DART+ South West

Technical Optioneering Report

East of St John's Road Bridge to Glasnevin Junction

Area from East of St John's Road Bridge to East of Phoenix Park Tunnel

Iarnród Éireann

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Glossary of Terms

Reference	Description
ABP	An Bord Pleanála
ACA	Architectural Conservation Area
APIS	Authorisation for Placing in Service
ASA	Application for Safety Approval
AsBo	Assessment Body
ASPSC	Application Specific Project Safety Case
ATP	Automatic Train Protection
CAF	Common Appraisal Framework
Cantilever	OHLE structure comprising horizontal or near horizontal members supporting the catenary projecting from a single mast on one side of the track.
Catenary	The longitudinal wire that supports the contact wire.
CAWS	Continuous Automatic Warning System
CBI	Computer-Based Interlocking
CCE	Chief Civils Engineers Department of IE
CCRP	City Centre Re-signalling Project
CCTV	Closed Circuit Television
CDP	County Development Plan
CIE	Córas Iompair Éireann
Contact wire	Carriers the electricity which is supplied to the train by its pantograph.
CPO	Compulsory Purchase Order
Cross overs	A set of railway parts at the crossing of several tracks which helps trains change tracks to other directions.
CRR	Commission for Rail Regulation (formerly RSC – Railway Safety Commission)
CSM RA	Common Safety Method for Risk Evaluation and Assessment
CTC	Central Traffic Control
Cutting	A railway in cutting means the rail level is below the surrounding ground level.
D&B	Design & Build (contractor)

Reference	Description
DART	Dublin Area Rapid Transit (IÉ's Electrified Network)
DART+	DART Expansion Programme
DeBo	Designated Body
Direct Current (DC)	Electrical current that flows in one direction, like that from a battery.
DCC	Dublin City Council
DRR	Design Review Report
DSR	Design Statement Report
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
EIS	Environmental Impact Statement
Electrification	Electrification is the term used in supplying electric power to the train fleet without the use of an on-board prime mover or local fuel supply.
EMC	Electromagnetic Compatibility
EMU	Electric Multiple Unit (DART train)
EN	European Engineering Standard
EPA	Environmental Protection Agency
EPO	Emerging Preferred Option
ERTMS	European Rail Traffic Management System
ESB	Electricity Supply Board
Four-tracking	Four-tracking is a railway line consisting of four parallel tracks with two tracks used in each direction. Four track railways can handle large amounts of traffic and are often used on busy routes.
FRS	Functional Requirements Specification
FSP	Final Supply Points
GDA	Greater Dublin Area
GI	Ground Investigation
HAZID	Hazard Identification
Horizontal Clearance	The horizontal distance between a bridge support and the nearest railway track is referred to as horizontal clearance. Bridge supports include abutments (at the ends of the bridge) and piers (at intermediate locations).

Reference	Description
HV	High Voltage
IA	Independent Assessor
IÉ	Iarnród Éireann
IM	Infrastructure Manager (IÉ)
IMSAP	Infrastructure Manager Safety Approval Panel
Insulators	Components that separate electricity live parts of the OHLE from other structural elements and the earth. Traditionally ceramic, today they are often synthetic materials.
KCC	Kildare County Council
Lateral Clearance	Clearances between trains and structures.
LCA	Landscape Character Area
Mast	Trackside column, normally steel that supports the OHLE.
MCA	Multi-criteria Analysis
MDC	Multi-disciplinary Consultant
MEP	Mechanical electrical and plumbing
MFD	Major Feeding Diagram
MMDC	Maynooth Multi-disciplinary Consultant
MV	Medium Voltage
NDC	National Biodiversity Data Centre
NIAH	National Inventory of Architectural Heritage
NoBo	Notified Body
NTA	National Transport Authority
OHLE	Overhead Line Equipment
Overbridge (OB)	A bridge that allows traffic to pass over a road, river, railway etc.
P&C	Points and Crossings
Pantograph	The device on top of the train that collects electric current from the contact wire to power the train.
PC	Public Consultation
Permanent Way	A term used to describe the track or railway corridor and includes all ancillary installations such as rails, sleepers, ballast as well as lineside retaining walls, fencing and signage.

Reference	Description
POAP	Plan-On-A-Page, high-level emerging programme
PPT	Phoenix Park Tunnel
PRS	Project Requirement Specification
PSCS	Project Supervisor Construction Stage
PSDP	Project Supervisor Design Process
PSP	Primary Supply Points
QA/QC	Quality Assurance/Quality Control
RAM	Reliability, Availability, Maintainability
RC	Reinforced Concrete
Re-signalling	Re-signalling of train lines will regulate the sage movement of trains and increase the capacity of train services along the route.
RMP	Record of Monuments and Places
RO	Railway Order
RPS	Record of Protected Structures
RSC-G	Railway Safety Commission Guideline
RU	Railway Undertaking (IÉ)
SAM	Safety Assurance Manager
SAP	Safety Approval Panel
SDCC	South Dublin County Council
SDZ	Strategic Development Zone
SET	Signalling, Electrical and Telecommunications
Sidings	A siding is a short stretch of railway track used to store rolling stock or enable trains on the same line to pass
SMR	Sites and Monuments Records
SMS	IÉ Safety Management System
TII	Transport Infrastructure Ireland
TMS	Train Management System
TPH	Trains per Hour

Reference	Description
TPHPD	Trains per Hour per Direction
TPS	Train Protection System
Track Alignment	Refers to the direction and position given to the centre line of the railway track on the ground in the horizontal and vertical planes. Horizontal alignment means the direction of the railway track in the plan including the straight path and the curves it follows.
TSI	Technical Specifications for Interoperability
TSS	Train Service Specification
TTAJV	TYPSA, TUC RAIL and ATKINS Design Joint Venture (also referred to as TTA)
Underbridge (UB)	A bridge that allows traffic to pass under a road, river, railway etc. The underneath of a bridge.
VDC	Direct Current Voltage
Vertical Clearance	For overbridges, an adequate vertical distance between railway tracks and the underside of the bridge deck (soffit) must be provided in order to safely accommodate the rail vehicles and the OHLE. This distance is known as vertical clearance and it is measured from the highest rail level.
WFD	Water Framework Directive

1 Introduction

1.1 Purpose of the Report

The purpose of this report is to provide technical input to the Preliminary Option Selection Report. This report shows the options considered as part of the project development and why the emerging preferred option was chosen.

This report provides the technical assessment of the area between Heuston West to the east of the Phoenix Park Tunnel. This report presents the approach to option development, options assessment, and options selection. This optioneering process incorporates assessment by the following Design Workstreams and specialist Project Teams:

- Permanent Way
- Civils and Structures
- Signalling, Electrification and Telecommunications (SET) and Low Voltage Power
- Overhead Line Equipment (OHLE)
- Environment
- Highways
- Geotechnical

The report provides:

- An area overview and a detailed description of the existing railway infrastructure and challenges.
- The Project Requirements for this area.
- The technical and environmental constraints, including the horizontal and vertical clearances at structures.
- The options considered for this area.
- The option selection process, leading to the identification of the Emerging Preferred Option, including the Sifting process and the Multi-Criteria Analysis process (no MCA undertaken for this Area).

1.2 DART+ Programme Overview

The DART+ Programme is a transformative railway investment programme that will modernise and improve the existing rail services in the Greater Dublin Area. It will provide a sustainable, electrified, reliable and more frequent rail service, improving capacity on rail corridors serving Dublin.

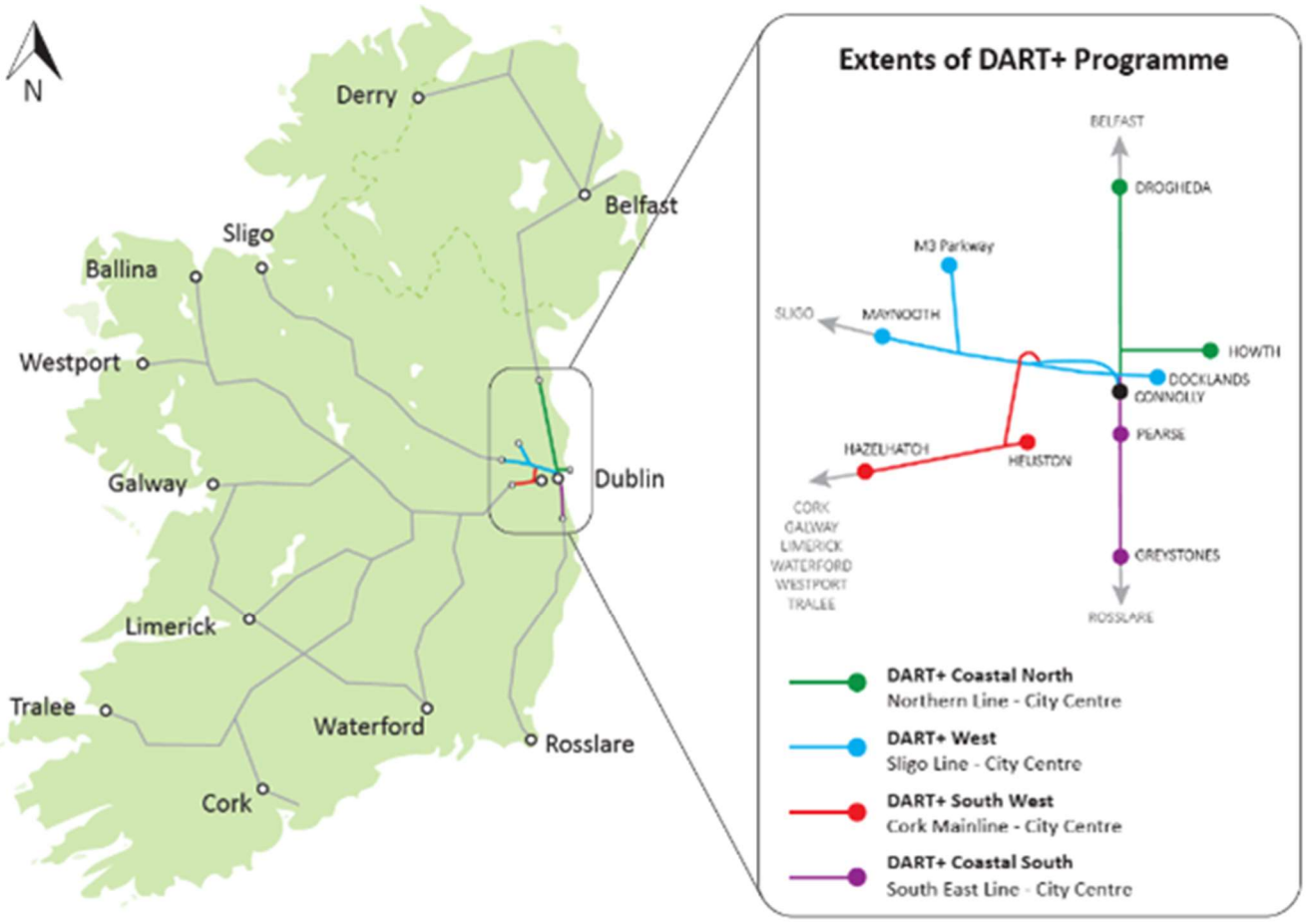


Figure 1-1 DART+ Programme

The current electrified DART network is 50km long, extending from Malahide / Howth to Bray / Greystones. The DART+ Programme seeks to increase the network to 150km. The DART+ Programme is required to facilitate increased train capacity to meet current and future demands which will be achieved through a modernisation of the existing railway corridors. This modernisation includes the electrification, re-signalling and certain interventions to remove constraints across the four main rail corridors within the Greater Dublin Area, as per below:

- DART+ South West (this Project) – circa 16km between Hazelhatch & Celbridge Station to Heuston Station and also circa 4km between Heuston Station to Glasnevin, via the Phoenix Park Tunnel Branch Line.
- DART+ West – circa 40km from Maynooth & M3 Parkway Stations to the City Centre.
- DART+ Coastal North – circa 50km from Drogheda to the City Centre.
- DART+ Coastal South – circa 30km from Greystones to the City Centre.
- DART+ Fleet – purchase of new electrified fleet to serve new and existing routes.

The DART+ Programme is a key element to the national public transportation network as it will provide a high-capacity transit system for the Greater Dublin Area and better connectivity to outer regional cities and towns. This will benefit all public transport users.

The Programme also has been prioritised as part of Project Ireland 2040 and the National Development Plan 2018-2027 as it is integral to the provision of an integrated, high-quality public transport system.

Delivery of the Programme will also promote transport migration away from the private car and to public transport. This transition will be achieved through a more frequent and accessible electrified service, which will result in reduced road congestion, especially during peak commuter periods.

Ultimately DART+ Programme will provide enhanced, greener public transport to communities along the DART+ Programme routes, delivering economic and societal benefits for current and future generations.

1.3 DART+ South West Project

The DART+ South West Project will deliver an improved electrified network, with increased passenger capacity and enhanced train service between Hazelhatch & Celbridge Station to Heuston Station (circa 16km) on the Cork Mainline, and Heuston Station to Glasnevin via Phoenix Park Tunnel Branch Line (circa 4km).

DART+ South West will complete four tracking between Park West & Cherry Orchard Station and Heuston Station and will also re-signal and electrify the route. The completion of the four tracking will remove a significant existing constraint on the line (i.e., where four tracks reduce to two), which is currently limiting the number of train services that can operate on this route. DART+ South West will also deliver track improvements along the Phoenix Park Tunnel Branch Line, which will allow a greater number of trains to access the city centre.

Upon completion of DART+ South West electrification, new DART trains will be used on this railway corridor, similar to those currently operating on the Malahide / Howth to Bray / Greystones Line.

Figure 1-2 DART+ South West Route Map

1.4 Capacity Increases Associated with DART+ South West

DART+ South West will improve performance and increase train and passenger capacity on the route between Hazelhatch & Celbridge Station to Heuston Station and through the Phoenix Park Tunnel Branch Line to the City Centre, covering a distance of circa 20km. It will significantly increase train capacity from the current 12 trains per hour per direction to 23 trains per hour per direction (i.e. maintain the existing 12 services, with an additional 11 train services provided by DART+ South West). This will increase passenger capacity from the current peak capacity of approximately 5,000 passengers per hour per direction to approximately 20,000 passengers per hour per direction. Upon completion of the DART+ South West Project, train services will be increased according to passenger demand.

1.5 Key Infrastructure Elements of DART+ South West

The key elements of DART+ South West are as follows:

- Completion of four-tracking from Park West & Cherry Orchard Station to Heuston Station, extending the works completed on the route in 2009.
- Electrification of the line from Hazelhatch & Celbridge Station to Heuston Station and also from Heuston Station to Glasnevin, via the Phoenix Park Tunnel Branch Line, where it will link with proposed DART+ West.
- Undertaking improvements / interventions of bridges to achieve vertical and horizontal clearances.
- Remove rail constraints along the Phoenix Park Tunnel Branch Line.
- Feasibility report and concept design for a new Heuston West Station.

The 'Emerging Preferred Option' will be compatible with the future stations at Kylemore and Cabra, although the construction of these stations is not part of the DART+ South West Project.

1.6 Route Description

The existing rail corridor extends from Heuston Station to Hazelhatch & Celbridge Station, the route also extends through the Phoenix Park Tunnel to Glasnevin. The area descriptions and extents are set out in Table 1-1 below.

Table 1-1 Route Breakdown

Area Name	Sub-area Description	Extents	Main Features
Hazelhatch to Park West	Area from Hazelhatch to Park West	West side of Hazelhatch & Celbridge Station to 50m to west of Cherry Orchard Footbridge (OBC8B).	Hazelhatch & Celbridge Station Adamstown Station Clondalkin/Fonthill Station Park West & Cherry Orchard Station Cherry Orchard Footbridge (OBC8B)
Park West to Heuston Station	Area around Le Fanu Bridge (OBC7)	West of Cherry Orchard Footbridge (OBC8B) to the East of the proposed Le Fanu Road Bridge (OBC7).	Le Fanu Road Bridge (OBC7)

Area Name	Sub-area Description	Extents	Main Features
	Area around Kylemore Bridge (OBC5A)	East of the proposed Le Fanu Road Bridge (OBC7) to the East of IE700B (i.e. the points for the Inchicore headshunt turnout).	Kylemore Road Bridge (OBC5A)
	Area around Inchicore Works	East of IE700B (i.e. the points for the Inchicore headshunt turnout to the west of Sarsfield Road Bridge (UBC4).	Inchicore Works Depot
	Khyber Pass Bridge (OBC5)	Vicinity of Khyber Pass Footbridge (OBC5)	Khyber Pass Footbridge (OBC5)
	Area around Sarsfield Road Bridge (UB4)	West of Sarsfield Road Bridge (UBC4) to the West of Memorial Road Bridge (OBC3)	Sarsfield Road Bridge (UBC4)
	Area around Memorial Bridge (OBC3)	Vicinity of Memorial Road Bridge (OBC3)	Memorial Road Bridge (OBC3)
	Area around South Circular Road Junction	East of Memorial Road Bridge (OBC3) to the West of IE720A (points)	South Circular Road Junction. South Circular Road Bridge (OBC1), St Johns Road Bridge (OBC0A)
	Area around Heuston Station and Yard	Area at Heuston Station Yard, including all platforms and sidings	Heuston Station Sidings around Heuston Station
St John's Bridge to Glasnevin Junction	Area from East of St Johns Road Bridge (OBC0A) to East of Phoenix Park Tunnel	East of St Johns Road Bridge (OBC0A) to East of Phoenix Park Tunnel	Potential Heuston West Station Liffey Bridge (UBO1) Conyngham Road Bridge (OBO2) Phoenix Park Tunnel
	Area from Phoenix Park Tunnel to Glasnevin Junction	East of Phoenix Park Tunnel to Glasnevin Junction	McKee Barracks Bridge (OBO3) Blackhorse Avenue Bridge (OBO4) Old Cabra Road Bridge (OBO5) Cabra Road Bridge (OBO6)

Area Name	Sub-area Description	Extents	Main Features
			Fassaugh Avenue Bridge (OBO7) Royal Canal and LUAS Twin Arch Bridge (OBO8) Maynooth Line Twin Arch Bridge (OBO9) Glasnevin Cemetery Road Bridge (OBO10)

2 Existing Situation

2.1 Overview

This part of the scheme is approximately 1.1 km long and extends from East of St John's Road Bridge (OBC0A) to the north portal of Phoenix Park Tunnel, encompassing Liffey Bridge (UBO1) and Conyngham Road Overbridge (OBO2). The permanent way here consists of 2 tracks running the length of the area (the Up Branch and Down Branch as well as a third track, the Down Loop, terminating at the end of Heuston Station - Platform 10). 3 no. crossovers and a turnout facilitate operational moves around Platform 10 and the bi-directional running capabilities of the Down Branch and Down Loop lines – the Down Loop terminating with a buffer stop just beyond Platform 10.

The main feature in this area is the Phoenix Park Tunnel, that has a length of approximately 700m and has two ballasted tracks through the tunnel with a central channel. A rectangular drain runs along the track axis (see Figure 2-1, Source: Phoenix Park Tunnel, drawing SDS-15-152-P03-022). A 300mm diameter pipe replaced part of the channel and is surrounded by free draining granular material. There is a lateral clearance issue in the tunnel with substandard separation between tracks and reduced clearances between trains and tunnel walls.

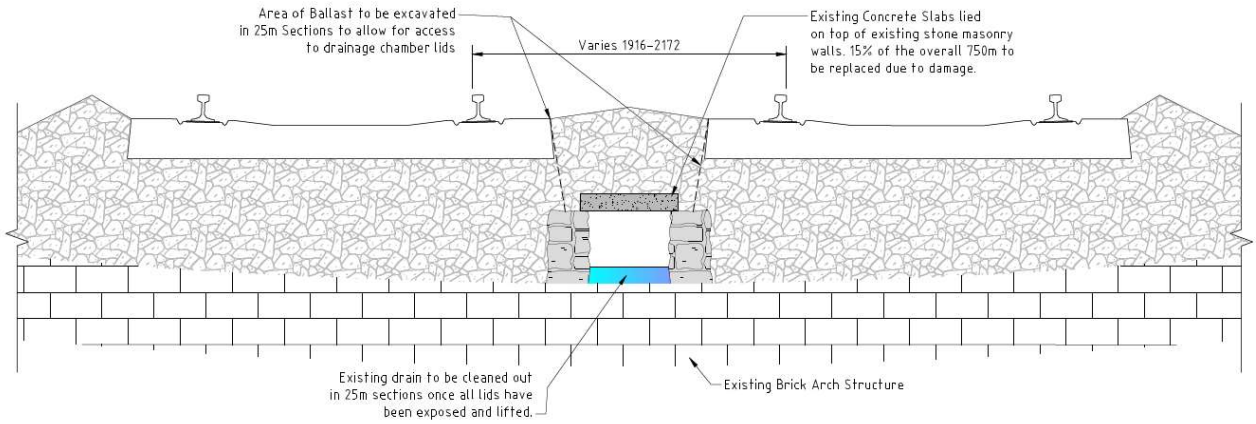


Figure 2-1 Typical section on Phoenix Park Tunnel showing existing drainage (note: central channel has since been infilled with a 300mm pipe and backfilled with granular material)

The permanent way in this area consists of 3 lines at grade until the branch lines cross the River Liffey over UBO1 where there are 2 tracks until the end of the area. The tracks pass beneath Conyngham Road OBO2 before entering the Phoenix Park Tunnel. An existing arch viaduct supports the tracks between the Liffey Bridge (UBO1) and the Conyngham Road bridge (OBO2).

There is a steel cantilever gantry HN331/HN332 located adjacent to 771A points at Heuston Station Platform 10.

This part of the scheme does not currently have any provision for electrification.

The major infrastructure features are shown in Figure 2-2 below.

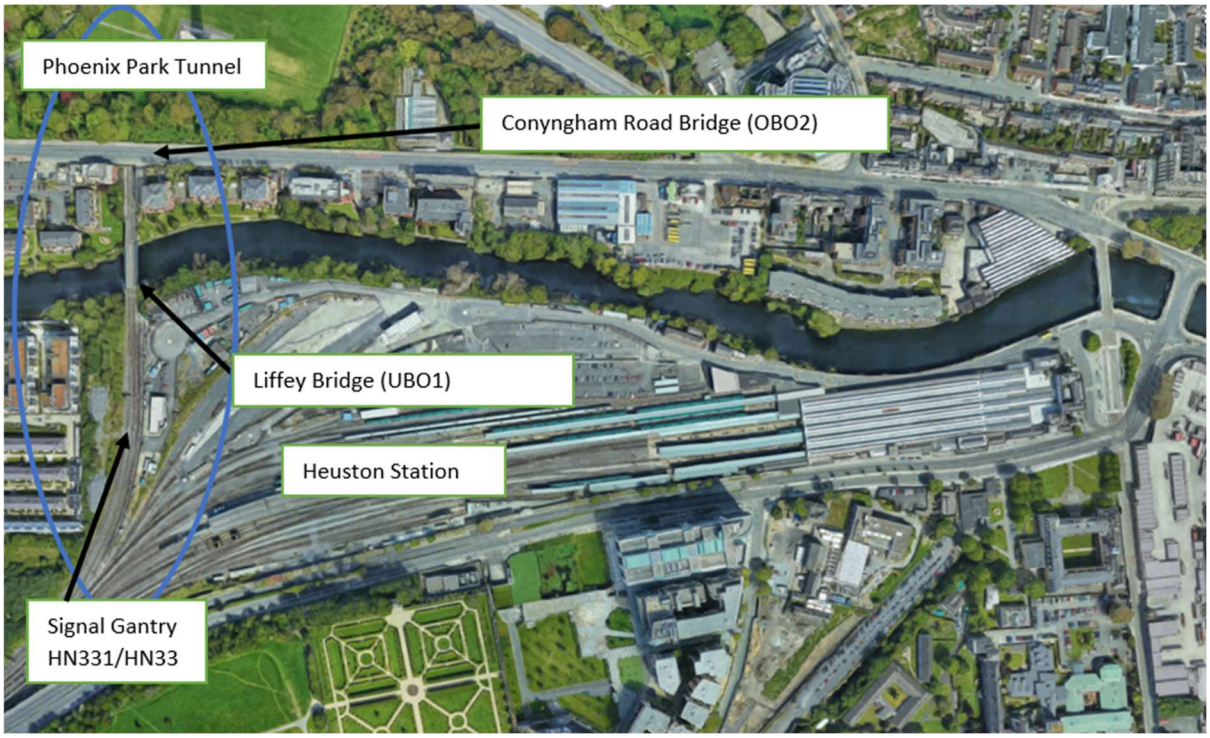


Figure 2-2 Aerial view of the approach to the Phoenix Park Tunnel

2.2 Challenges

The alignment of the tracks in this area is constrained by structures Liffey Bridge (UBO1), Conyngham Road Bridge (OBO2), the arch viaduct and the Phoenix Park Tunnel, all with limiting features in terms of width and/or height.

The most limiting feature is the Conyngham Road Bridge (OBO2) which has a limited clearance height and with limited scope for increasing the road level.

The existing fixed track system presently installed on Liffey Bridge (UBO1) is to be retained in order to avoid major bridge intervention.

The Phoenix Park Tunnel has limited lateral clearances, constraining the scope for track realignment.

2.3 Structures

2.3.1 Signal Gantry HN331/HN332

HN331/HN332 is a steel cantilever gantry located adjacent to 771A points at Heuston Station Platform 10. This gantry will need to be removed to facilitate the installation of the electrification system.

2.3.2 Liffey Bridge (UBO1)

The Liffey Bridge (UBO1) is a rail bridge spanning the River Liffey near Heuston Station. Constructed between 1872 and 1877, the bridge is of wrought iron. On either side of Liffey Bridge (UBO1), there are approach spans of three masonry, semi-circular arches built in stone. Historically used for freight traffic, the bridge has been reopened to regular passenger traffic since November 2016. There is no pedestrian or road traffic access to the bridge, while trains approach the bridge from the South at Heuston Station Platform 10 and from the North via the Phoenix Park Tunnel.

Figure 2-3 Liffey Bridge (UBO1) (Deck Level – Facing South)

2.3.3 Conyngham Road Bridge (OBO2)

Conyngham Road Bridge (OBO2) is a single span bridge which partially covers the entrance to the Phoenix Park Tunnel on the Heuston side. The road bridge has a width of 21m approx. and a clear span of 8.5m approx. The bridge superstructure consists of precast reinforced concrete beams of 760mm depth and 2280mm spacing, with precast reinforced concrete transverse slabs of 225mm thickness. The vertical clearance to the bridge soffit is 4.385m on the Down Line and 4.285m on the Up line based on the current alignment. An OHLE solution is not possible with the existing vertical clearance, and track and / or structure intervention is required.

Figure 2-4 Conyngham Road Bridge (OBO2) – Southern Elevation

2.3.4 Phoenix Park Tunnel

The Phoenix Park Tunnel was built in 1877 and begins at the Conyngham Road Bridge (OBO2) near Heuston Station, running underneath the Phoenix Park for approximately 700m before re-emerging close to the junction of the North Circular Road and Infirmary Road. The tunnel was originally built by the Great Southern and Western Railway company to connect Heuston Station to the Dublin Docklands, and was primarily used for freight. It reopened on 21 November 2016 for regular passenger traffic, previously used for freight only services.

Figure 2-5 Phoenix Park Tunnel, North Portal

2.4 Permanent Way and Tracks

The Permanent Way between Islandbridge Junction and the north portal of Phoenix Park Tunnel consists of 3 tracks from St Johns Road Bridge (OBC0A) to the Liffey Bridge (UBO1) and then 2 tracks running the length of the remaining area of the scheme. The third line terminates at Liffey Bridge (UBO1) with a buffer stop. 3 no. crossovers and a turnout facilitate operational moves around Platform 10 and the bi-directional running capabilities of the Down Branch and Down Loop lines. Maximum line speed on the Branch lines between Islandbridge Junction and Glasnevin Junction is 30mph, with 20mph in the Down Loop.

The P&C point numbers for the crossovers are 720A&B and 771A&B (Down Branch to Up Branch – either end of Heuston Platform 10), 772 A&B (Down Branch to Down Loop) to the north of Platform 10 and 725 Points (Up Main to Down Loop connection, south of Platform 10). A schematic layout of the tracks is shown below.

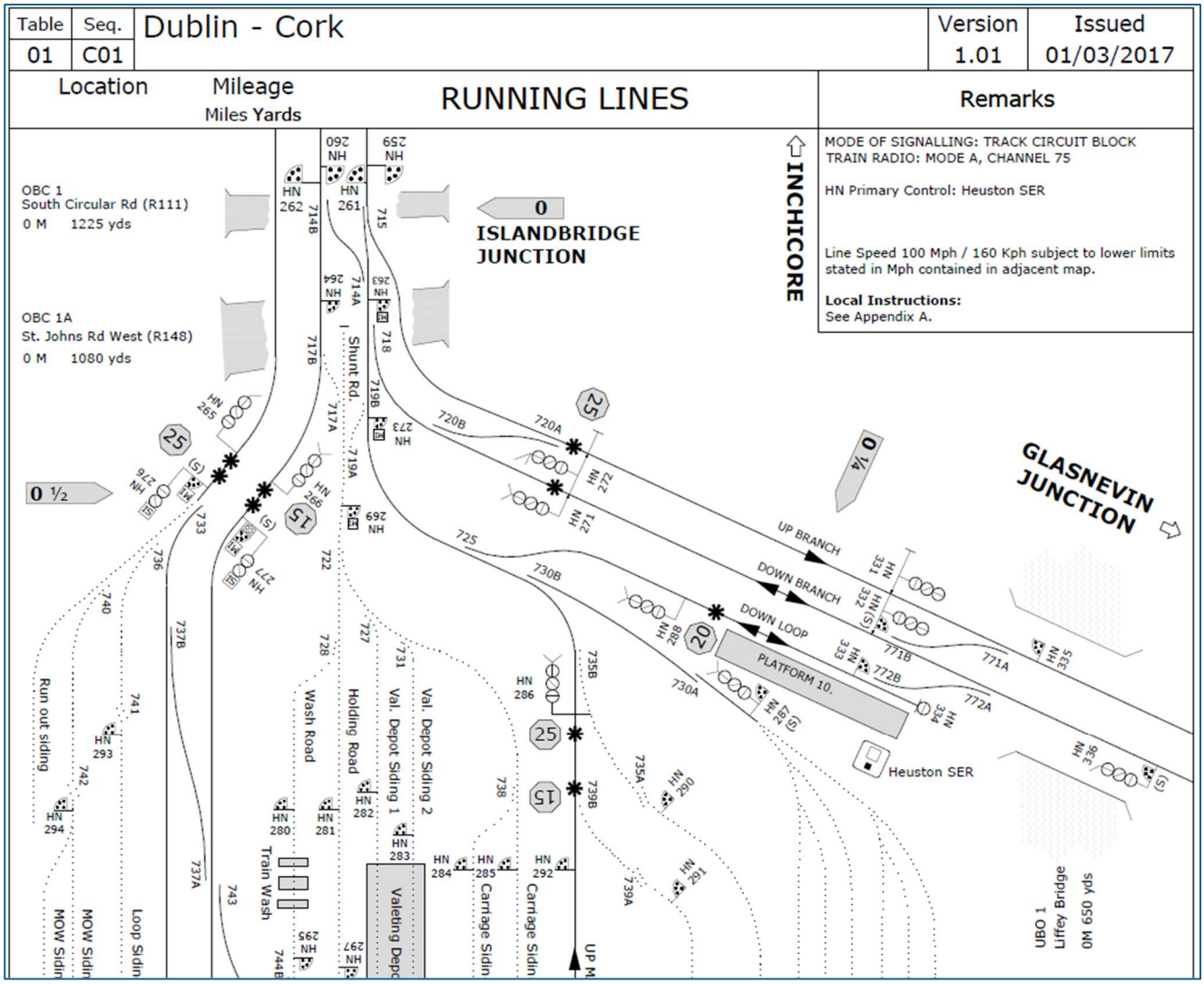


Figure 2-6 Existing Track Layout in this area up to UBO1 (from Route Information Book)

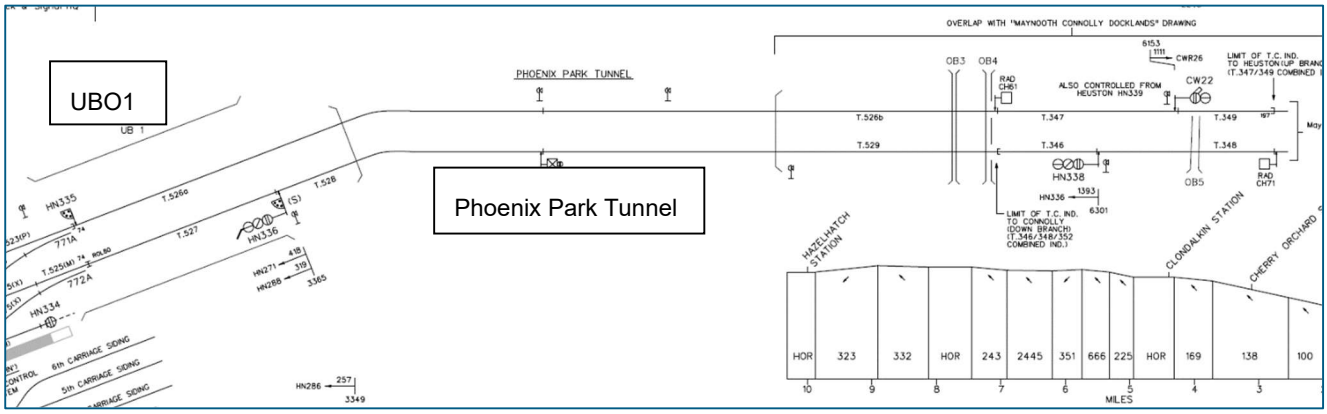


Figure 2-7 Existing Track Layout in this area UBO1 to PPT (from Scheme Plan S.221/121)

From south to north, where the branch lines depart from the main lines at Islandbridge Junction, the horizontal track alignment is a tight left-hand horizontal curve, sub-350m radius. The alignment then straightens out prior to the Liffey River Underbridge on the approach to Phoenix Park Tunnel. On entering the tunnel, the track

proceeds on a sharp right-hand curve, where the minimum radii are circa 285m Up Branch and 233m Down Branch.

From Islandbridge Junction travelling north, the gradient falls steeply at 1 in 83 to a low point at Conyngham Road, before rising at 1 in 376 on the approach to Phoenix Park Tunnel.

The Up Branch and Branch Slow lines on the Glasnevin route in this area are tightly constrained in both the horizontal and vertical plane by the existing structures – namely Liffey Bridge (UBO1), Conyngham Road Bridge (OBO2) and Phoenix Park Tunnel, as can be seen from the following images.

Figure 2-8 Liffey Bridge (UBO1) fixed rail restraint

The picture above clearly shows the fixed rail restraint system that constrains the alignment over the structure.

Figure 2-9 Conyngham Road Bridge (OBO2) / Phoenix Park Tunnel South Portal

The picture above shows the overbridge carrying Conyngham Road that constrains the alignment beneath the structure.

Figure 2-10 View of Phoenix Park Tunnel.

The separation between tracks is, at less than 1.97m. Also, the distance between tracks and tunnel wall is limited.

The picture above shows the arch structure of Phoenix Park Tunnel, which has limited clearance for realignment of the track and installation of OHLE equipment. It is worth noting that the tunnel lining alignment has a noticeable kink at around 170m from the south entrance.

2.5 Existing Retaining Walls

According to existing IE database records, the following retaining walls are recorded at the following locations:

Table 2-1 Existing Retaining Walls

Track Section	Asset ID	Start Mileage	End Mileage	Side	Wall Type	Wall Height	Description
Connolly - Heuston	RWO000DA	0m 0646yrds	0m 666yrds	Down	Masonry	7.0m	N/A
Connolly - Heuston	RWO000UA	0m 0642yrds	0m 0699yrds	Up	Masonry	7.0m	N/A

2.6 Other Railway Facilities

The current service Platform 10 is located immediately south of the Liffey Bridge (UBO1). Note that a separate report has been produced to assess the feasibility of a station at Platform 10.

2.7 Road Network

Conyngham Road, which is located above Conyngham Road Bridge (OBO2), has a carriageway width of 12.6m, consisting of an outbound marked cycle lane, a single vehicular lane in either direction and a dedicated inbound/eastbound bus lane. There are footpaths on both sides of the carriageway with widths of 2.4m to the North and 2.9-3.4m to the South.

The road gradient is at an average of 1%, falling from east to west, towards the South Circular Road intersection with Conyngham Road.

This is currently the main pedestrian connector for those choosing to walk between the city centre and Chapelizod / Islandbridge. The route is designated for an upgrade as part of the Bus Connects that will reduce the vehicular carriageway widths to allow for wider segregated footpaths and cycle tracks.

Figure 2-11 Overview of Conyngham Road

2.8 Ground Conditions and Topography

The topography is generally flat, with the land north and south of the River Liffey sloping gently towards the river. South of the River Liffey on the west side of the railway, the ground level of the existing Clancy Quay development is approximately 4m to 5m below the existing track level. North of the River Liffey the railway is located on masonry arches on the approach to Phoenix Park Tunnel with the surrounding ground levels located circa 4m to 5m below the track level.

According to geological mapping, the superficial deposits in this area are anticipated to comprise urban (made ground), alluvial and gravel deposits overlying bedrock (limestone and shale). It is expected that a layer of till will exist below the made ground deposits. On the south approach to UBO1, the superficial deposits are described as gravel deposits. The superficial deposits on the banks, beneath the River Liffey and close to the southern

portal of Phoenix Park Tunnel is described as alluvium. The superficial deposits surrounding the Phoenix Park Tunnel are shown to comprise till overlying bedrock (limestone and shale).

Historical ground investigations south of the River Liffey show the ground conditions to typically comprise made ground, underlain by clays and gravels overlying limestone bedrock. Made ground generally consisted of clay gravel with concrete, red brick, steel with a maximum thickness of 3.50m. Made ground deposits were underlain by gravelly clay and gravel (of limestone) with occasional layers of sand. Bedrock comprising of strong to moderately strong limestone with laminated mudstone and shale was encountered at depths ranging from 22.70m bgl (13.49m AOD) to 24.55m bgl (15.39m AOD). Hazardous and non-hazardous material within soil samples was identified near to the current location of the National Train Control Centre in 2019.

North of the River Liffey, historical ground investigation west of the railway typically comprise made ground (recorded as clay and rubble), underlain by gravel and sand. Bedrock was encountered between 6.70m bgl to 10.67m bgl. A historical ground investigation east of the railway encountered made ground (fill) underlain by clay and a coarse gravel. Sandy ballast and large ballast is recorded between 8.50m bgl and 15.50m bgl. The superficial deposits overlie bedrock recorded as black limestone at 15.50m bgl.

Groundwater strikes were recorded at 7.50m bgl and 13.50m bgl to the south of the River Liffey, whereas groundwater was recorded between 4.40m bgl to 9.80m bgl, north of the River Liffey.

2.9 Environment

This area covers the Slow/DART lines East of St John's Road (OBC0A) to 200m past the north-east end of the Phoenix Park Tunnel. It includes Platform 10 in Heuston Station as well. Much of the residential areas to the north-east of and south of the Phoenix Park areas are serviced by mainly low-pressure gas pipelines.

O'Devaney Gardens is a residential area and also a Strategic Development Regeneration Area to the east of the rail corridor and the North Circular Road. Saint Brian's Military Hospital is also in this area. Parklodge Apartments are adjacent to the rail corridor. The Phoenix Park is a key recreational and amenity area for residents and tourists and is classed by Dublin City Council (DCC) as a site of archaeological potential and a Conservation Area. The People's Park is located in the area south of the tunnel and has a playground adjacent to Infirmary Road. There is also a veterinary clinic here. Just to the west of the Garda Headquarters is the southern part of Dublin Zoo in proximity to the rail corridor. Clancy Quay to the south is one of Ireland's largest private sector rented residential developments with a number of apartment blocks.

At the north-east end of the Phoenix Park Tunnel are the Garda Headquarters/ McKee Barracks. The barracks are a Designated Landscape (Conservation Area). The North Circular Road area has a designated landscape protection objective, encompassing several houses on the National Inventory of Architectural Heritage (NIAH), many houses on the Record of Protected Structures (RPS), and further north along the Drumalee Road. The R806 and Marlborough Road overbridges are NIAH. A row of houses along Garda Terrace where the rail line enters the tunnel are on the RPS. On one side of the tunnel entrance there is gate lodge which is both an NIAH and an RPS; on the other side of the tunnel entrance are gates/railings/walls, a feature which is also on the NIAH and RPS. The Wellington Monument, People's Park and Sean Heuston Monument are also on the NIAH; another feature just south of this monument is classed as an RPS. The view from the wellington Monument is a DCC Protected View. The Liffey Bridge (UBO1) is also an NIAH, as is a sentry box on the southern bank. DCC has a landscape protection objective associated with the River Liffey. At Clancy Quay on the western side of the rail corridor as it turns towards the South Circular Road area number of NIAH and an RPS.

The presence of the existing rail line has reduced biodiversity potential along the route to a large degree, however there remain hotspots of interest in relation to hedgerows and treelines for bats in particular (Phoenix Park Tunnel has bat roost potential). Badger activity was also found along the section from the R806 and the tunnel. The

Liffey is known to host salmonid fish species, and the section of the river from just upstream of bridge to the coast is designated as an Annex I Habitat (as the uppermost part of the Liffey Estuary). Invasive species were noted; there is a significant linear stand of Japanese knotweed running adjacent the rail corridor from the Liffey Bridge (UBO1) as far as the South Circular Road, with some on the southern side of the road also.

The existing rail corridor traverses an old gravel quarry at the bend past Clancy Quay. The whole of the Phoenix Park is a Geological Heritage Area/ County Geological Site (recommended for Geological Natural Heritage Area) due to the unusual complexity of the site for its glacial form and representing an extensive natural landscape within the confines of a city. Groundwater vulnerability across this area ranges from low to high. The subsoils underlying much of this area comprise mainly limestone tills, gravel tills and alluvial deposits.

Refer to **Section 4.1** (Environment) for further details.

2.10 Utilities

This area contains 13 no. utilities along Conyngham Rd as well as 3 no. utility crossings. Service providers with network assets in this area include the following:

- Aurora
- British Telecoms (BT)
- Eir
- ESB Networks
- Dublin City Council / Irish Water (Foul Water Sewers)
- Dublin City Council / Irish Water (Water Supply)
- Dublin City Council Public Lighting
- Gas Networks Ireland (GNI)
- Virgin Media

Data in the form of utility service records have been gathered from all providers in the area. The majority of services are located within Conyngham Road through Conyngham Road Bridge (OBO2). Hence, where modifications are required to existing bridges and/or to the road network in the immediate vicinity of existing structures, impacts on utilities will be inevitable.

The 3 no. utilities present at track level cross the railway corridor below the tracks. Where track lowering is proposed, consideration of the impacts on these services will also be necessary.

3 Requirements

3.1 Specific Requirements

- Electrification of the DART Slow lines (Up Branch & Down Branch).
- Provide sufficient vertical clearance for OHLE at structures through track lowering and / or structural interventions.
- Safe rolling stock passing clearance.
- Compliant road design
- Track alignment and drainage requirements (standards)

3.2 Systems Infrastructure and Integration

In addition to the track and civil infrastructure modifications relating to them DART+ South West Project, there is a requirement to provide Overhead Line Electrification Equipment (OHLE) signalling and telecoms infrastructure.

The electrification system will be similar in style to that currently used on the existing DART network and integrated and compatible across the DART+ Programme. There will be a potential requirement to provide 6 additional power substations along the rail line to provide the requisite power for the network demand. It is envisaged that a standardised approach to electrification will be adopted, but those area-specific interventions will also be required.

The Low Voltage and Telecommunications networks required for Signalling will be 'global systems' and are unlikely to vary significantly between or within the various areas. In order to achieve the necessary capacity enhancements and performance required for the introduction of the new electric multiple unit (EMU) fleet, it will be necessary to upgrade the existing signalling system as well as replacing some of the legacy signalling system. This will include provision of Relocatable Equipment Buildings (REB) where required along the route in order to accommodate signalling equipment and associated power supplies and backup.

Significant upgrades to the existing telecommunications infrastructure will be required to facilitate improvements to the radio-based technologies used on the network and for signalling and communication with the existing and future network control centres.

3.2.1 Electrification System

The OHLE system architecture is currently being developed. The Dart wide programme will adopt a 1500V Direct Current (DC) OHLE system to provide electrical power to the network's new electric train fleet.

It should be noted that all OHLE diagrams in this report are for visual information only. Final dimensions, lengths, heights and cantilever types are to be defined in the reference design and subsequent design stages of the project.

The OHLE concept comprises a pre-sagged simple (2-wire) auto-tensioned system, supported on galvanised steel support structures.

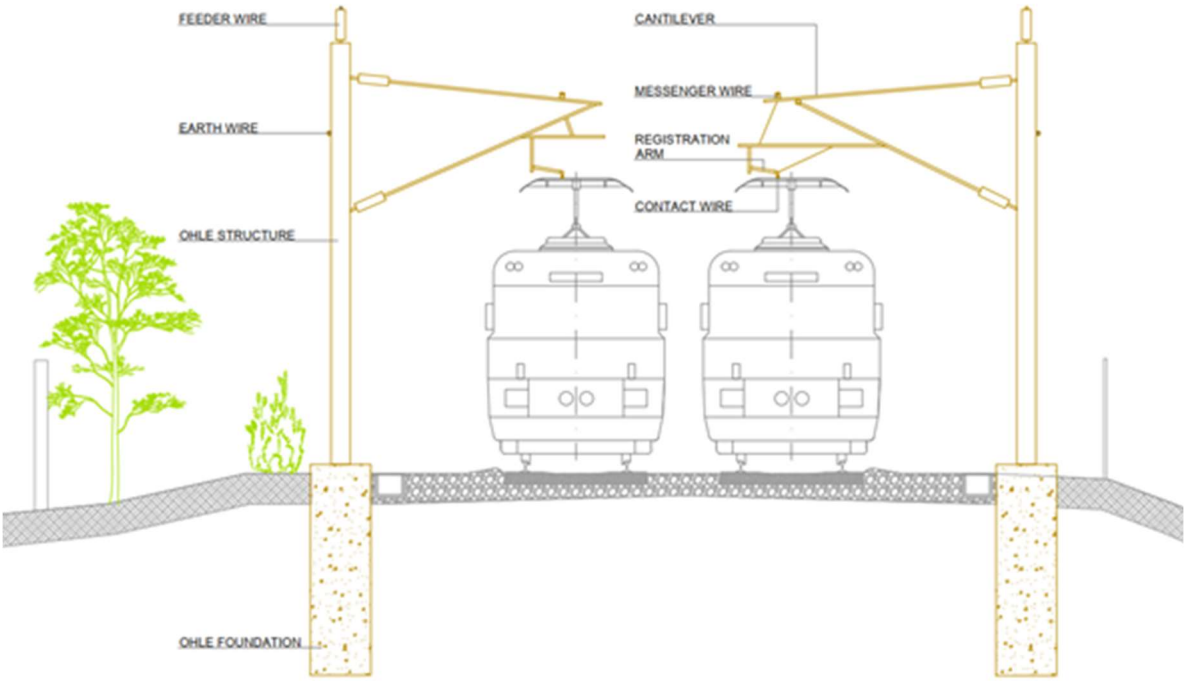


Figure 3-1 Typical OHLE arrangement in two track open route

Nominal contact wire height is 4.7m, and heights through stations may be slightly higher to achieve minimum protection by clearance distances. Minimum contact wire height without a derogation is 4.4m under all conditions including sag, and it may be necessary at certain bridges to place the contact wire height at 4.2m under all conditions.

Additional feeder cables will be supported from the masts at heights between 6.5m and 8m on each side of the track. An earth wire will also be suspended from the masts.

Maximum tension length is 1600m, and maximum half tension length is 800m. Overlaps will comprise three spans, with spring tensioners used throughout. Midpoint Anchors (MPAs) will generally be of the tie-wire type, although the portal type may be needed in some locations.

At intervals of up to 1500m the OHLE wires will be anchored at an arrangement known as an overlap, and a new set of wires will take over. The anchors provide the mechanical tension that the wires need to perform reliably and safely. In areas of crossovers and junctions, additional wiring will be provided for the extra tracks, and these will also be provided with anchors.

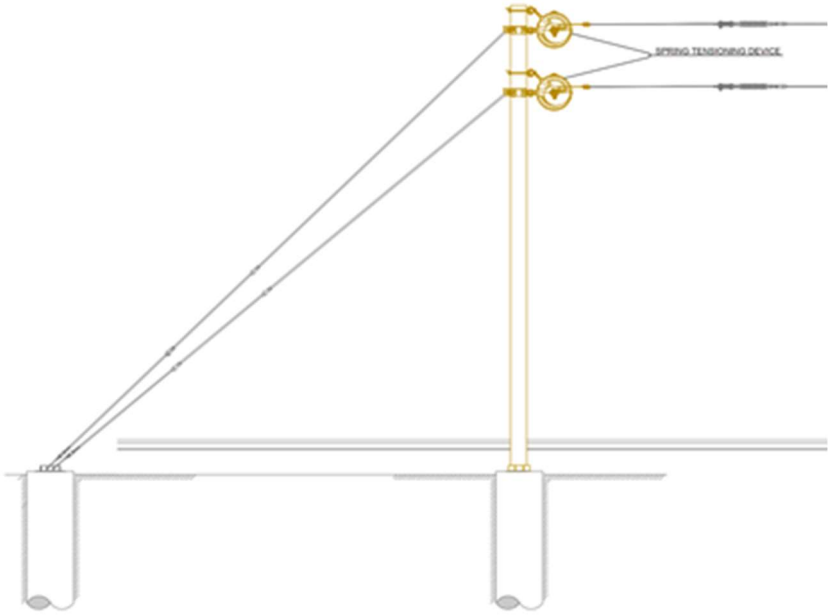


Figure 3-2 Typical anchor structure

The OHLE configuration through the overbridges for each track or civils option is being assessed using a calculator derived from the OHLE FRS, and a set of configurations agreed with Irish Rail through the Interface Coordination Document (ICD) process. This includes level and graded free running options, as well as level and graded options with elastic bridge arms fitted to the bridge.

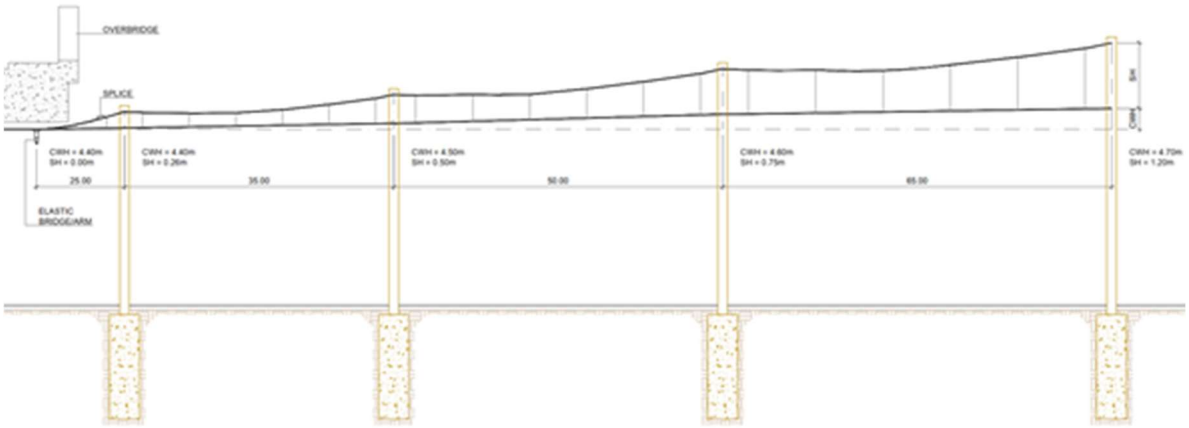


Figure 3-3 Typical arrangement on approach to a low bridge

The OHLE configuration through the tunnels is dependent on the shape, size and construction of the tunnel. Options available include continuation of the flexible OHLE system through the tunnel with a small system height with more frequent supports from the tunnel roof. This arrangement will be hidden within the tunnel.

Occasionally, the size, shape or construction of a tunnel may be restrictive enough that a rigid bar system needs to be used instead of flexible wires. This arrangement will also be hidden within the tunnel, but may extend for a short distance outside the tunnel before reverting to the flexible wire system.

3.2.2 Substations

In order to facilitate the introduction of the new OHLE scheme across the DART+ network a power supply study has been carried out. There is a requirement to provide 6 new substations at the following locations:

- Islandbridge
- Le Fanu
- Park West
- Kishoge
- Adamstown
- Hazelhatch

3.3 Design Standards

Please refer to Annex 3.2 for the design standards that will be used for the scheme.

4 Constraints

4.1 Environment

This area covers the Slow/DART lines between East of St John's Road (OBC0A)to 200m past the north-east end of the Phoenix Park Tunnel. It includes Platform 10 in Heuston Station as well.

Starting at the north-east end of the Phoenix Park Tunnel, this area commences approx. from the R806 and the Garda Headquarters/ McKee Barracks. The barracks are also by Dublin City Council (DCC) as a Designated Landscape (Conservation Area). There is also a block of apartment here adjacent the rail corridor (Park Lodge Apartments). To the east of the rail corridor, the North Circular Road area has a DCC landscape protection objective (Z2) to "protect and improve the amenities of residential conservation areas" which encompasses the North Circular Road area extending to the boundary of the Phoenix Park. Within this area, there are several houses on the National Inventory of Architectural Heritage (NIAH) either side of the North Circular Road, and many houses on the Record of Protected Structures (RPS) on either side of the North Circular Road and further north along the Drumalee Road.

O'Devaney Gardens, which is a residential area and also a Strategic Development Regeneration Area (SDRA), is located to the east of the rail corridor and the North Circular Road. Within this area (approx. 400m from the east side of the rail centreline) is Saint Brian's Military Hospital.

Heading towards the Phoenix Park Tunnel, Blackhorse Avenue Bridge (OBO4) is an NIAH, as is McKee Barracks Bridge (OBO3). Between this section from Blackhorse Avenue towards the tunnel, there were four scat features identified during the 2020 ecology survey which indicate badger presence. There is also a row of houses along Garda Terrace where the rail line enters the tunnel which are on the RPS. On one side of the tunnel entrance there is gate lodge which is both an NIAH and an RPS; on the other side of the tunnel entrance are gates/railings/walls, a feature which is also on the NIAH and RPS. Here at the corner of Infirmary Road and the tunnel entrance is Cara Veterinary Clinic.

The existing rail line then heads under the south-east section of the Phoenix Park through the Phoenix Park Tunnel. The 2020 ecology survey noted that the tunnel has bat roost potential.

The Phoenix Park itself is a key recreational and amenity area for residents and tourists and is classed by DCC as a site of archaeological potential and a Conservation Area. The People's Park is located in the area south of the tunnel and has a playground adjacent to Infirmary Road; the People's Park is also an NIAH (of regional importance). The Sean Heuston Monument is located approx. 100m to the south of the centreline of the tunnel and is an NIAH; another feature just south of this monument is classed as an RPS. The Wellington Monument, approx. 100m to the east of the is an NIAH, and the view from this monument is a DCC Protected View.

The whole of the Phoenix Park is also a Geological Heritage Area/ County Geological Site (recommended for Geological Natural Heritage Area). Just to the west of the Garda Headquarters, the southern part of Dublin Zoo falls within the 100-300m buffer band from existing rail centreline. The groundwater vulnerability under the Phoenix Park is rated as low.

As the tunnel emerges from Conyngham Road Bridge (OBO2), it crosses the Liffey Bridge (UBO1) which is also an NIAH (regional importance). A sentry box on the southern bank of the River Liffey and approx. 150m west of the rail centreline is also an NIAH. DCC has a landscape protection objective (Z11) to "protect and improve canal, river and coastal amenities", which includes the River Liffey. The Liffey is known to host salmonid fish species, and the section of the river from just upstream of bridge all the way to the coast is designated as an Annex I

Habitat, as it is the uppermost part of the Liffey Estuary. The groundwater vulnerability underlying the river corridor is classed as moderate/high.

At Clancy Quay on the western side of the rail corridor as it turns towards the South Circular Road, are three workshop buildings which are each an NIAH (of regional importance) and an RPS. Clancy Quay is one of Ireland's largest private sector rented residential developments with a number of apartment blocks. An officer's house and a guard house located approx. 100m from the rail centreline on Artillery parade are both NIAH (of regional importance). As the existing rail corridor follows this bend past Clancy Quay, it traverses the area of a historic gravel quarry, dating from the early to mid-20th century. The 2020 ecology survey noted a significant linear stand of Japanese knotweed running adjacent to the rail corridor from the Liffey Bridge (UBO1), past Platform 10, as far as the South Circular Road. Some Japanese knotweed was also found on the southern side of the South Circular Road. The groundwater vulnerability in this part is rated as low.

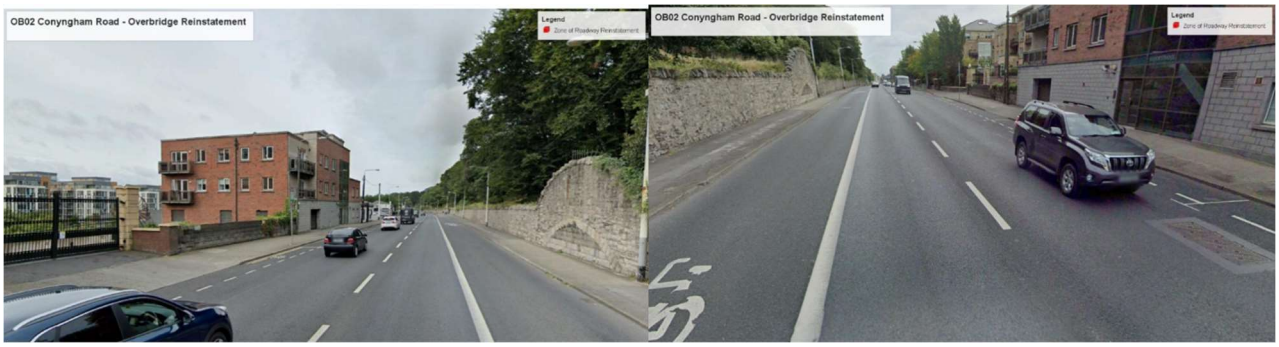
The subsoils underlying much of this area are tills derived from limestones; alluvial deposits are found along the River Liffey and some gravel tills under Clancy Quay, however much of the 'subsoil' directly adjacent the river corridor is classed as 'urban' reflecting city development.

Much of the residential areas to the north-east of and south of the Phoenix Park are serviced by mainly low-pressure gas pipelines; a medium pressure pipelines traverse the rail corridor along the Conyngham Road.

4.2 Roads

Conyngham Road is traversed by the railway by means of Conyngham Road Bridge (OBO2). At the bridge location the existing footpaths have boundary walls; to the North by Phoenix Park retaining wall (2.8-3.2m high), to the south west of Conyngham Road Bridge (OBO2) by Sunnybank apartment building face and to the south east of Conyngham Road Bridge (OBO2) by Riverpark apartment complex retaining wall (0.65m high) entrances. This provides limits to temporary traffic management strategies without having to provide pedestrian overbridges or diversions through Phoenix Park.

Adjacent apartments have vehicular accesses within the immediate vicinity and pedestrian accesses within 20m of Conyngham Road Bridge (OBO2). These provide challenges to the extent to which the road could be raised to accommodate a bridge replacement, if required to improve OHLE clearances.



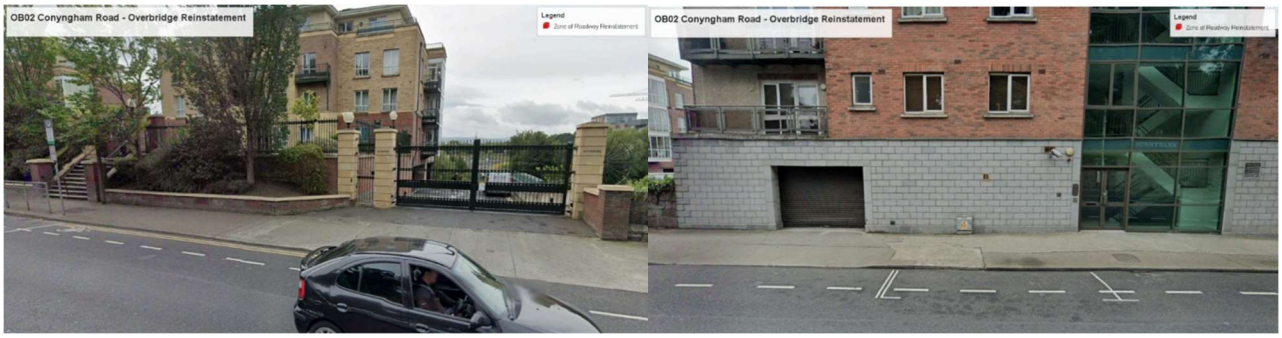


Figure 4-1 Constraints on Road Design

4.3 Permanent Way

The vertical and horizontal alignment is constrained by the elements summarised in the Table and Figure below.

Table 4-1 Permanent Way Geometrical Constraints

ID	Name	Description
1	Existing Liffey Bridge (UBO1)	Liffey Bridge (UBO1) features a fixed track system which is to be retained and is a major constraint in terms of the horizontal and vertical Permanent Way alignment.
2	Existing Conyngham Road Bridge (OBO2)	Conyngham Road Bridge (OBO2) is a major constraint in terms of the horizontal and vertical Permanent Way alignment in that the height beneath the existing bridge is limited.
3	Existing Phoenix Park Tunnel – Lateral Clearances	Phoenix Park Tunnel has limited clearances to the arch and is a major constraint in terms of the horizontal and vertical Permanent Way alignment. The tunnel lining has a kink in its alignment (around 170 m from the south entrance).
4	Existing Phoenix Park Tunnel – Invert slab level	The existing ballast depth under the sleepers is known to be reduced through the tunnel. The scope for track lowering that would improve lateral passing clearances due to the shape of the cross section of the tunnel is then limited.

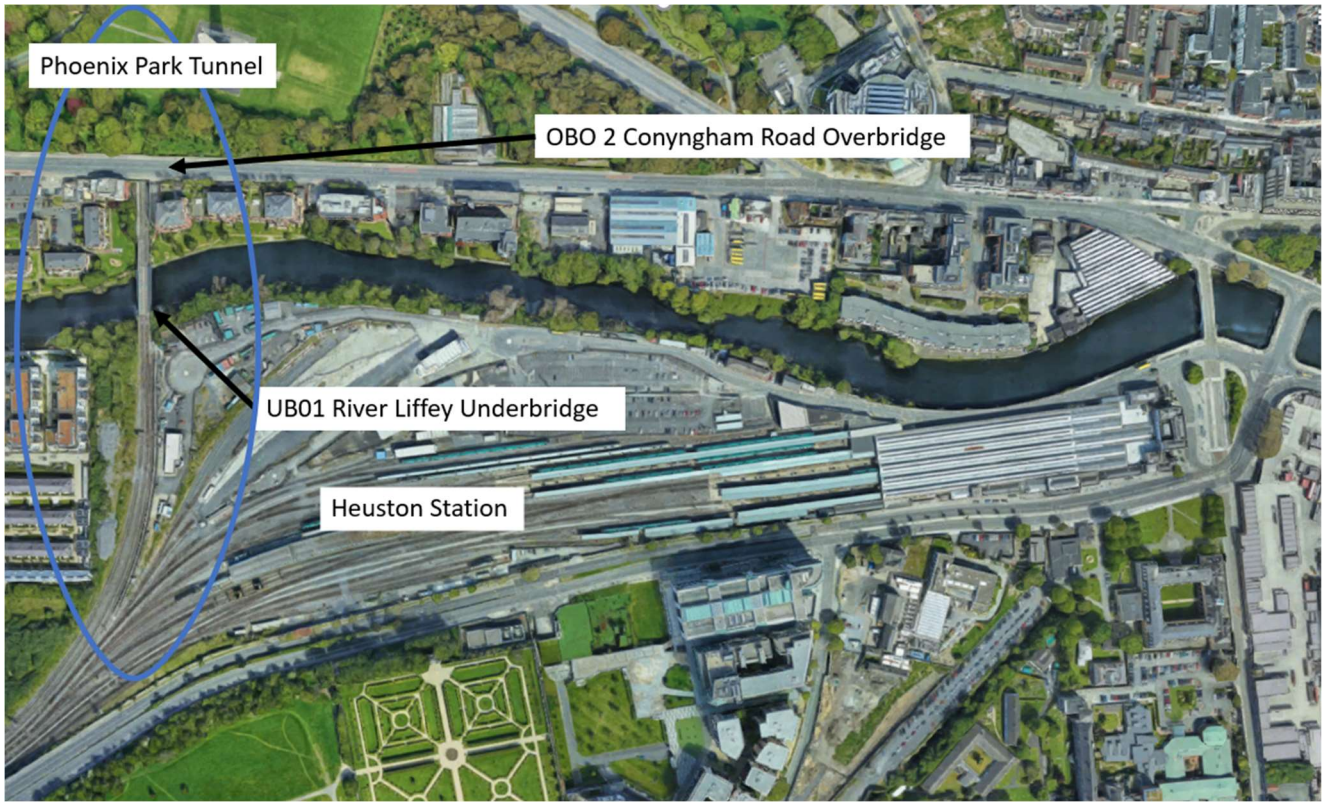


Figure 4-2 Constraints of permanent way design

The main constraint for the alignment on the Up Branch and Down Branch lines on the Glasnevin route in this area are the existing structures – namely Liffey Bridge (UBO1), Conyngham Road Bridge (OBO2) and Phoenix Park Tunnel.

In addition to the structural constraints that will have an effect on the track alignment, there is an existing track drainage system installed in Phoenix Park Tunnel. The track realignment would require the reconstruction and integration of the track drainage system.

4.4 Existing Structures

The Phoenix Park Tunnel has limited clearances to the arch, particularly constraining horizontal realignment of tracks. The tunnel however has sufficient vertical clearance for the installation of electrification. As such no structural interventions are anticipated.

The existing Conyngham Road Bridge (OBO2) does not have adequate vertical clearance for implementation of electrification, requiring track or structural intervention. Due to the existing track drainage system under the Phoenix Park Tunnel, and the proximity between Conyngham Road Bridge (OBO2) and the Liffey Bridge (UBO1), track lowering should be minimized to avoid further interventions to the Phoenix Park Tunnel and Liffey Bridge (UBO1).

Electrification of the existing Liffey Bridge (UBO1) is possible, since this structure is an underbridge. The bridge features a fixed track system which is to be retained and is a major constraint in terms of the horizontal and vertical track alignment. OHLE will need to be supported from the bridge structure and this may require bridge strengthening.

Gantry HN331/HN332 will need to be removed to facilitate the installation of the electrification system.

4.5 Geotechnical

No onerous ground or groundwater conditions are anticipated in this area based on existing information. Hazardous material has been identified in soil samples close to the proposed National Train Control Centre location which is adjacent to this area.

The invert level of the existing Phoenix Park Tunnel is anticipated to be close to the base of the existing trackbed formation level. This may constrain the amount of track lowering that can be achieved at this location.

It is likely that the existing retaining walls in this area will remain unaffected by the proposals.

4.6 Existing Utilities

There are many utilities traversing and alongside the existing rail corridor. The majority of utilities that cross the rail corridor are concentrated in Conyngham Road Bridge (OBO2), with exception to 2no combined sewers and 1no Virgin Media duct that cross underneath the tracks. Any option that requires minor / major bridge intervention works will cause major disruption to the services in Conyngham Road Bridge (OBO2). Temporary diversions will be needed in this case. Any option that requires track lowering will avoid any diversion for the utilities located in Conyngham Road Bridge (OBO2). However, track lowering has potential to disrupt a number of services shown below in Figure 4-3:

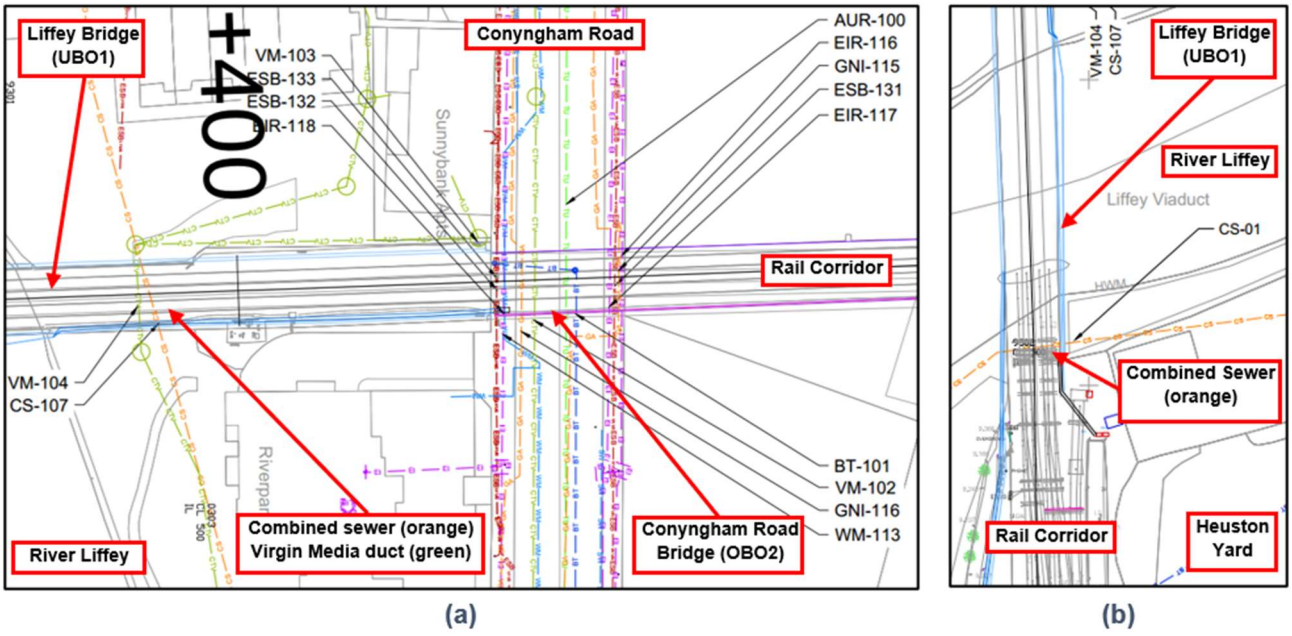


Figure 4-3 (a) 1no Combined Sewer and 1no Virgin Media (b) 1no Combined Sewer

The level in which the tracks are lowered will dictate whether a diversion is needed for the above services. This is dependent on the option chosen for this area.

5 Options

5.1 Options Summary

Permanent way options comprise realignments to provide standard clearances, both vertically and horizontally.

A total of 3 no. 'Main Options' have been developed for this area of the scheme. Main Options are decomposed into 'Option Variations' where only small differences exist between proposed solutions (e.g. different vertical clearance dimensions at Conyngham Road Bridge (OBO2)), but the broader option remains unchanged. As such, drawings for all Option Variations have not been developed. The Main Options include a 'Do-Nothing' Option and a 'Do-Minimum' Option.

- A Do-Nothing option means that the design endeavours to achieve the project requirements without any intervention to the existing infrastructure.
- A Do-Minimum option means that the design endeavours to achieve the project requirements with only minor intervention to the existing infrastructure.

A summary of Main Options is presented in the table below. A detailed description of each Main Option and their Option Variations is included Section 5.2 below. Note that the Liffey Bridge (UBO1) and adjacent arch viaduct are underbridges and hence is not constrained by height clearance for the electrification. It also has adequate width for the proposed Dart infrastructure. Therefore, no interventions are required for Liffey Bridge (UBO1) and adjacent arches.

Table 5-1 Main Options Summary

Option	Description	
	Conyngham Road Bridge (OBO2)	**Phoenix Park Tunnel**
Option 0: Do Nothing	The existing infrastructure remains unchanged. There are no interventions.	The existing infrastructure remains unchanged. There are no interventions.
Option 1: Do Minimum	This option endeavours to achieve the electrification project requirements without widening the existing rail corridor and provides additional vertical clearance at Conyngham Road Bridge (OBO2) by track lowering only.	New track alignment and slab track, with OHLE. Tunnel may require improvement works.
Option 2	This option combines track lowering with structural intervention of Conyngham Road Bridge (OBO2) and lifting of Conyngham Road in order to provide sufficient vertical clearance to accommodate electrification by providing room for the OHLE – albeit with a reduced contact wire height that will require a derogation.	New track alignment and slab track, with OHLE. Tunnel may require improvement works.

5.2 Options Descriptions

This section describes the Main Options that have been considered. Option Variations are elaborated within the Main Option text. With the exception of Option 0 (Do-Nothing) and Option 1 (Do-Minimum), there are some design disciplines that have technical features that are common to all Options (e.g. OHLE and Cable & Containment). Similarly, there are technical aspects that have been considered but are determined to have no (or insignificant) bearing on the development or selection of Options (e.g. ground conditions). To remove repetition among the Option descriptions, these issues are addressed at the end of the Option description section.

5.2.1 Option 0: Do-Nothing

5.2.1.1 Conyngham Road Bridge (OBO2)

The Do-Nothing Option proposes no changes to the existing road or rail infrastructure. The vertical clearance at Conyngham Road Bridge (OBO2) would not be resolved. As such, this option would not facilitate the installation of an OHLE system. The project requirements would not be achieved.

5.2.1.2 Phoenix Park Tunnel

The Do-Nothing Option proposes no changes to the existing rail infrastructure. The tracks would not be realigned or modified. The lateral clearance issue at PPT would not be resolved. As such, this option would not comply with the project requirements.

The assessment of the lateral clearances in PPT is included in the drawings listed in the Table 5-2.

Table 5-2 Option 0: Do-Nothing – Assessment of lateral clearances in PPT

Drawing Number	Name
DP-04-23-DWG-PW-TTA-35755-v01-S0	Phoenix Park Tunnel Track Plan Layout – Option 0 Do Nothing, Existing situation
DP-04-23-DWG-PW-TTA-35756-v01-S0	Phoenix Park Tunnel Cross Sections (Sheet 1 of 2) – Option 0 Do Nothing, Existing situation
DP-04-23-DWG-PW-TTA-35757-v01-S0	Phoenix Park Tunnel Cross Sections (Sheet 2 of 2)– Option 0 Do Nothing, Existing situation

5.2.2 Option 1: Do-Minimum

5.2.2.1 Conyngham Road Bridge (OBO2)

This Option seeks to achieve the electrification of the DART Slow lines by means of minor interventions only – specifically, the implementation of the maximum possible track lowering at Conyngham Road Bridge (OBO2).

A review of the constraints has concluded that a maximum track lower of circa 370mm under Conyngham Road Bridge (OBO2) would achieve a reduced vertical clearance of 4.566m that would require a derogation for OHLE due to the reduced contact wire height. A slab track system is proposed.

This vertical alignment of this option is shown in drawing number DP-04-23-DWG-PW-TTA-35742-v01-S0.

5.2.2.2 Phoenix Park Tunnel

This Option seeks to achieve improved clearances by a realignment of the track and the installation of a slab track system. The proposed alignment improves the lateral passing clearances to structure and between passing trains.

The assessment of the lateral clearances in PPT is included in the drawings listed in the Table 5-3 Option 1: Do-Minimum – Assessment of lateral clearances in PPT Table 5-3 .

Table 5-3 Option 1: Do-Minimum – Assessment of lateral clearances in PPT

Drawing Number	Name
DP-04-23-DWG-PW-TTA-35758-v01-S0	Phoenix Park Tunnel Track Plan Layout – Option 1 Do Minimum, Existing situation
DP-04-23-DWG-PW-TTA-35759-v01-S0	Phoenix Park Tunnel Cross Sections (Sheet 1 of 2) – Option 1 Do Minimum, Existing situation

Drawing Number	Name
DP-04-23-DWG-PW-TTA-35760-v01-S0	Phoenix Park Tunnel Cross Sections (Sheet 2 of 2)– Option 1 Do Minimum, Existing situation

5.2.3 Option 2

5.2.3.1 Conyngham Road Bridge (OBO2)

This Option seeks to achieve the electrification of the DART Slow lines by means of a combination of interventions – track lower, bridge intervention and road raising at Conyngham Road. The existing track horizontal alignment will be retained throughout this area, whilst the vertical alignment remains as existing over Liffey Bridge (UBO1) and through Phoenix Park Tunnel. A slab track system is proposed.

This vertical alignment of this option is shown in drawing number DP-04-23-DWG-PW-TTA-35743-v01-S0.

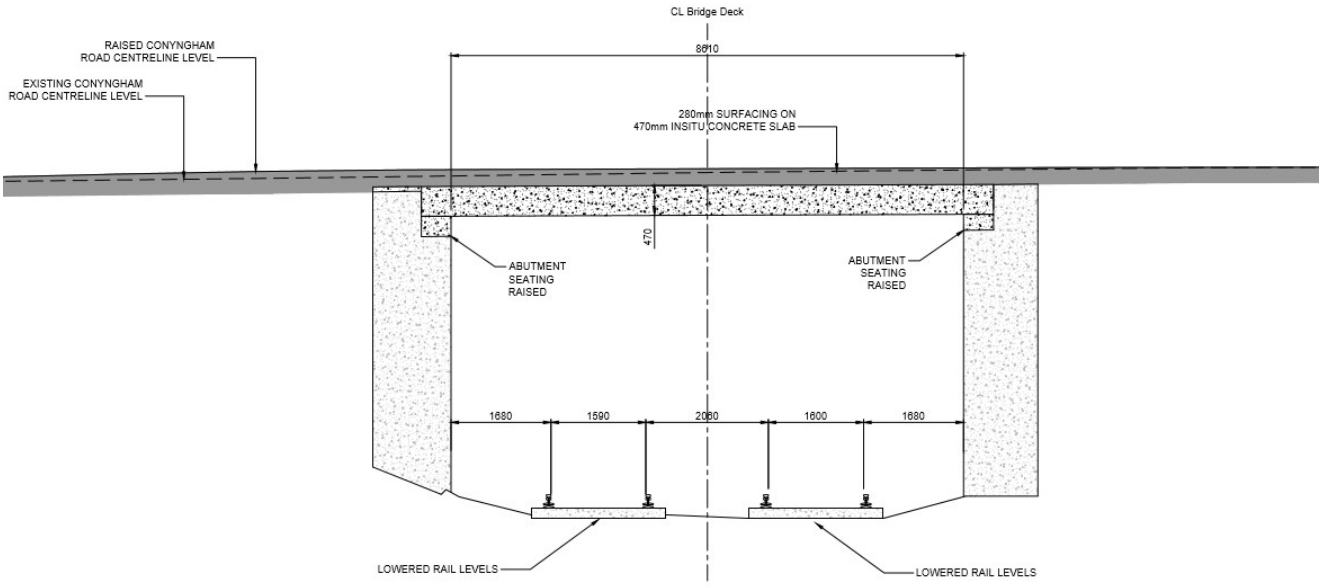


Figure 5-1 Cross Section at Conyngham Road Bridge (OBO2)

Due to the constraints on road design solutions (previously mentioned in Section 4) the level of road and adjacent footpaths would only be raised by approx. 100-120mm at the bridge. This is necessitated to tie back into existing footpaths without severely impacting on the adjacent apartments' accesses (see DP-04-23-DWG-CV-TTA-35270-V01-S0).

As aforementioned the required vertical levels would require track lowering (around 150mm) plus the road level increase (around 100mm) and the reduction of the bridge deck thickness compared to the existing bridge.

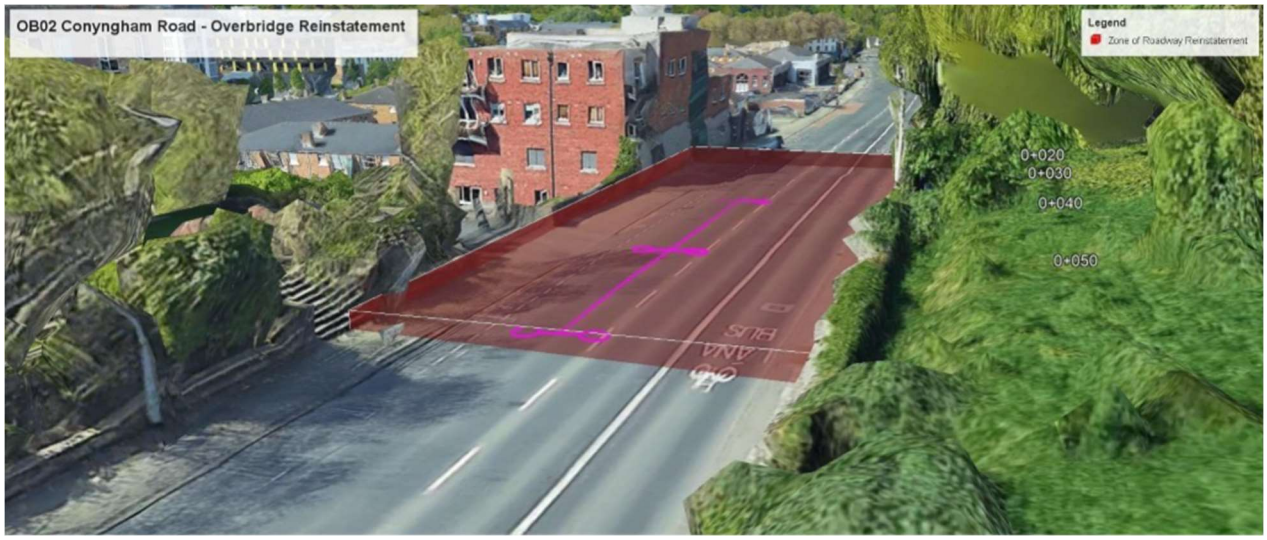


Figure 5-2 Extent of Roadworks Reinstatement at Conyngham Road Bridge (OBO2)

5.2.3.2 Phoenix Park Tunnel

As with the Do-minimum option, this Option seeks to achieve improved clearances by a realignment of the track and the installation of a slab track system. The proposed alignment improves the lateral passing clearances to structure and between passing trains.

5.3 OHLE Arrangement – All Do-Something Options

The Phoenix Park Tunnel is directly adjacent to the Conyngham Road Bridge (OBO2), and so these two structures have been considered together when defining the OHLE solution for each option.

Two OHLE options for this location exist and are applicable to both Option 1 and 2 above.

Table 5-4 OHLE options

Option	Conyngham Road Bridge (OBO2) Solution	Phoenix Park Tunnel Solution
OHLE1	Flexible OHLE	Flexible OHLE
OHLE2	Rigid Overhead Bar	Rigid Overhead Bar

5.3.1 Option OHLE 1

This option is the least visually intrusive at the open sections of route south of Conyngham Road Bridge (OBO2) and north of the tunnel.

The existing Conyngham Road Bridge (OBO2) has a 4.264m minimum soffit height. For a potential OHLE solution with CW height of 4.2m, the minimum requirement of soffit height is 4.46m between OHLE supports with slab track in place. Even adding a 100mm track lower or using Rigid Overhead Contact Line (ROCL), this is still 112mm less than the minimum requirement. Therefore, no OHLE solution is possible for Option 0 or Option 1.

For bridge options 1 and 2, the Conyngham Road Bridge (OBO2) soffit height provides an OHLE configuration with graded contact wire, twin contact equipment (zero system height), and a contact wire height of 4.2m through the bridge under all conditions. Derogation will be required for a reduced contact wire height below 4.4m. OHLE through the bridge will be fitted, with elastic bridge arms supported from the bridge at multiple locations due to its length. Two pocket location will be designed within the bridge deck to position the bridge arm between bridge

support beams and so reduce the clearance requirement between the OHLE support. This is an essential requirement to provide sufficient clearance for OHLE in all the options. Electrical clearances will be 100mm static, and 80mm dynamic. Slab track will be used through Conyngham Road Bridge (OBO2) and Phoenix Park Tunnel, so no upward track movement allowance has been provided.

The Phoenix Park Tunnel is configured such that the OHLE can pass through the tunnel, but due to its length it will be connected to the tunnel at multiple locations. This option provides a continuation of the flexible OHLE through the tunnel. The opportunity exists to begin grading the contact wire up from 4.2m to a greater value within the tunnel; and the opportunity will also be taken to open up a system height within the tunnel, removing the need for elastic bridge arms which can create dynamic resonance problems when used in multiples. The support and registration through the tunnel in this option is likely to comprise a small system height cantilevers supported from the centre of the tunnel roof. Electrical clearances will be 150mm static and 100mm passing.

Due to the shape of the tunnel and restricted clearance between the OHLE live equipment and the tunnel face in this option, compression arms will be used where necessary to keep all the registration from the centre of the tunnel. Due to the low line speed at the location (30kph) it will be possible to use compression arms at multiple locations without affecting the dynamic performance of the system.

The length of the tunnel is approximately 700m, and so to avoid putting any midpoint anchor structure within the tunnel, a derogation will be required to have a half tension length of over 800m. This can be justified based on the lower operating temperature range which will be experienced in the tunnel, leading to smaller along-track movements than would be experienced by an open-air tension length.

A midpoint anchor will be placed at the south exit of the Conyngham Road Bridge (OBO2), and an overlap structure will be place at the Northern Portal of the tunnel to form the half tension length. Mast spacings to the south of Liffey Bridge (UBO1) will be dependent on the design of OHLE at the Heuston west station throat, which will follow at a later stage of the design development.

An overlap structure will be placed at the east exit of the Phoenix Park Tunnel before reverting to normal mast spacings.

5.3.2 Option OHLE 2

This option offers some robustness advantages over OHLE 1 but is more expensive and will result in a minor increase in visual intrusion at the Southern Portal end and a significant increase at the Northern Portal. This option will only be pursued if the tunnel condition requires it.

This option provides ROCL throughout the bridge and tunnel section. This option offers some advantages in terms of robustness, which can be advantageous in tunnels with a corrosive environment. However, this option is likely to be more expensive, due to the requirement for more frequent tunnel supports than with the flexible OHLE option. This option also requires transition arrangements at each end of the ROCL section where the flexible OHLE takes over. At these transitions, the OHLE tension must be transferred into the Conyngham Road Bridge (OBO2) deck (at the Southern transition) and into the ground (at the North transition outside the tunnel, where a conventional anchor structure can be used). The ROCL will also unavoidably need a midpoint anchor within the tunnel. Anchor points will need to be regularly inspected. For these reasons, the ROCL option is only likely to be pursued if the further design development demonstrates that option OHLE1 is not feasible, either due to tunnel conditions or another constraint.

5.4 Permanent Way

In the two main options, the permanent way solutions follow the existing rail corridor footprint, being constrained by existing structures - Liffey Bridge (UBO1), Conyngham Road Bridge (OBO2) and Phoenix Park Tunnel. In order to improve the maintainability of the clearances to the structure a slab track system is proposed from Liffey Bridge (UBO1) to the north portal of Phoenix Park Tunnel. Because of this, the minimum lateral passing clearances may be reduced as well as the required vertical clearances at Conyngham Road Bridge (OBO2) linked also to the reduced maintenance allowances.

5.4.1 Design Speed, Track Spacing and lateral clearance criteria

At the Phoenix Park Tunnel, the design speed considered is 30km/h (20mph).

The track interval followed in the proposed solution is a 6-foot interval of 1.970m, considering the constrained existing space.

In order to perform a clearance analysis along the tunnel, both for the existing ballasted track and for the proposed slab track, the structural clearance considered is a combination of the IRL2 reference profile, stated at CME-TMS-327 Vehicle Gauging (NNTR), adding the track tolerances stated at 1.4 of I-PWY-1101.

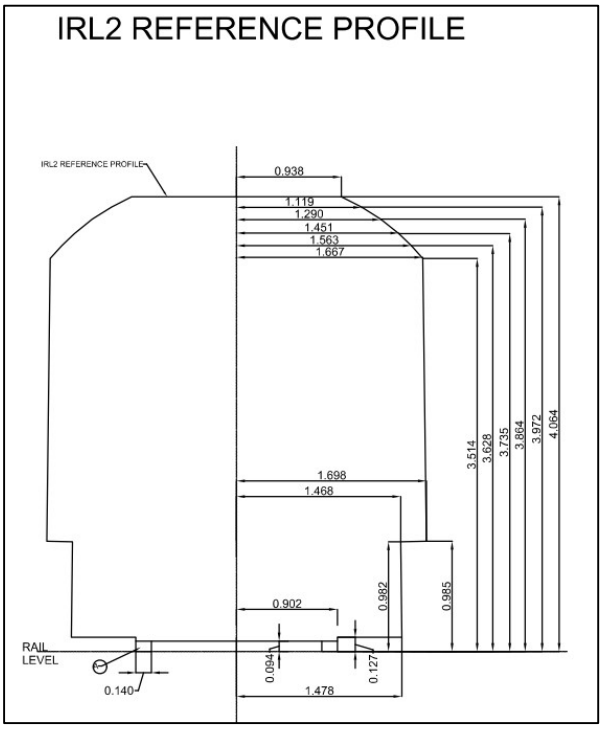


Figure 5-3 IRL2 Gauge

The tolerance values considered in the existing ballasted track are:

- Gauge widening and rail side-wear: 8mm
- Cross-level variation: 20mm
- Horizontal alignment variation: 25mm
- Vertical alignment variation: 25mm.

The sequence in which these values have been applied to the IRL2 profile is:

1. 25mm added horizontally to each profile vertex (horizontal alignment variation).
2. 8mm added horizontally to each profile vertex (gauge widening and rail side-wear).
3. 25mm added vertically to each profile vertex (vertical alignment variation).
4. The profile is rotated with the existing cant.
5. Cross-level variation is applied as an additional rotation of ±20mm to the existing cant. The envelope of both rotations is considered as the final profile for the clearance analysis.

For the proposed slab track the following tolerance values have been considered (these values are recommended in EN15723-3):

- Gauge widening and rail side-wear: 8mm
- Cross-level variation: 5mm
- Horizontal alignment variation: 5mm
- Vertical alignment variation: 5mm.

The sequence in which these values have been applied to the IRL2 profile is:

1. 5mm added horizontally to each profile vertex (horizontal alignment variation).
2. 8mm added horizontally to each profile vertex (gauge widening and rail side-wear).
3. 5mm added vertically to each profile vertex (vertical alignment variation).
4. The profile is rotated with the designed cant.
5. Cross-level variation is applied as an additional rotation of ±5mm to the designed cant. The envelope of both rotations is considered as the final profile for the clearance analysis.

As per the safety margin, the document RSC-G-002-B, which states 150mm for structures and 100mm for passing clearances between trains, has been used.

Further to initial feasibility design it has been established that Reference Profile IRL2a will be that used in further design development, but IRL2 has been adjudged sufficient for feasibility design work to date. Construction tolerances will be added.

5.4.2 Drainage

An upgrade to slab track is being proposed in the Phoenix Park Tunnel, which will require a dedicated drainage system. Therefore, an integrated drainage solution is to be designed to ensure a safe and reliable operation of the infrastructure.

There may be a need for attenuation given the change in the permeability of the catchment. The portals of the tunnel will be upgraded to slab track, making it necessary to ensure that no additional flows are discharged at the current outfall (potentially to the Liffey River).

Several options at this regard have been explored, assuming at this stage an additional catchment of 780 m² (65 x 12 m):

- To reuse an existing attenuation facility if one exists. No existing attenuation features have been identified to date, so this option has been discarded.
- To liaise with the consenting authority in order to get consent for discharge into the Liffey without additional attenuation, since the change in the catchment is minor. This engaging process is ongoing.

- To design an attenuation feature to limit the discharge to the Liffey River. Two alternatives have been analysed:
    - Using oversize pipes.
    - Adding a new attenuation tank.

Using oversize pipes, runoff would be collected at track level and it would be discharged into the oversize pipe. A flow control device would be used to limit discharge and the pipe from this device would then convey the flow to the River Liffey in a controlled manner.

If a new attenuation tank is provided, the location and access for maintenance would be considered.

This drainage strategy will be re-assessed at a later stage so the approach can be validated, and the different elements defined (cover and invert levels, pipe alignment, outfall location, inspection chambers, flow control, etc.). Consultations with the consenting authority will be carried out in order to ensure agreement with this approach and final definition on the maximum allowable discharge.

In case a new outfall to the Liffey River is required, additional consultations will be carried out and OPW Section 50 requirements shall be considered.

5.5 Geotechnical (All Do-Something Options)

New track alignments and electrification interventions will require detailed geotechnical design for the following elements:

- Earthworks and track bed formation design for new slews and vertical alignments changes for the proposals. Due to the potential constraints of the Phoenix Park Tunnel invert being potentially close to the base of the existing trackbed, a slab track may be required to achieve the require vertical and lateral clearances.
- Overhead Line Equipment foundation design.

5.6 Roads (Only Option 2)

The only road works anticipated are associated with option 2.

The level of road carriageway raising noted under the option summary could be achieved with an asphalt overlay but the footpaths would require local reconstruction to facilitate the road raising as well as to accommodate the reinstatement of utilities. The extent of the works would be between 50-70m in length across the entire width of the road ‘right of way’.

A localised low point would be introduced on the eastern side of the bridge and consequently new double gullies would be required to replace the gully currently located adjacent to the bridge.

If the bus corridor upgrades commence prior to rail scheme, then the extent of reinstatement will be nominally more costly primarily owing to the aesthetic finishes to defined segregated cycle lanes.

5.7 Heuston West Station

The development of a new station Heuston West is being studied on the site of the existing Platform 10 south to the Liffey Bridge (UBO1).

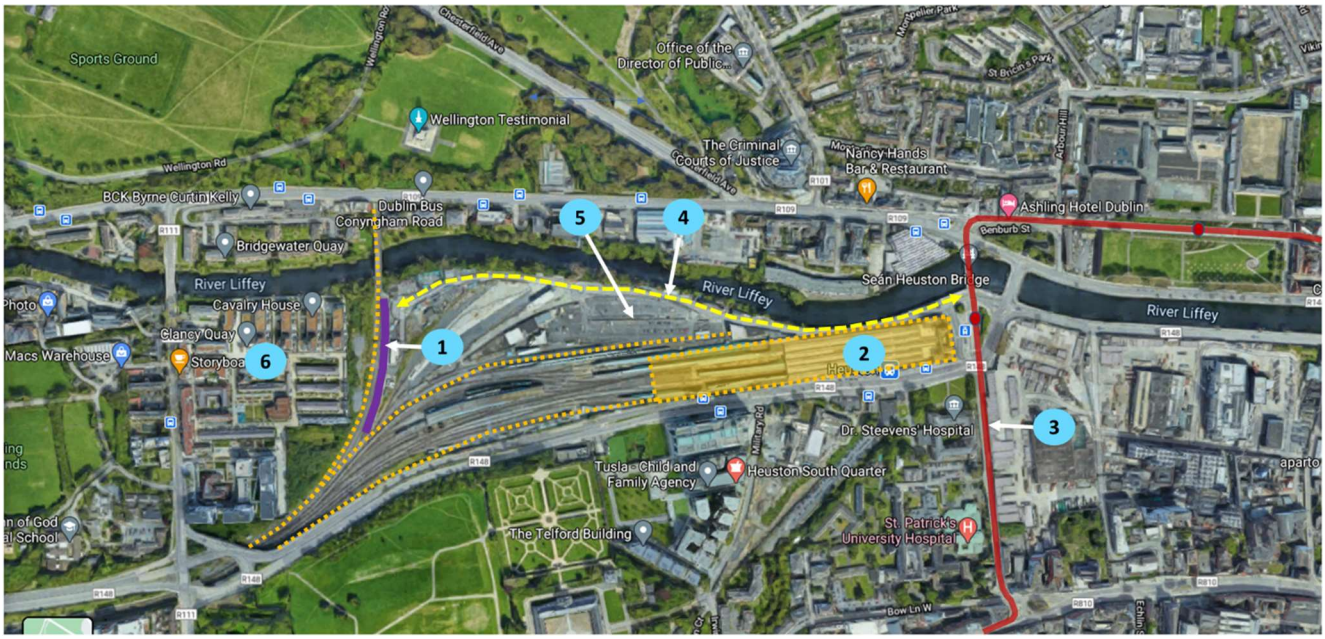


Figure 5-4 Heuston West station. Existing context

The existing context of the area is shown in Figure 5-4 above, where the numbers correspond to:

1) Platform 10
2) Heuston station
3) LUAS
4) Existing route
5) Car park area
6) Clancy Quay development

The scope of the station comprises these basic features:

- Two open platforms, 174 m long, finished with ramps for maintenance and event access to trackway.
- A pedestrian footbridge or underpass connecting both station sides.
- According to Accessibility requirements, access to footbridge or underpass should be done by stairs and ramp, or by stairs and lift.
- Two refuges will be allocated per platform, not reducing the general platform width.
- Platform area and track area will be limited by a fence. Station access will be closed in non-operation hours.
- At least one of the station sides will be accessed by road, including a set-down stop area for vehicles and conditions for the Fire services vehicle access.

The designs must encompass pedestrian and road accesses to the Heuston LUAS stop. Also, to provide access to the West, to the adjacent Islandbridge area. This access requires the study of two basic options: One through a pedestrian overbridge connecting above track; the other by means of an underpass which may be though the bridge arches at the north riverside.

The permanent Way design at this area is specifically constrained by the new station design considering that:

- The available position for the platform is limited between the Liffey Bridge (UBO1) and the Heuston Yard junctions to the south.
- The track design features a radius of 315m through the Platforms, pending a detailed study to confirm a 350m radius, which is the minimum required by the CCE-TMS-345 standard for the extension of existing platforms.
- Clearance to the Clancy Quay Development.

Figure 5-5 Platforms position for the potential Heuston West Station.

The design options under study deal with the different ways of arranging the pedestrian route above or below the trackway. The access from the east side is proposed through the existing road, aiming to produce the less impact possible in the existing rail facilities.

Figure 5-6 below shows one of the options under analysis, where the connection between the platforms is done by means of a stairs and lifts.

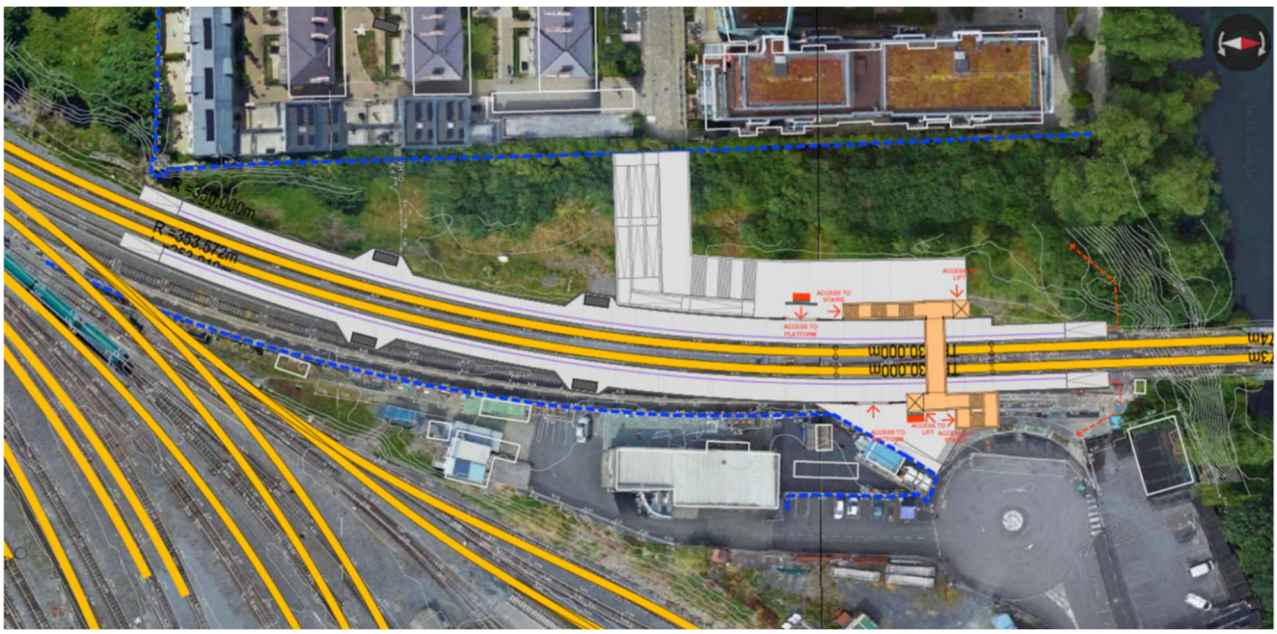


Figure 5-6 Station option with pedestrian overbridge with stairs and lifts.

The existing road to Heuston station is being also studied, to analyse its use for vehicles and pedestrians in conjunction with the station function.

5.8 Cable and Containments (All Do-Something Options)

Existing containment routes consist of buried duct, surface troughing and ladder rack/tray. With the exception of Option 0, all other engineering options will require the relocation of various cables and containments.

Where new containment is required to interface with proposed SET installation these shall be interfaced appropriately with the existing containment runs. Where cable ducts are required to pass under the railway track they shall be contained by a suitable under track crossing

Where there is a required change of direction for cabling draw-chambers shall be installed (surface or otherwise). Draw-pits will be of adequate size to enable cables to be drawn in without damage and accommodating the cable bending radius.

These containment solutions shall be utilised for all SET cabling requirements with services separated as far as is reasonably practical.

5.9 Substations

In order to facilitate the introduction of the new OHLE scheme across the DART+ network, a power supply study has been undertaken. Following review of this study there is a requirement to provide 6 new substations at the following locations:

- Islandbridge
- Kylemore
- Park West
- Kishoge
- Adamstown

- Hazelhatch

Details of the proposed location at Islandbridge is highlighted in drawing DE-04-23-DWG-CV-TTA-08604 in the appendices, and this assumes independent ESB supplies to the substation.

The footprint may need to change if supplies are not available and alternative feeding arrangements need to be considered. Also, any decision on preferred location will only be provisional until the availability of ESB supplies and the route for incoming cables is established.

The required footprint for the substation sites has been determined and based on information in the ESB Construction Standard and the DART+ Traction Power Functional Requirements specification (MAY-MDC-HVP-DART-SP-E-0001), the nominal land-take requirement is estimated to be 20m by 50m for the substation building and compound (including ESB substation requirements directly adjoining). The shape of the available land and its relationship to the vehicle access point will also need to be considered.

6 Options Selection Process

6.1 Options Selection Process

A clearly defined appraisal methodology has been used in the selection of the Emerging Preferred Option for the Project. Consistent with other NTA projects, it is based on 'Guidelines on a Common Appraisal Framework for Transport Projects and Programmes' (CAF) published by the Department of Transport, Tourism, and Sport (DTTAS), March 2016 (updated 2020) and informed by TII's Project Management Guidelines (TII PMG 2019). The Option Selection Process involves a three-stage approach as summarised below:

- Stage 1 Preliminary Assessment (Sifting)
- Stage 2 Multi Criteria Analysis (MCA)
- Stage 3 Emerging Preferred Option

The starting principle of the optioneering process and a focus of the Project Team has been to reduce the potential impacts on the surrounding environs by accommodating necessary works and interventions within the existing rail corridor, where practicable. However, it is acknowledged that as the Kildare Line is an existing operational rail line operating in a pre-defined corridor, the options to accommodate the necessary works at some locations along the route are limited due to spatial constraints.

6.2 Stage 1 Preliminary Assessment (Sifting)

The Stage 1: Preliminary Assessment (Sifting) involves an initial assessment of a long list of options, each of which are assessed against Engineering, Economic and Environmental criteria.

The assessment is based on whether an option meets the Project Objectives / Requirements and whether the option is technically feasible. All feasible options are brought forward to the second stage of the assessment process (MCA) to be explored in greater detail.

The options assessed, ranged from a 'Do-Nothing' Option, Do-Minimum' Option to a range of 'Do-Something' Options, each of the options were assessed to determine if they were feasible and met the Project Objectives / Requirements.

6.3 Preliminary Assessment Sifting

The tables below provide details of the assessment undertaken as part of the Stage 1 Preliminary Assessment (Sifting) Process. Options deemed feasible and fulfilled the project requirements would be brought forward to Stage 2 MCA for a more detailed assessment (note that following sifting an MCA was not required).

Table 6-1 Sifting Process – Conyngham Road Bridge (OBO2)

Option	Requirements		Description
0	Engineering	Constructability	Not applicable. No intervention proposed.
		Geometrical fitness for intervention	Not applicable. No intervention proposed.
		Safety	Not applicable. No intervention proposed.
		OHLE to be installed	FAIL. No intervention proposed. Electrification of the DART+ tracks not achieved.
		Electrical clearance for electrification	FAIL. No intervention proposed. Vertical electrical clearance at structures not achieved.

Option	Requirements		Description
		Safe rolling stock passing clearances	PASS. No intervention proposed.
		Compliant road design	PASS. No intervention proposed.
		Track alignment and drainage (standards)	PASS. No intervention proposed.
	Economy		Compatible with the investment guidelines and programme for DART+
	Environment		No impact on Environmental sites of National of International significance.
	SIFTING OUTCOME		**FAIL. Do not progress to Stage 2 Assessment**
1	**Engineering**	Constructability	PASS. Proposal requires slab track installed in Phoenix Park Tunnel. Unknown ground conditions and the presence of an existing drainage channel in Phoenix Park Tunnel may make construction difficult.
		Geometrical fitness for intervention	PASS. This would require a minimum track lowering of circa 388mm, which is difficult to achieve (Per Way Variation 3) in technical terms as GI and existing drainage channel through Conyngham Road Bridge (OBO2) and Phoenix Park Tunnel unknown and steep gradients exceeding 1.5% feature in the vertical alignment design (Max. 1.859% in PPT).
		Safety	PASS. No issues.
		OHLE to be installed	PASS. Reduced contact wire height achieved will require a derogation (OHLE equipment to be installed between bridge beams).
		Electrical clearance for electrification	PASS. This option achieves a reduced electrical clearance of 4.566m at Conyngham Road Bridge (OBO2).
		Safe rolling stock passing clearances	PASS. Horizontal alignment maintained as existing.
		Compliant road design	PASS. No intervention proposed.
		Track alignment and drainage (standards)	PASS.
	Economy		Compatible with the investment guidelines and programme for DART+.
	Environment		No impact on Environmental sites of National of International significance.
	SIFTING OUTCOME		**PASS. Proceed to Stage 2 Assessment**
2	**Engineering**	Constructability	PASS. Re-construction of Conyngham Road Bridge (OBO2) would be difficult but is considered feasible.
		Geometrical fitness for intervention	PASS. This would require a minimum track lowering of circa 200mm.
		Safety	PASS. No issues.
		OHLE to be installed	PASS. Reduced contact wire height achieved will require a derogation.
		Electrical clearance for electrification	PASS. This option achieves electrical clearance in structures (with derogations).
		Safe rolling stock passing clearances	PASS. Horizontal alignment maintained as existing.
		Compliant road design	PASS. Option is in accordance with derogated standards.
		Track alignment and drainage (standards)	PASS.
	Economy		Compatible with the investment guidelines and programme for DART+
	Environment		No impact on Environmental sites of National of International significance.
	SIFTING OUTCOME		**PASS. Proceed to Stage 2 Assessment**

Table 6-2 Sifting Process – Phoenix Park Tunnel

Option	Requirements		Description
0	Engineering	Constructability	Not applicable. No intervention proposed.
		Geometrical fitness for intervention	Not applicable. No intervention proposed.
		Safety	Not applicable. No intervention proposed.
		OHLE to be installed	FAIL. No intervention proposed. Electrification of the DART+ tracks not achieved.
		Electrical clearance for electrification	PASS. No intervention proposed.
		Safe rolling stock passing clearances	FAIL. Existing lateral clearances are not compliant with standards.
		Track alignment and drainage (standards)	PASS. No intervention proposed.
	Economy		Compatible with the investment guidelines and programme for DART+
	Environment		No impact on Environmental sites of National of International significance.
	SIFTING OUTCOME		**FAIL. Do not progress to Stage 2 Assessment**
1	Engineering	Constructability	PASS. Proposal requires slab track installed in Phoenix Park Tunnel. Associate tunnel improvement works may be necessary. Unknown ground conditions and the presence of an existing drainage channel in Phoenix Park Tunnel may make construction difficult.
		Geometrical fitness for intervention	PASS. Localised tunnel structural intervention may be needed.
		Safety	PASS. No issues.
		OHLE to be installed	PASS.
		Electrical clearance for electrification	PASS. Vertical clearance will allow for electrification in the tunnel.
		Safe rolling stock passing clearances	PASS. Horizontal is improved.
		Track alignment and drainage (standards)	PASS.
	Economy		Compatible with the investment guidelines and programme for DART+.
	Environment		No impact on Environmental sites of National of International significance.
	SIFTING OUTCOME		**PASS. Proceed to Stage 2 Assessment**

6.3.1 Summary of Sifting Process Results

The summary of the options that pass the sifting process for Conyngham Road Overbridge (OBO2) and Phoenix Park Tunnel are shown in Table 6-3 and Table 6-4.

Table 6-3 Summary of Sift Process Results – Conyngham Road

Main Option	Sifting Process Result
Option 0: Do Nothing	FAIL
Option 1: Do Minimum	PASS
Option 2 – Do Something	PASS

Table 6-4 Summary of Sift Process Results – Phoenix Park Tunnel

Main Option	Sifting Process Result
Option 0: Do Nothing	FAIL
Option 1: Do Minimum	PASS

Conyngham Road Bridge (OBO2) has Do Minimum and a Do Something (Option 2) options that pass the sifting process. The Do Minimum is contingent on a validation process to prove certain initial assumptions which will occur later in the scheme development process. Should this exercise demonstrate that this Option is feasible then it would be preferred over the Do Something Option and would be brought forward as the Emerging Preferred Option.

The Phoenix Park Tunnel is limited in terms of possible interventions and the Do minimum is realistically the only feasible option. It will therefore be taken forward to the Emerging Preferred Route.

No MCA process is therefore deemed required through this area.

6.4 Emerging Preferred Route

At the current stage of design development, the Emerging Preferred Option aligns with do-minimum option which in all cases anticipates little or no intervention to the bridges. Where the required electrical clearance beneath the bridges is sub-standard, clearances will be increased by means of track lowering, fitted OHLE and / or derogation from Standard.

Detailed surveys are currently being undertaken, this information will be used to establish if the do-minimum options under consideration are feasible, or if more significant interventions are required to the bridges. Should derogations not be acceptable then bridge interventions will be required.

Appendix A - Sifting Process Backup

Appendix B – Supporting Drawings

The following drawings accompany this Technical Report:

Permanent Way Drawings

DP-04-23-DWG-PW-TTA-35742

DP-04-23-DWG-PW-TTA-35743

DP-04-23-DWG-PW-TTA-35755

DP-04-23-DWG-PW-TTA-35756

DP-04-23-DWG-PW-TTA-35757

DP-04-23-DWG-PW-TTA-35758

DP-04-23-DWG-PW-TTA-35759

DP-04-23-DWG-PW-TTA-35760

Roads Drawing

DP-04-23-DWG-CV-TTA-35270- v02-S3