction Risk and Order of Magnitude	€ 13,044,870.51	€ 16,726,626.55
17	Inflation to 2022 @ 2.5%	€ 8,400,000.00	€ 10,700,000.00
	<b>Total</b>	<b>€ 73,624,352.57</b>	<b>€ 94,333,132.73</b>
	<b>Difference</b>		€ 20,708,780.16

## 6.4 Costs Summary for All Scenarios

Figure 21 provides the estimated costs for converting the line section from Ranelagh and Sandyford to a metro standard to the extent required by each of the three scenarios. In the event that it is deemed that road segregation is not a requirement for Scenario 1 or 3, estimated costs for each scenario reduce by €20 million. As Scenario 2 involves a fully automated rail system, full segregation from roads and other points of interface with pedestrians and vehicles is an absolute requirement.

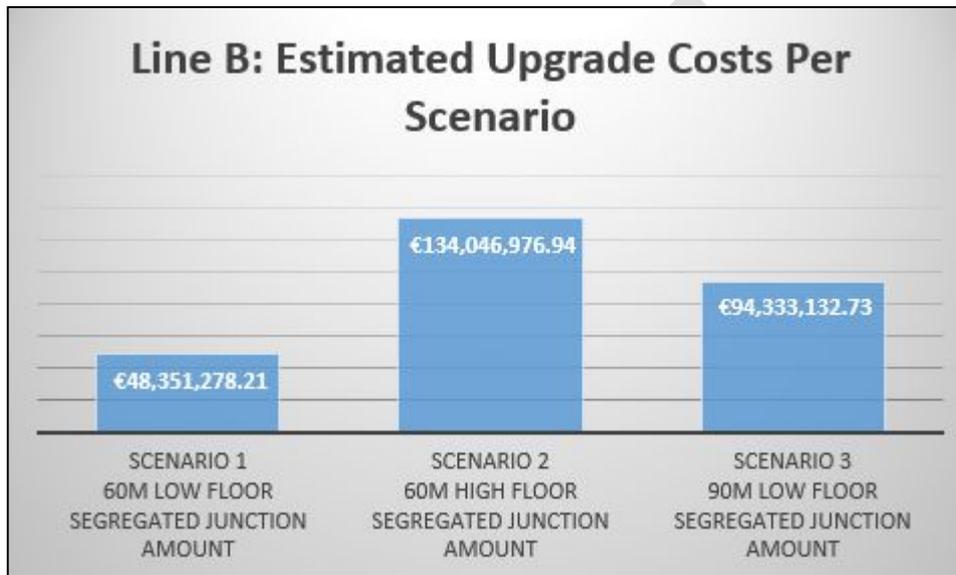


Figure 21: Overall cost estimates for Line B for all scenarios

A large proportion of the additional costs for Scenario 2 arise from the work to raise the platform heights, install safety gates at platforms and modify access routes to each platform, including foot bridges and additional lifts (as the track cannot be crossed).

## 7 CONCLUSION

The extent of engineering work and costs for upgrading Line B (from Ranelagh to Sandyford) to a metro standard is fully contingent on the type of metro operations proposed for NMN once the two systems are connected at Ranelagh.

Three different operating scenarios were chosen for this study with all three also including segregation from road junctions. Considering the vehicle passenger carrying capacities for each scenario outlined in Section 4, the following can be assumed:

- Scenario 1, with a 60m long, 2.65m wide low-floor light rail vehicle, operating at a headway of 2 minutes, could provide a capacity of up to 13,200 PDPH on this corridor for approx. €50 million;
- Scenario 3, with the same vehicle form factor and headway as Scenario 1 but with an increased length of 90m, could provide a capacity of 22,300 PDPH for approx. €95 million; and
- Scenario 2, with a high-floor fully automatic vehicle with 60m length, operating at a headway of 90 seconds, could provide a capacity of approx. 18,000 PDPH on this line section at a cost of approx. €135 million.

All figures in this study are indicative and subject to further engineering analysis.

## 8 APPENDICES

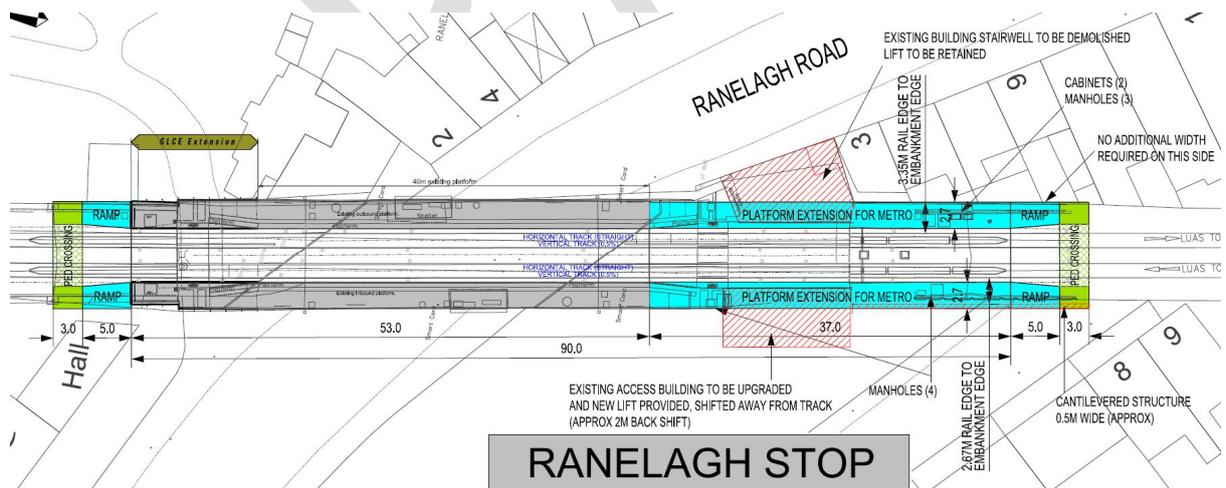
### 8.1 APPENDIX 1: LINE B STUDY AREA SCENARIO 3 STOP ANALYSIS

#### Ranelagh Stop



*Ranelagh aerial view*

Ranelagh Stop is proposed to be extended towards Sandyford (south) to facilitate a NMN connection with steep gradient and vertical curve on the north side, which would not allow extending the platforms in that direction.



*Ranelagh proposed 90m extension*

<b>Ranelagh Stop</b>	
<b>Existing</b>	
Current length	53m + 5.0m; lateral
Track alignment	Straight, +0.5% grade
Track type	Slab (Edilon blocks type)
Current obstructions	St. Stephen's Green side future vertical curve to link with NMN alignment. Sandyford side reduced platform width 2.2m inbound, stair and lift cores both platforms
Current access	From outbound platform side only. Staircase and lift to outbound platform + pedestrian underpass to inbound platform
<b>Proposal</b>	<b>Difficult for construction access and impacts</b>
Where to extend	Extend on Sandyford side by 37m plus ramp (5m) and pedestrian crossing (3m).
Pedestrian access	From inbound platform side, new stairs and lift. From outbound platform side, staircase removed, lift kept. Pedestrian underpass may be kept.
Constraints	2.7m wide platforms, as per existing Ranelagh platforms width.
<b>Proposed works</b>	
Extended platform edge straight?	Yes
Platform works	Build up over existing retained embankment walkways and place of safety and cantilever additional 500mm for inbound only.
Ramp works	Yes, new ramps on both sides (currently there is no ramp and PD at the St. Stephen's Green side).
Track works (track surface)	Retrofitting slab track with derailment containment in 4ft with track precast panels. Derailment containment to be dismantled in the area.
Manholes cable duct works	Manholes, P&S Cabinet, Lighting Poles
Structural works (walls, gabions, etc.)	Cantilever additional 500mm for inbound platform only and reconfiguration of both vertical access cores and provision of new lift. Structural works required for both platforms to span over the original stairwell cores voids for a length of approx. 12m.
Off platform drainage works	No
Hardscape/softscape works	Hardscape: new parapets and glass panels in extended section.
Power and system works (Overhead Catenary System (OCS)?)	AVLS relocation, additional lighting, P&S Cabinet, track bonding.
Pedestrian crossing (PC) and access re-routing	New PCs both sides. Access re-routing during construction based on phases.
Other works	Construction access from road or private property below.

Impacts and land take	
Impact on private property?	No
Other impacts?	Yes, part of the grassed area south-west of the bridge will be impacted by the new access core to inbound platform.
Pedestrian access during works	
Impacted - to be agreed at construction design stage, probably variable with construction phases.	

DRAFT



*Ranelagh Stop photos*



<b>Beechwood Stop</b>	
<b>Existing</b>	
Current length	5m + 53m + 5m; lateral
Track alignment	Straight, +1.4% grade
Track type	Ballast
Current obstructions	Beechwood Road on St. Stephen's Green side
Current access	From St. Stephen's Green side, PC on both sides
<b>Proposal</b>	<b>Easy</b>
Where to extend	Extend on Sandyford side by 37m; ramp can be reduced to 4.4m to achieve 5%.
Pedestrian access	Not changed
Constraints	Minor: cabinet on outbound platform
<b>Proposed works</b>	
Extended loading edge straight?	Yes
Platform works	Standard construction of platform slabs and ramps over existing ballast formation. Cable ducts to be incorporated into the new platforms and locally re-routed.
Ramp works	New ramps to be built on Sandyford side. Length can be reduced to 4.4m due to gradient.
Track works (track surface)	Ballast track to be retrofitted with embedded pre-cast panels or fully replaced with embedded track.
Manholes cable duct works	2x outbound, 2x inbound
Structural works (walls, gabions, etc.)	No
Off platform drainage works	No
Hardscape/softscape works	Yes, new softscape edges on both sides.
Power and system works (OCS?)	Yes, AVLS relocation, additional lighting, track bonding.
Other works	No
<b>Impacts</b>	
Impact on private property?	No
Other impacts?	No
<b>Pedestrian access during works</b>	
From Dunville Avenue, unaffected.	



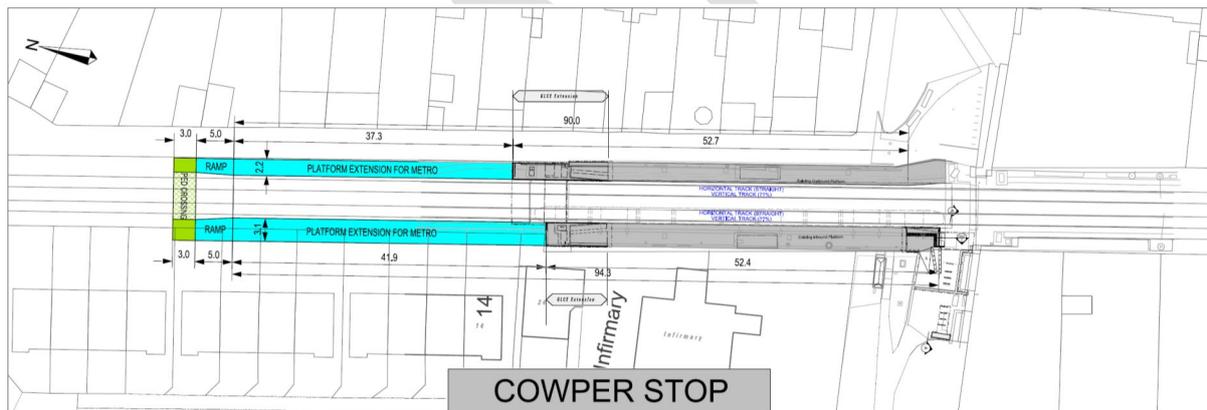
*Beechwood Stop photos*

## Cowper Stop

Cowper Stop has the potential to be extended on both sides; therefore, both options have been examined.



*Cowper aerial view (St. Stephen's Green side)*



*Cowper possible 90m extension towards St. Stephen's Green – not preferred*



<b>Cowper Stop</b>	
<b>Existing</b>	
Current length	Staggered lateral platforms. 5m + 52.7m + 5.0m
Track alignment	Straight, +0.5% grade
Track type	Ballast
Current obstructions	Manholes, P&S Cabinet, OCS Poles
Current access	From Sandyford side only, combined with PC between the two areas split by the Luas corridor
<b>Proposal</b>	<b>Medium difficulty for construction access</b>
Where to extend	Inbound: Extend on Sandyford side by 37.6m plus ramp and PC Outbound: Extend on Sandyford side by 41.8m plus ramp and PC
Pedestrian access	As existing, but becoming the centre of the newly extended platforms. Crossing pedestrians and wheelchair users will have to be re-routed through the extended platforms (80m longer detour).
Constraints	Manholes, P&S Cabinet, OCS Poles, Luas property low wall on inbound and property boundary line on outbound side.
<b>Proposed works</b>	
Extended loading edge straight?	Yes
Platform works	Standard construction of platform slabs and ramps over existing ballast formation. Cable ducts to be incorporated into the new platforms and locally re-routed.
Ramp works	New ramps Sandyford side (outbound and inbound).
Track works (track surface)	Ballast track to be retrofitted with embedded pre-cast panels or fully replaced with embedded track.
Manholes cable duct works	Manholes, P&S Cabinet, OCS Poles.
Structural works (walls, gabions, etc.)	Minor structural works to adjust walls and levels in the pedestrian access area. Low hardscape wall to be demolished on inbound side.
Off platform drainage works	No
Hardscape/softscape works	New landscaping and edging on both sides.
Power and system works (OCS?)	Yes, AVLS relocation, additional lighting, P&S Cabinet, OCS Poles.
Other works	Re-route pedestrian/cycle access.
<b>Impacts</b>	

Impact on private property?	No if minimum 2.1m outbound platform width accepted at pinchpoint.
Other impacts?	Pedestrian route
<b>Pedestrian access during works</b>	
As existing, only temporarily affected during part of the works.	



*Cowper Stop photos*



## Milltown Stop

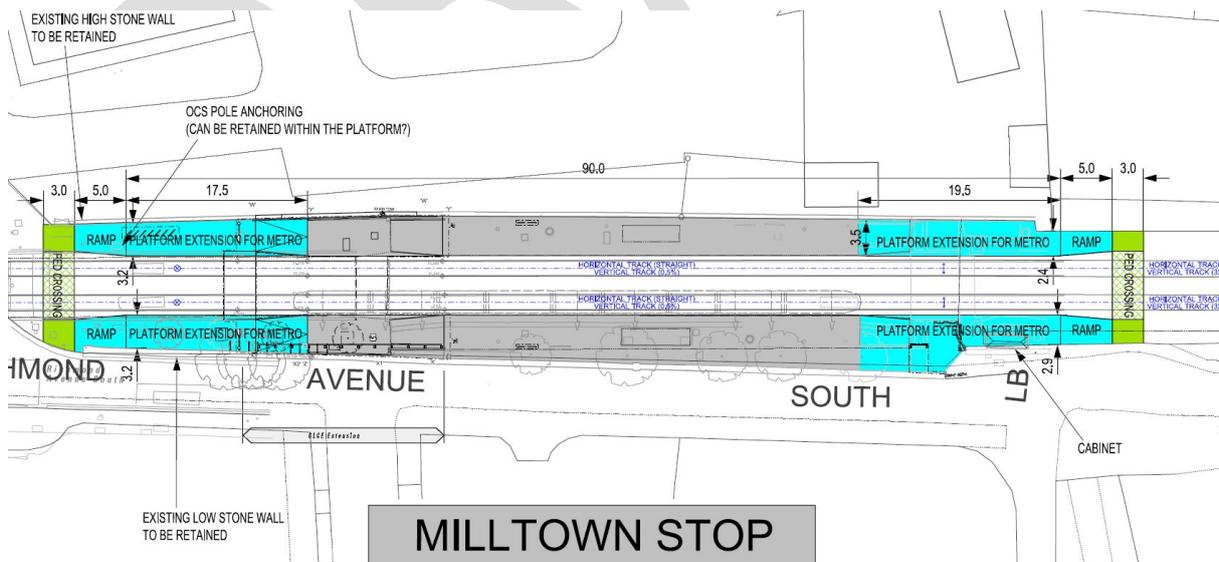


*Milltown aerial view*

Milltown Stop is proposed to be extended on both sides. This is to close the gap between the current 55m extension works (towards St. Stephen's Green) and the Alexandra College access road junction (approx. 17.5m), and to extend the remaining part (approx. 19.5m) towards Sandyford.

Extending completely towards St. Stephen's Green would not be possible for the presence of the road junction.

Extending completely towards Sandyford would not make use of the existing embedded track to the north and could potentially require landtake to the south along the south-bound (SB) track. Bringing the stop adjacent to the road junction would also be more efficient from an operational viewpoint and safer, as it combines the two pedestrian crossings in one.



*Milltown proposed 90m extension*

<b>Milltown Stop</b>	
<b>Existing</b>	
Current length	5m + 53m + 5m; lateral
Track alignment	Straight, +0.5% grade
Track type	Ballast Sandyford, Embedded St. Stephen's Green
Current obstructions	Not major: bicycle stands and OCS tensioning poles (with protection cage) St. Stephen's Green side both inbound and outbound, stop cubicle Sandyford side inbound
Current access	From both ends, with PC on both sides
<b>Proposal</b>	
<b>Easy to extend</b>	
Where to extend	Extend on both sides, St. Stephen's Green 17.5m + 5m & Sandyford 19.5m + 5m by rebuilding ramps at the end of new platform extensions on both sides.
Pedestrian access	As per existing, on both ends.
Constraints	Narrow platform ends Sandyford side (2.9m inbound and 2.4m outbound for the last 10m and 3m approx.), 6 manholes; bicycle racks, trees, stop cubicle.
<b>Proposed works</b>	
Extended platform edge straight?	Yes
Platform works	Standard construction of platform slabs and ramps over existing ballast formation Sandyford side and over existing paved area St. Stephen's Green side. Cable ducts Sandyford side to be incorporated into the new platforms and locally re-routed.
Ramp works	New ramps Sandyford side (outbound and inbound) and St. Stephen's Green side (outbound and inbound).
Track works (track surface)	Ballast track to be retrofitted with embedded pre-cast panels or fully replaced with embedded track Sandyford side. None St. Stephen's Green side (already embedded).
Manholes cable duct works	2x outbound, 2x inbound.
Structural works (walls, gabions, etc.)	Remove soil bank, new boundary wall (inbound-Sandyford).
Off platform drainage works	No
Hardscape/softscape works	Bicycle racks, tree.
Power and system works (OCS?)	AVLS relocation, move stop cubicle, additional lighting.
Other works	No other major works

Impacts	
Impact on private property?	No
Other impacts?	No other major impacts
Pedestrian access during works	
As existing with staged construction, or divert via Sandyford entrance during St. Stephen's Green side works.	



*Milltown Stop photos*

## Windy Arbour Stop

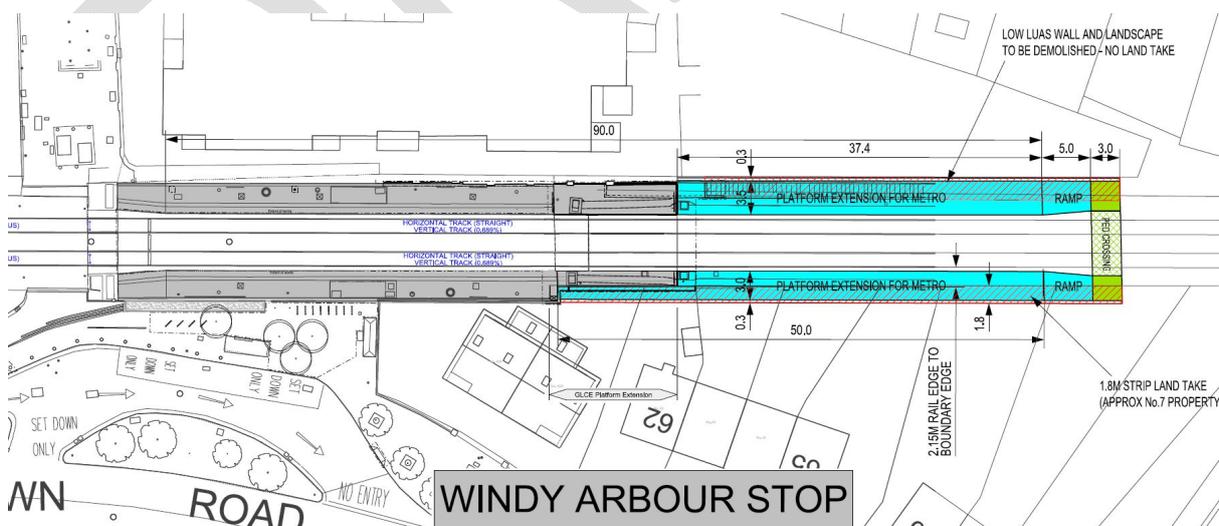


*Windy Arbour aerial view*

Windy Arbour Stop is proposed to be extended towards Sandyford in order to maintain the pedestrian route across the northern end of the current stop.

Extending towards St. Stephen's Green would make the pedestrian route convoluted, adding an approx. 80m long detour, and would unnecessarily overload the platforms with pedestrian passing traffic and increase risk due to pedestrians directly crossing stepping down and up the two platforms.

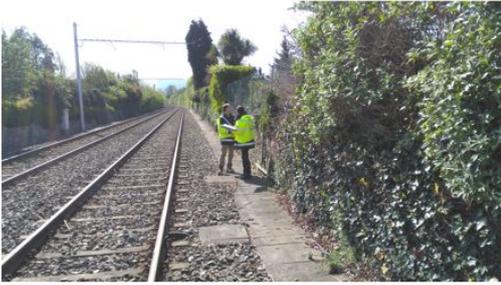
As there is landtake necessary on both extension sides (Sandyford and St. Stephen's Green) along the inbound track, pedestrian movements are the determining factor here.



*Windy Arbour proposed 90m extension*

<b>Windy Arbour Stop</b>	
<b>Existing</b>	
Current length	5m + 53m; lateral
Track alignment	Straight, +0.7% grade with vertical curve on St. Stephen's Green side
Track type	Ballast
Current obstructions	Properties boundary wall on inbound-Sandyford side
Current access	From St. Stephen's Green side only, PC on St. Stephen's Green side only (following GLCE)
<b>Proposal</b>	<b>Confined construction</b>
Where to extend	Extend on Sandyford side by 37.4m (platforms), plus 5m ramps plus 3m PC.
Pedestrian access	As is, not impacted.
Constraints	No. 7 properties (back gardens) on inbound-Sandyford side, 3 manholes, P&S cabinet, OCS poles.
<b>Proposed works</b>	
Extended platform edge straight?	Yes
Platform works	Standard construction of platform slabs and ramps over existing ballast formation and subgrade. Cable ducts to be incorporated into the new platforms and locally re-routed. GLCE inbound platform extension (narrow) to be widened for a length of 12.5m approx.
Ramp works	Yes, on Sandyford side
Track works (track surface)	Ballast track to be retrofitted with embedded pre-cast panels or fully replaced with embedded track Sandyford side (45.4m).
Manholes cable duct works	3 manholes, P&S cabinet, poles
Structural works (walls, gabions, etc.)	New boundary wall (inbound-Sandyford)
Off platform drainage works	None
Hardscape/softscape works	Yes
Power and system works (OCS?)	Yes, AVLS relocation, 3 manholes, P&S cabinet, poles, additional lighting.
Other works	No other major works
<b>Impacts</b>	
Impact on private property?	No. 7 properties back gardens, inbound Sandyford side (58m by 1.8m strip approx.)

Other impacts?	No other major impacts
<b>Pedestrian access during works</b>	
Not impacted	



*Windy Arbour Stop photos*

## Dundrum Stop

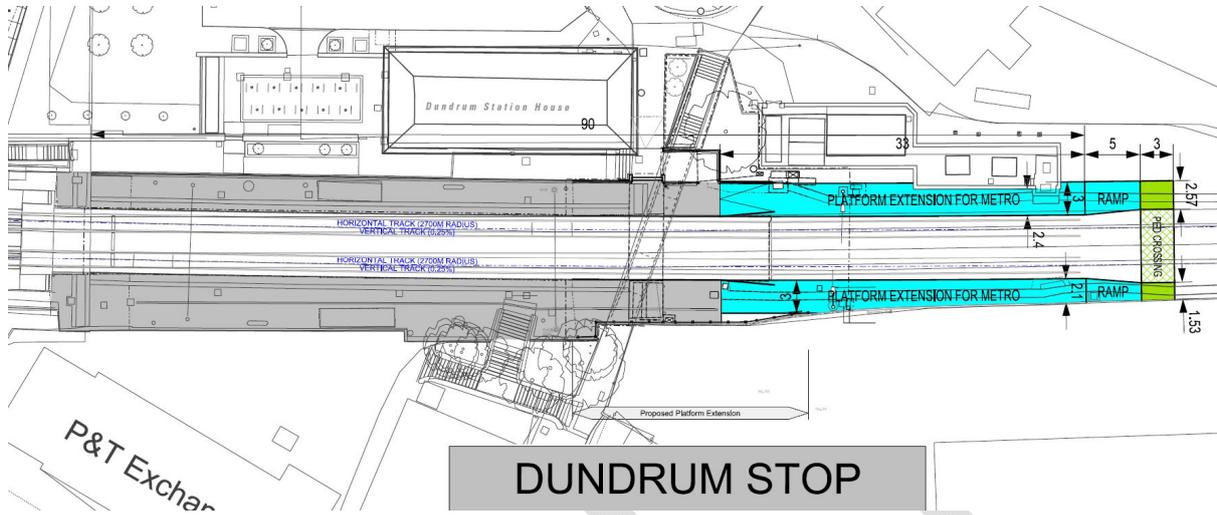


*Dundrum aerial view*

Dundrum Stop presents opportunities to be extended on both sides, St. Stephen's Green over the Taney Bridge, or Sandyford over the retained embankment. Current extension of GLCE is being built on the Sandyford side.

The preferred solution is to proceed with a full extension towards Sandyford, as extending the platforms towards St. Stephen's Green would present more challenges as follows:

- Significant civil works over the bridge, more difficult from a constructability point of view and more visually intrusive (as the current deck should be raised by approx. 650mm to reach platform level);
- Lifting the bridge balustrade by 650mm for the length of platform extension, with significant visual impact on the architectural line of the structure;
- Adding significant dead load on the bridge;
- Difficult track retrofitting as standard pre-cast track panels would not fit over the more complex direct fixation on plinths. Track modifications to upgrade into embedded system would entail significant disruption and cost; and
- Modification of the levels and pedestrian ramps for both accesses at St. Stephen's Green end to inbound and outbound platforms.

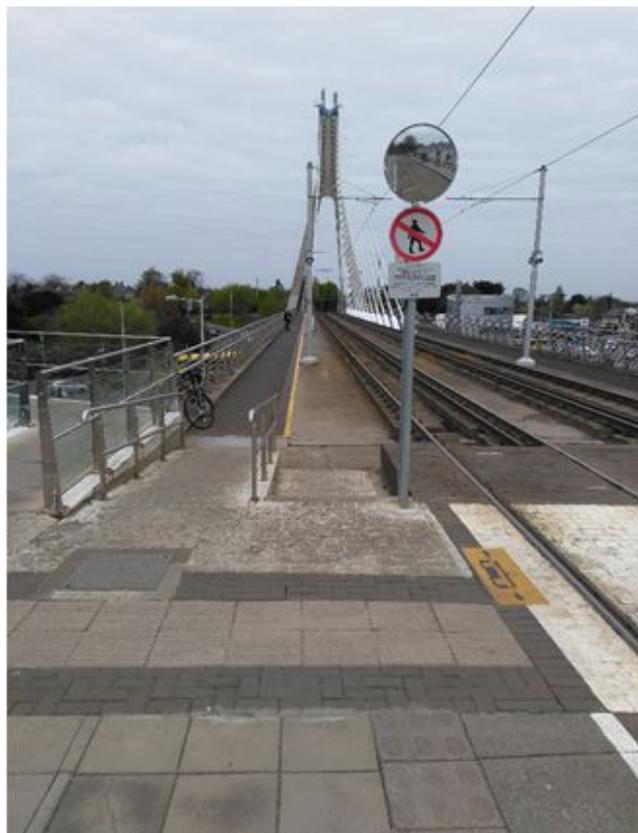


## DUNDRUM STOP

*Dundrum proposed 90m extension*

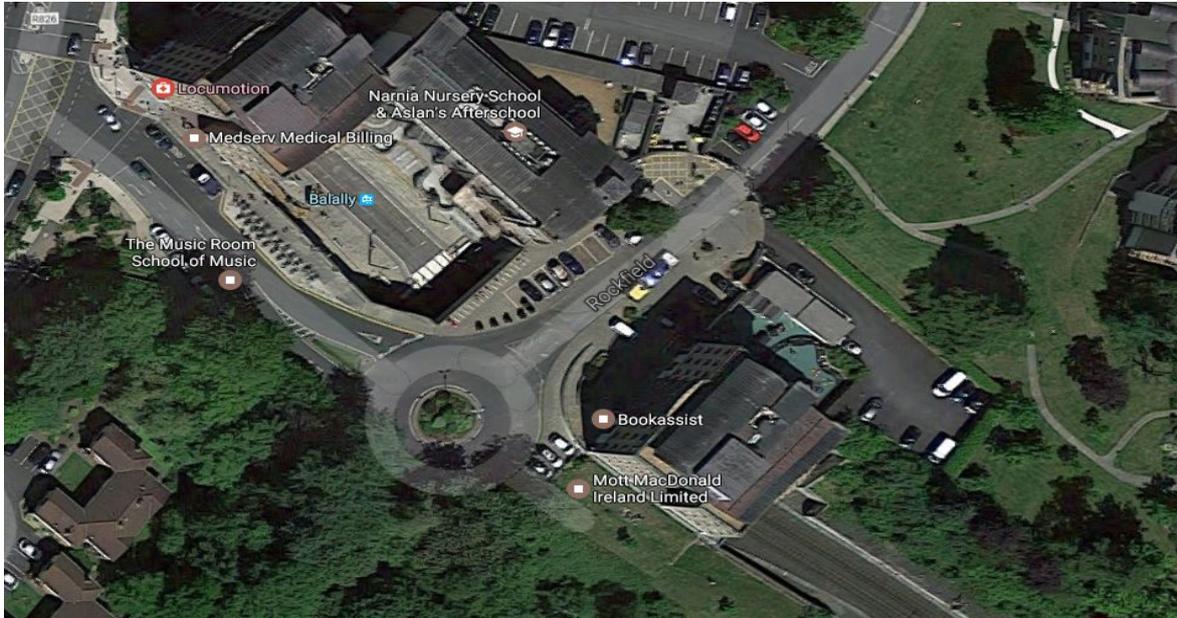
<b>Dundrum Stop</b>	
<b>Existing</b>	
Current length	3.7m + 57m + 5m; lateral
Track alignment	Straight, +0.25% grade; Horizontal curve R2700 (constant)
Track type	Ballast
Current obstructions	Taney bridge with raised plinth track and derailment containment on St. Stephen's Green side, ESS low wall and reduced width of retained embankment inbound side on Sandyford side
Current access	Lift and stairs from St. Stephen's Green end, stairs and accesses at grade from Sandyford end; PC on both sides
<b>Proposal</b>	<b>Medium difficulty to extend</b>
Where to extend	Extend on Sandyford side by 33m, plus 5m ramps & 3m PC.
Pedestrian access	As is, both ends untouched.
Constraints	Trackside cabinet, substation low wall outbound, ducting, tight property line inbound (restricting width of the inbound platform extension to min 2.1m).
<b>Proposed works</b>	
Extended loading edge straight?	No, R2700

Platform works	Standard construction of platform slabs and ramps over existing ballast formation and subgrade. Cable ducts to be incorporated into the new platforms and locally re-routed.  New inbound platform extension 2.1m wide towards the end, new outbound platform extension 2.4m wide at pinchpoint around ESS low wall.
Ramp works	Yes, on Sandyford side
Track works (track surface)	Ballast track to be retrofitted with embedded pre-cast panels or fully replaced with embedded track Sandyford side (41m).
Manholes cable duct works	Ducts in concrete trough set in ballast, trackside cabinet
Structural works (walls, gabions, etc.)	Strengthen and raise existing boundary wall (inbound-Sandyford)
Drainage works (other than platform)	None
Hardscape/softscape works	Yes
Power and system works (OCS?)	AVLS relocation; ducts in concrete trough set in ballast, trackside cabinet, substation, additional lighting.
Other works	
<b>Impacts</b>	
Impact on private property?	No
Other impacts?	No
<b>Pedestrian access during works</b>	
Not impacted	



*Dundrum Stop photos (upper 3 photos looking Sandyford, lower photo looking St. Stephen's Green)*

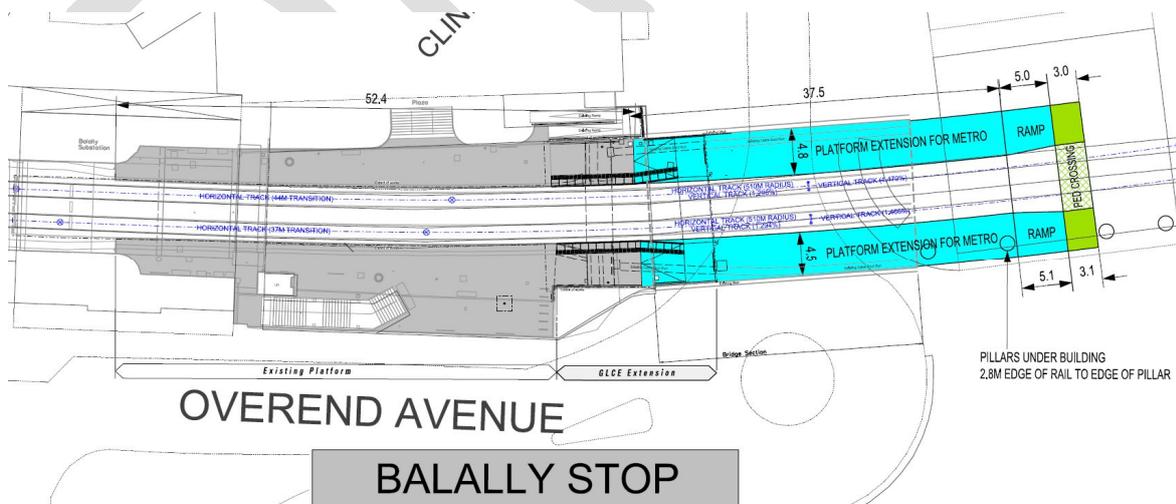
## Balally Stop



Balally aerial view

Balally Stop is proposed to be extended towards Sandyford as there is insufficient width within the underpass towards St. Stephen's Green (refer to photos on the right, looking towards St. Stephen's Green).

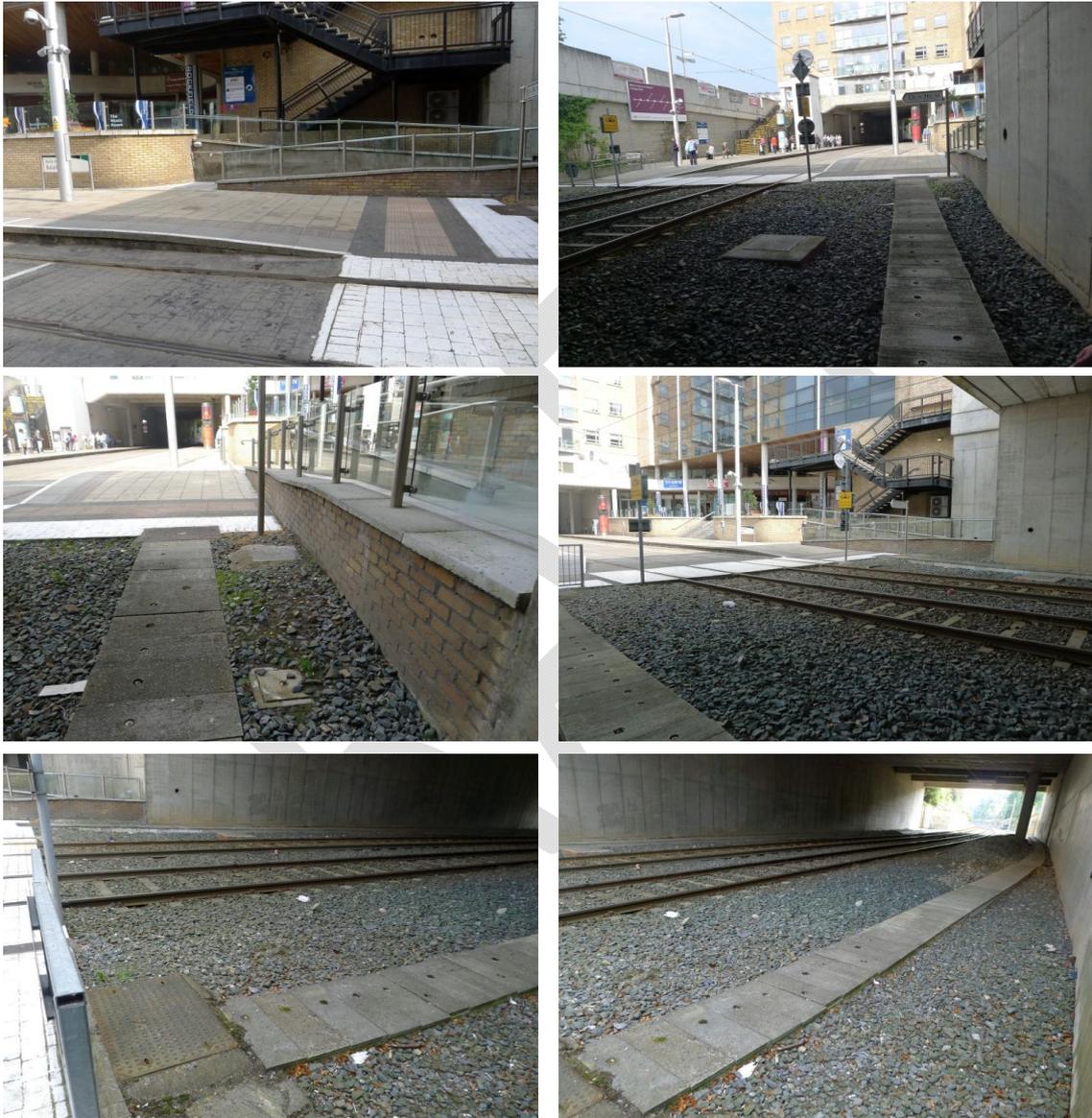
This extension will almost entirely fall within the existing underpass box beneath the office building.



Balally proposed 90m extension

<b>Balally Stop</b>	
<b>Existing</b>	
Current length	53m + 5m; lateral
Track alignment	Straight, +1.3% to 1.5% grade; Horizontal curve R510
Track type	Ballast
Current obstructions	Building by others over the trackwork restricting width on St. Stephen's Green side, columns on the Sandyford side
Current access	Lift, stairs to the centre of inbound platform, stairs only to the centre and Sandyford side of outbound platform; PC on Sandyford side only
<b>Proposal</b>	<b>Medium difficulty to extend - accessibility</b>
Where to extend	Extend on Sandyford side by 37m, plus 5m ramps & 3m PC.
Pedestrian access	As is, both sides untouched.
Constraints	Ducts in concrete trough, structural columns inbound side.
<b>Proposed works</b>	
Extended platform edge straight?	No, horizontal curve with R510
Platform works	Standard construction of platform slabs and ramps over existing ballast formation and subgrade. Cable ducts to be incorporated into the new platforms and locally re-routed.
Ramp works	Yes, on Sandyford side. Not possible to provide ramps and PC on St. Stephen's Green side.
Track works (track surface)	Ballast track to be retrofitted with embedded pre-cast panels or fully replaced with embedded track Sandyford side (41m).
Manholes cable duct works	Ducts in concrete trough set in ballast.
Structural works (walls, gabions, etc.)	None
Off Platform Drainage works	None
Hardscape/softscape works	Yes
Power and system works (OCS?)	AVLS relocation, additional lighting under the tunnel.
<b>Impacts</b>	
Impact on private property?	No
Other impacts?	No
<b>Pedestrian access during works</b>	

Impacted. Construction in stages due to wheelchair users not having access to outbound platform from above.



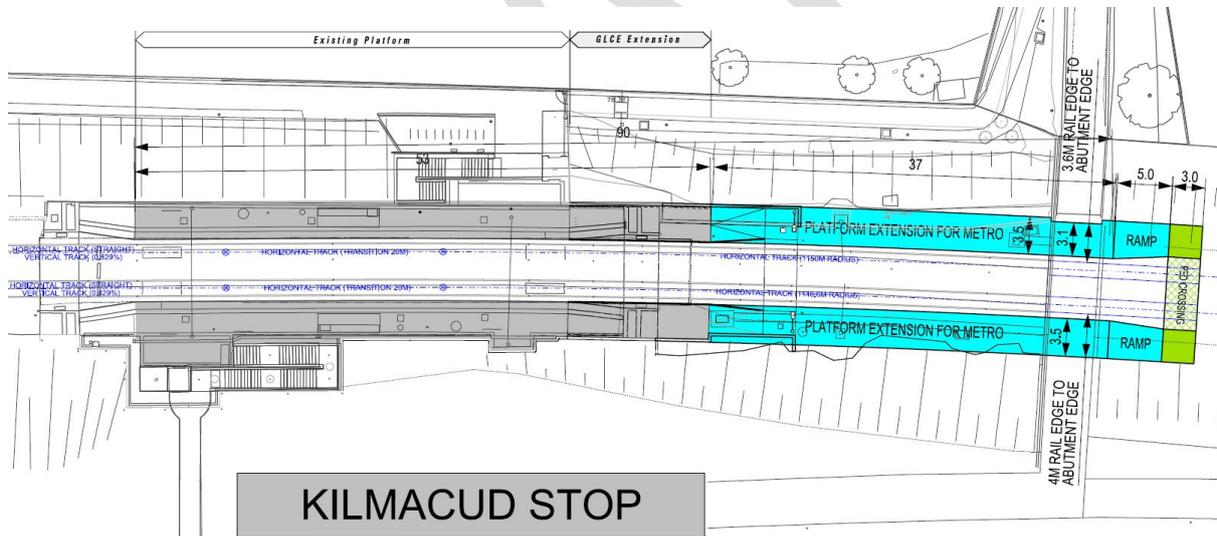
*Balally Stop Photos*

## Kilmacud Stop



*Kilmacud aerial view*

Kilmacud Stop has the potential to be extended on both sides but it is proposed to fully extend it towards Sandyford as this side shows less constraints. This is also in consideration of the fact that there is sufficient width under the Sandyford side pedestrian overbridge.



*Kilmacud proposed 90m extension*

<b>Kilmacud Stop</b>	
<b>Existing</b>	
Current length	5m + 53m + 5m; lateral
Track alignment	Horizontal curve R 1,150m (very large)
Track type	Ballast
Current obstructions	Limited obstructions on both sides: low retaining wall on Sandyford side outbound, gabions and cabinets/manholes on SSG side.
Current access	Separate lifts and stairs to the centre of both platform; PC on both sides
<b>Proposal</b>	<b>Medium difficulty to extend for accessibility</b>
Where to extend	Extend on Sandyford side by 37m, plus 5m ramps & 3m PC.
Pedestrian access	As is, both sides untouched.
Constraints	Ducts in concrete trough both sides, 1.8m high retaining wall outbound, overbridge abutments (at an offset of 3.6m and 4.0m from nearest rail, leaving a platform width of in excess of 3.0m), OCS tensioning poles (one on each side)
<b>Proposed works</b>	
Extended platform edge straight?	No, R 1,150m
Platform works	Standard construction of platform slabs and ramps over existing ballast formation and subgrade. Cable ducts to be incorporated into the new platforms and locally re-routed.
Ramp works	Yes, on Sandyford side.
Track works (track surface)	Ballast track to be retrofitted with embedded pre-cast panels or fully replaced with embedded track Sandyford side (37m).
Manholes cable duct works	Ducts in concrete trough set in ballast and 1 manhole per side
Structural works (walls, gabions, etc.)	Low wall to be demolished and re-built set-back.
Off platform drainage works	None
Hardscape/softscape works	Both on both sides following extension works, some rock head trimming back on inbound platform side and protection net to be re-fixed.
Power and system works (OCS?)	AVLS relocation, additional lighting columns.
Other works	
<b>Impacts</b>	
Impact on private property?	No
Other impacts?	No

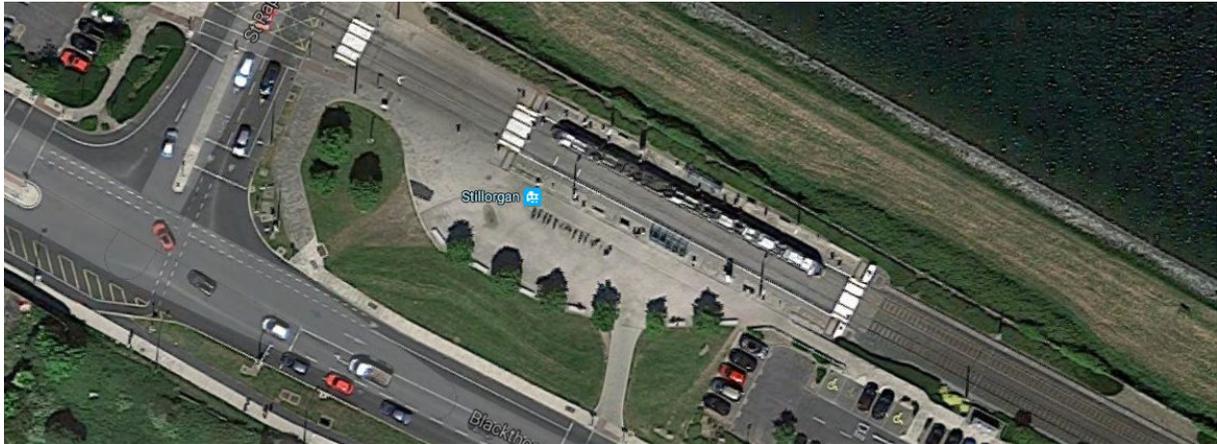
**Pedestrian access during works**

Not impacted.



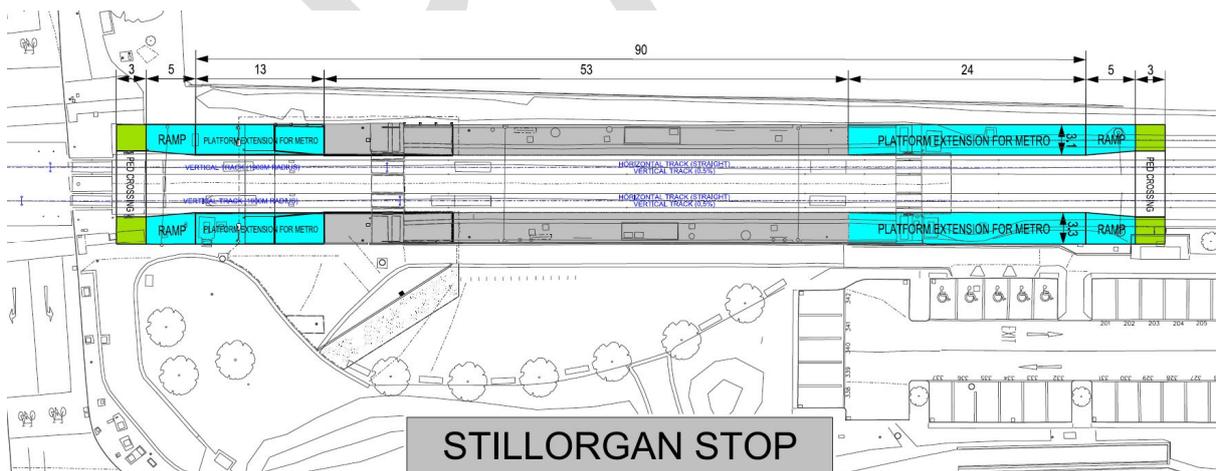
*Kilmacud Stop photos*

## Stillorgan Stop (non-segregated)



*Stillorgan aerial view*

Stillorgan Stop has the potential to be extended on both sides and it is proposed to do so to make the best use of public space and of the remaining section of embedded track between the current stop and the road junction. This is also in consideration of the fact that combining the two PCs (road junction and stop) is safer and operationally more efficient. Works on the two sides will be carried out in two phases not to block both stop accesses and ramps.



*Stillorgan proposed 90m extension*

<b>Stillorgan Stop</b>	
<b>Existing</b>	
Current length	5m + 53m + 5m
Track alignment	Straight
Track type	St. Stephen's Green Embedded – Sandyford Ballast
Current constraints	None
Current access	Free access to both platforms - PC on both sides
<b>Proposal</b>	<b>Easy</b>
Where to extend	St. Stephen's Green side 13m + 5m ramp, Sandyford side 24m + 5m ramp + 3m PC
Pedestrian access	As per existing
<b>Proposed works</b>	
Extended platform edge straight?	Yes
Platform works	Standard construction of platform slabs and ramps over existing ballast formation and subgrade on Sandyford side. Cable ducts to be incorporated into the new platforms and locally re-routed.  Standard construction of platform slabs and ramps over existing paved areas.
Ramp works	Demolish and rebuild no. 2 5m long ramps with 3m wide pedestrian crossings
Track works (track surface)	Sandyford side only, 24m of track retrofitting panels over ballast track or new embedded track.
Manholes cable duct works	No. 4 manholes on St. Stephen's Green side to be lifted and incorporated into the platform and ballast cable duct plus no. 3 manholes on Sandyford side.
Structural works (walls, gabions, etc.)	No
Drainage works (other than platform)	No
Hardscape/softscape works	Yes, hardscape on St. Stephen's Green side and Softscape on Sandyford side.
Power and system works (OCS?)	AVLS relocation. Stop cubicle on inbound Sandyford side can be kept and platform built around its basement (local pinchpoint).
Other works	No
<b>Pedestrian access during works</b>	

One side at a time, works phased.



*Stillorgan Stop photos*

## Sandyford Stop



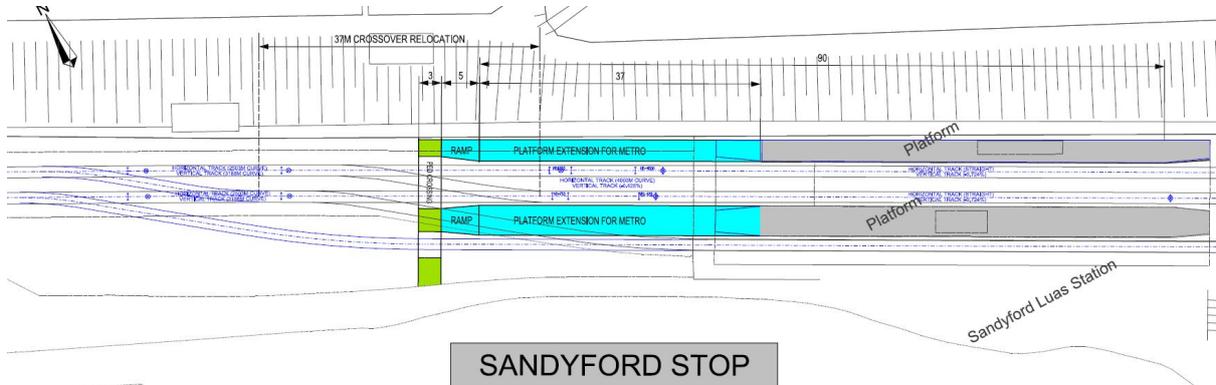
*Sandyford aerial view*

Sandyford Stop can only be extended towards St. Stephen's Green as there are complex trackworks and geometries on the Sandyford side to allow for the links to Line B1 and the entrance to the depot.

The stop is currently designed to cater for a mixed service of passing trams (Bride's Glen-St. Stephen's Green) and turning-back trams (St. Stephen's Green-Sandyford), plus the necessary connections in and out of the adjacent depot. For this reason, the stop has three tracks with three side platforms (one lateral and one island) and a series of crossovers plus a simple junction.

This functional configuration is deemed necessary and sufficient for the future NMN line upgrade, even with the increased frequencies.

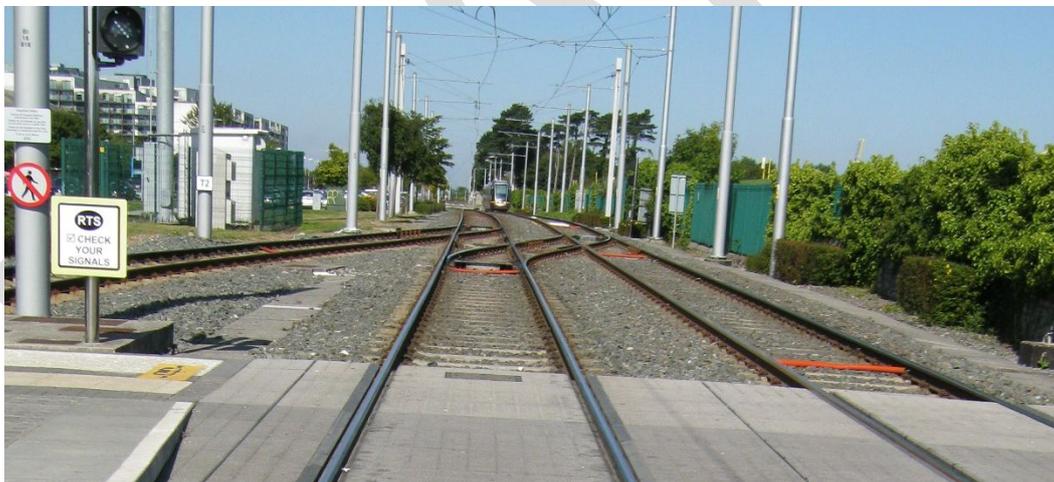
The design proposal is therefore to maintain the current functional lay-out, while extending the two platforms to 90m, and shifting all the necessary trackworks towards St. Stephen's Green (one crossover and the third track connection – one turnout).



*Sandyford proposed 90m extension*

<b>Sandyford Stop</b>	
<b>Existing</b>	
Current length	5m + 53m + 5m
Track alignment	Straight
Current constraints	Trackworks on both sides, with Sandyford side trackworks not modifiable (Line B1 link and entrance to depot)
Current access	Free access to both platforms - PC on both sides
<b>Proposal</b>	<b>Easy</b>
Where to extend	St. Stephen's Green side 37m + 5m ramp + 3m PC
Pedestrian access	As per existing
<b>Proposed works</b>	
Extended loading edge straight?	Yes (R4,000 not visible)
Platform works	Standard construction of platform slabs and ramps over existing ballast formation and subgrade on St. Stephen's Green side. Cable ducts to be incorporated into the new platforms and locally re-routed.
Ramp works	Demolish and rebuild 5m long ramps with 3m wide pedestrian crossings.
Track works (track surface)	37m of new embedded track.

Manholes cable duct works	Ducts in concrete trough set in ballast and 1 manhole per side.
Structural works (walls, gabions, etc.)	No
Drainage works (other than platform)	No
Hardscape/softscape works	Yes, hardscape on St. Stephen's Green side and softscape on Sandyford side.
Power and system works (OCS?)	AVLS relocation. Stop cubicle on inbound Sandyford side can be kept and platform built around its basement (local pinchpoint).
Other works	Trackworks. Extending third track by 37m and shifting existing ballast turnout. Shifting existing ballast crossover. All systems to be shifted and updated accordingly. Modify vertical track alignment to shift vertical curve away from new crossover location, this is likely to have an impact over up to 300m long ballast track section to be lifted and slewed (no new track, just existing ballast track alignment modification).
<b>Pedestrian access during works</b>	
As existing, in phases.	





*Sandyford Stop photos*

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## 8.2 APPENDIX 2: LINE B STUDY AREA SCENARIO 2 PLATFORM DRAWINGS

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### 8.3 APPENDIX 3: LINE B STUDY AREA SCENARIO 3 PLATFORM DRAWINGS

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