Lucan to City Centre Core Bus Corridor Scheme

September 2022

Preliminary Design Report

BUS CONNECTS

SUSTAINABLE TRANSPORT FOR A BETTER CITY.

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List of Acronyms

Acronym	Definition
AVL	Dublin Bus Automatic Vehicle Location
BCID	BusConnects Infrastructure Dublin
BCPDGB	BusConnects Preliminary Design Guidance Booklet
BJTR	Bus Journey Time Report
br/bl DBC	brown/black Dublin Boulder Clay
CBC	Central Bus Corridor
CBR	California Bearing Ratio
CPO	Compulsory Purchase Order
DCC	Dublin City Council
CSC	Corrected Scrim Condition
DEHLG	Department of Environment, Heritage and Local Government
DETR UK	Department of Environment, Transport and the Regions
DfT	Department for Transport (UK)
DLAM	Dublin Local Area Model
DM	Do Minimum
DMRB	TII's Design Manual for Roads and Bridges
DMURS	Design Manual for Urban Roads and Streets
DNO	Distribution Network Operator
DRA	Designer's Risk Assessment
DS	Do Something
DTTAS	Department of Transport, Tourism and Sport
ED/ED's	Engineering Design/Engineering Designer's
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMRA	Eastern and Midlands Region
EPR	Emerging Preferred Route
GDA	Greater Dublin Area
GDACNP	Greater Dublin Area Cycle Network Plan
GDRCoP	Dublin Greater Dublin Regional Code of Practice
GDSDS	Greater Dublin Strategic Drainage Study
GIS	Geographical Information Systems
GT	Glacial Till
HGV	Heavy Goods Vehicle
HP	High Pressure
KFPA	Kerbs, Footways and Paved Areas
HSQ	Heuston South Quarter
LED	Light Emitting Diode
LMST	Limestone
LP	Low Pressure
LVSC	Liffey Valley Shopping Centre
MASP	Metropolitan Area Strategic Plan
MCA	Multi-Criteria Assessment
MG	Made Ground
NCDWC	National Construction and Demolition Waste Council
NCM	National Cycle Manual
NDA	National Disability Authority
NPF	National Planning Framework
NSS	National Spatial Strategy
NTA	National Transport Authority

OPW	Office of Public Works
PDR	Preliminary Design Report
PMG	Project Management Guidelines
PMSC	People Movement Signals Calculator
PRC	Practical Reserve Capacity
PRO	Preferred Route Option
ROCK	Bedrock
RSA	Road Safety Audit
RSESs	Regional Spatial and Economic Strategies
RTPI	Real Time Passenger Information
SDRAs	Strategic Development and Regeneration Areas
SDCC	South Dublin County Council
SSD	Stopping Sight Distances
STMG	Sustainable Transport Measures Grants
SuDS	Sustainable (Urban) Drainage Systems
TII	Transport Infrastructure Ireland
TGD	Building Regulations Technical Guidance Document
TS	Topsoil
TSM	Traffic Sign Manual

Executive Summary

This Preliminary Design Report has been prepared for the Lucan to City Centre Core Bus Corridor and builds on the previous Options Study Feasibility Report and the Preferred Route Options Report for the Lucan to City Centre scheme.

This report summarises the project background and the need for the scheme in the context of National and Local Planning Policy, summarises the existing physical conditions and documents the surveys undertaken in developing the design.

The report also details the preliminary design, sets out traffic management proposals and outlines the traffic modelling undertaken and the outputs from the junction modelling.

The land use and acquisition requirements are summarised in this report, along with details of affected landowners and property owners, and proposed accommodation works.

The report concludes that the design of the Lucan to City Centre Core Bus Corridor scheme wholly achieves the scheme objectives. In doing so, it fulfils the aim of providing enhanced walking, cycling and bus infrastructure on a key access corridor in the Dublin region, enabling the delivery of efficient, safe, and integrated sustainable transport movement along the corridor.

1 Introduction and Description

1.1 Introduction

BusConnects is the National Transport Authority's (NTA) programme to improve bus and sustainable transport services. It is a key part of the Government's polices to improve public transport and address climate change. The NTA established a dedicated BusConnects Infrastructure team to advance the planning and construction of the BusConnects Dublin - Core Bus Corridors Infrastructure Works (herein after called the 'CBC Infrastructure Works'). It comprises an inhouse team including technical and communications resources and external service providers procured from time-to-time to assist the internal team in the planning and design of the twelve Proposed Schemes.

The CBC Infrastructure Works involves the development of continuous bus priority infrastructure and improved pedestrian and cycling facilities on twelve radial core bus corridors in the Greater Dublin Area (GDA), across the local authority jurisdictions of Dublin City Council (DCC), South Dublin County Council (SDCC), Dún Laoghaire-Rathdown County Council (DLRCC), Fingal County Council (FCC), and Wicklow County Council (WCC). Overall, the CBC Infrastructure Works encompasses the delivery of approximately 230 km of dedicated bus lanes and 200 km of cycle tracks along twelve stand-alone Core Bus Corridors Schemes.

Lucan to City Centre Core Bus Corridor of the CBC Infrastructure Works (herein after called the 'Proposed Scheme') measures approximately 9.7 km from end to end.

The Proposed Scheme commences at Junction 3 of the N4 Lucan Road / Lucan bypass where the C-Spine route terminates before splitting to branch routes, and is directed east towards the City Centre. From the R136 Ballyowen Road junction with the R835 Lucan Road the route runs east along the R835 Lucan Road to the roundabout serving the Lucan Retail Park and also the N4 Lucan Road eastbound on-slip. It is then routed via the N4 (passing the Liffey Valley Shopping Centre) as far as Junction 7 (M50) and via the R148 along Palmerstown bypass, Chapelizod bypass, Con Colbert Road, St John's Road West, ending at Frank Sherwin Bridge, where it will join the prevailing traffic management regime on the South Quays.

At Junction 3 of the N4, cycle facilities are provided along R136 Ballyowen Road between Hermitage Road and the R835 Lucan Road, and then along the length of the Core Bus Corridor to Junction 2 of the N4. From there cycle facilities are provided along Old Lucan Road either side of the M50 and through Palmerstown village, to the start of the R148 Chapelizod bypass, at which point they will connect with other future cycle facilities through Chapelizod village. Cycle facilities are also provided on the R148 between Con Colbert Road and the end of the corridor at Heuston station on St John's Road West.

The scheme will require a number of significant structures, bridges, gantries, retaining walls and switch back ramps as described in Section 8 of this report.

Refer to Figure 1-1 for overall layout of the Proposed Scheme.

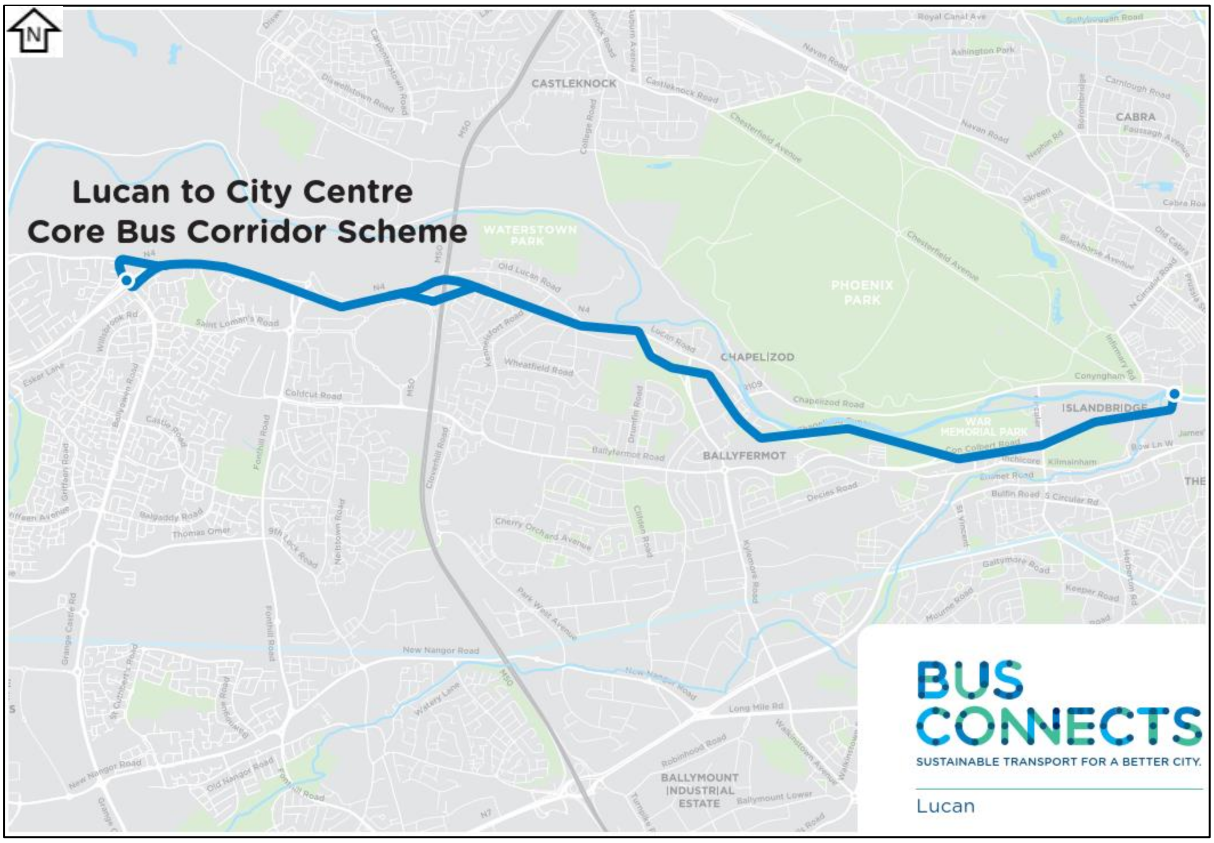

Figure 1-1: Proposed Scheme Route Overview

1.2 Scheme Aims and Objectives

The aim of the Proposed Scheme is to provide enhanced walking, cycling and bus infrastructure along this key access corridor in the west Dublin region, which will enable and deliver efficient, safe, and integrated sustainable transport movement along the corridor.

The objectives are to:

- Enhance the capacity and potential of the public transport system by improving bus speeds, reliability and punctuality through the provision of bus lanes and other measures to provide priority to bus movement over general traffic movements;
- Enhance the potential for cycling by providing safe infrastructure for cycling, segregated from general traffic wherever practicable;
- Support the delivery of an efficient, low carbon and climate resilient public transport service, which supports the achievement of Ireland's emission reduction targets;
- Enable compact growth, regeneration opportunities and more effective use of land in Dublin, for present and future generations, through the provision of safe and efficient sustainable transport networks;
- Improve accessibility to jobs, education and other social and economic opportunities through the provision of improved sustainable connectivity and integration with other public transport services; and
- Ensure that the public realm is carefully considered in the design and development of the transport infrastructure and seek to enhance key urban focal points where appropriate and feasible.

1.3 Project Background

The Transport Strategy for the Greater Dublin Area 2016 – 2035 sets out a network of the bus corridors forming the "Core Bus Network" for the Dublin region. Sixteen indicative radial CBCs were initially identified for redevelopment. This is shown in Figure 1-2 below (extract from Transport Strategy for the Greater Dublin Area 2016-2035).

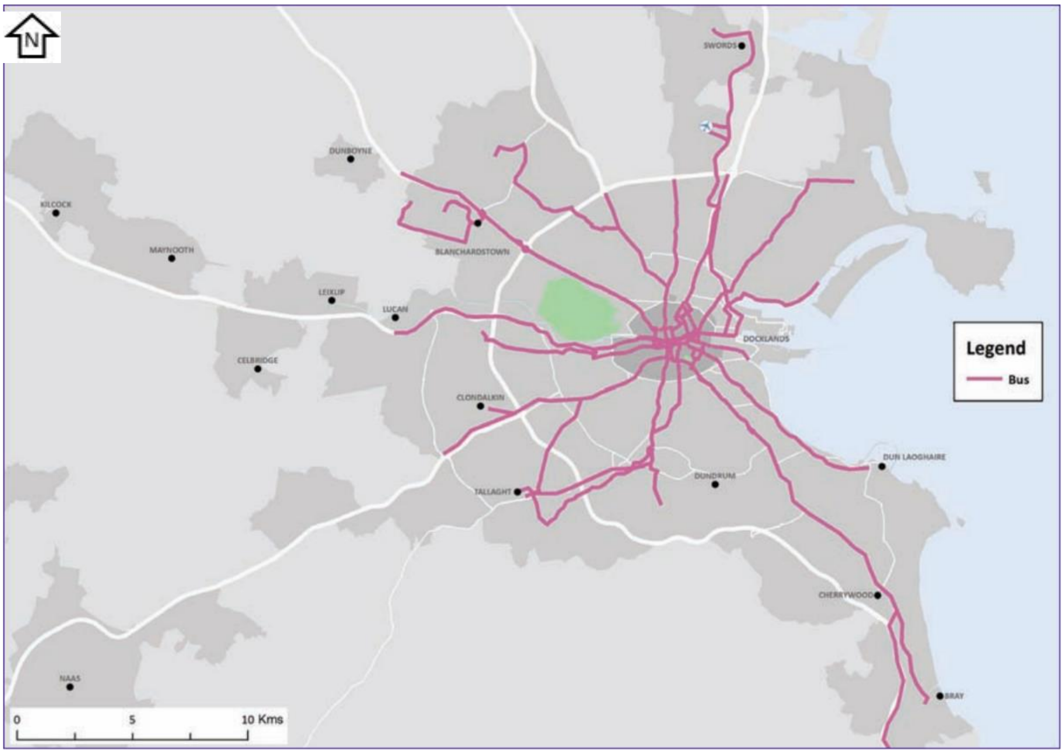

Figure 1-2 2035 Core Bus Network – Radial Corridors

Collectively, these corridors currently have dedicated bus lanes along less than one third of their combined lengths which means that for most of the journey, buses as well as cyclists are competing for space with general traffic. This means that bus services are directly impacted by the increasing levels of congestion. This results in delayed buses and unreliable journey times for passengers. Following the completion of the Feasibility and Options studies, sixteen radial corridors were taken forward.

In June 2018, the NTA published the Core Bus Corridors Project Report. The report was a discussion document outlining proposals for the delivery of a CBC network across Dublin. The Proposed Scheme is identified in this document as forming part of the Radial Core Bus Network, designated as Lucan to City Centre CBC.

In the context of the proposed planning applications for the CBC Infrastructure Works, the initial sixteen radial CBCs have been grouped as twelve individual Schemes. The twelve Schemes that will be the subject of separate applications to An Bord Pleanála for approval are listed below:

- Clongriffin to City Centre Core Bus Corridor Scheme;
- Swords to City Centre Core Bus Corridor Scheme;
- Ballymun / Finglas to City Centre Core Bus Corridor Scheme;
- Blanchardstown to City Centre Core Bus Corridor Scheme;
- **Lucan to City Centre Core Bus Corridor Scheme;**
- Liffey Valley to City Centre Core Bus Corridor Scheme;
- Tallaght / Clondalkin to City Centre Core Bus Corridor Scheme;
- Kimmage to City Centre Core Bus Corridor Scheme;
- Templeogue / Rathfarnham to City Centre Core Bus Corridor Scheme;
- Bray to City Centre Core Bus Corridor Scheme;
- Belfield / Blackrock to City Centre Core Bus Corridor Scheme; and
- Ringsend to City Centre Core Bus Corridor Scheme.

The twelve radial routes that form the CBC Infrastructure works is shown within Figure 1-3.

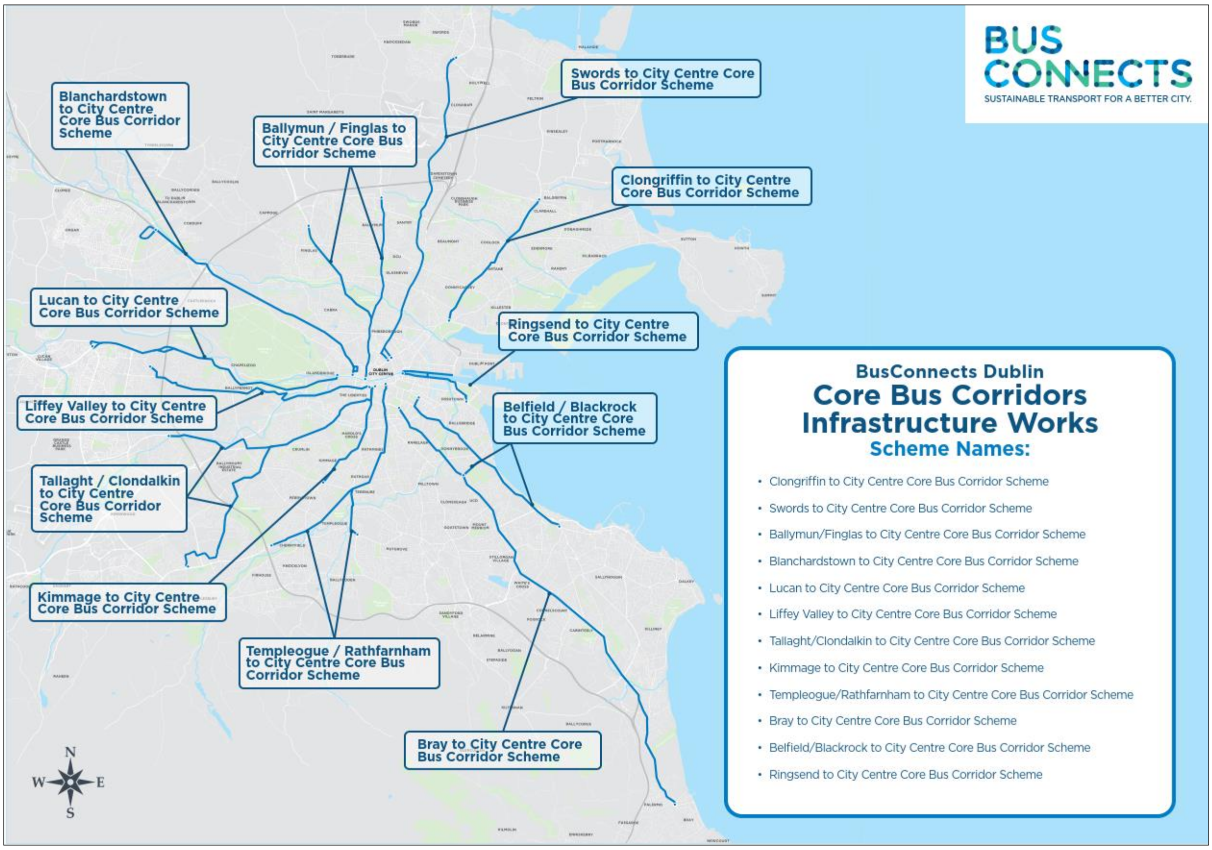

Figure 1-3 BusConnects Radial CBC Network

1.4 Proposed Construction Procurement Method

All of the design-related documentation and background design information should be included with the tender documentation as part of the specification of the Works Requirements. Usually, this includes the definitive Project Brief and all of the documents that have contributed to it, including the Feasibility Studies / Preliminary Reports, Output Specifications, Functional Requirements etc. It also includes any prescriptive drawings and specifications that have been developed in detail sufficient for statutory approval purposes.

Consequently, the design information presented in this report ensures that the objectives of the Proposed Scheme are met, in accordance with current design standards and guidance documents. It further ensures that sufficient land will be acquired during the Compulsory Purchase Order (CPO) process in order to construct the Proposed Scheme and fulfil the design requirements.

Future design stages will be constrained by the requirement to adhere to the design requirements, to incorporate the mitigation specified in the Environmental Impact Assessment Report (EIAR) and to utilise the available land for its construction and any proposed design modifications will require NTA review and acceptance prior to implementation into the Proposed Scheme design.

During preliminary design development, designers' risk assessments were undertaken, details of these are included in Appendix A.

1.5 Stakeholder Consultation

Throughout the development of the design there has been extensive stakeholder consultation including three rounds of non-statutory public consultation have taken place over the following dates:

- 14th November 2018 to 19th March 2019 - Consultation on Emerging Preferred Route;
- 4th March 2020 - 17th April 2020 - Consultation on Preferred Route Option; and
- 4th November 2020 - 16th December 2020 - Consultation on Preferred Route Option.

Refer to the BusConnects website for the Lucan to City Centre Core Bus Corridor Consultation Submissions Summary Reports for information on the non-statutory consultations at the link below.

https://busconnects.ie/wp-content/uploads/2022/02/06-lucan-to-city-centre-report-on-cbc-public-consultation-3.pdf

Consultation with the principal project stakeholders (i.e. SDCC, DCC, statutory undertakers / utility companies) has taken place to date in order to:

- Inform the scheme development process at particular locations;
- Identify constraints and opportunities within the study area, scheme corridor and route options considered;
- Further refine the scheme objectives;
- Discuss potential mitigation measures and options; and
- Identify planning requirements, conditions and implications with respect to the proposed scheme design measures.

Specific scheme requirements have been discussed and agreed during workshops, with the Local Authorities, and meetings, at Steering Group and Programme level. The BusConnects Infrastructure Team has taken cognisance of any specific requirements and recommendations emerging from this process when exploring feasible scheme options and preparing the preliminary design.

In addition to the principal project stakeholders, consultations have taken place with:

- Representative groups;
- Chartered landowners (i.e. owners of lands at any specific locations); and
- Directly impacted landowners.

1.6 Audit of the Existing Situation

The following surveys and desktop studies have been conducted to inform the preliminary design of the Proposed Scheme.

- Problem Identification Audit;
- Accessibility Audit;
- Route Infrastructure Audit;
- Existing Structures Study;
- Existing Route Collision Analysis;
- Private Landings Study;
- Baseline Tree Survey;
- Cycle Journey Time Study;
- Phase 1 Utility Survey;
- Bus Stop Study;
- Traffic Surveys (JTC, ATC, pedestrian and cyclists counts);
- Parking Study; and
- Bus Journey Time Study;

These surveys have been supplemented with secondary record data including: utility record information, Office of Public Works (OPW) Catchment Flood Risk Assessment and Management (CFRAM) Flood Models, Irish Water (IW) drainage models and existing traffic signal data from DCC.

A number of environmental surveys have also been carried out by the Environmental Impact Assessment (EIA) team. Refer to the Environmental Impact Assessment Report for further information.

1.7 Purpose of the Preliminary Design Report

The purpose of the Preliminary Design Report (PDR) is to outline the design intent of the Proposed Scheme and to support the Compulsory Purchase Order (CPO) documentation and Environmental

Impact Assessment Report (EIAR) which form part of the Planning Application to An Bord Pleanála. In particular, the PDR outlines the following:

- Sets out the context for the Proposed Scheme, the justification for the Proposed Scheme, the basis for selecting the proposed scheme improvements, and the design criteria;
- Describes the elements of the Proposed Scheme listed in the preliminary design drawings;
- Summarises the existing physical conditions, addressing, in particular, ground conditions in general and particularly in areas of new construction, existing pavement quality, tree survey information, utility information, road traffic information including existing bus patterns, bus stop usage, traffic signal system, and other relevant information;
- Details and summarises the surveys and studies undertaken in developing the design,
- Sets out traffic management proposals, i.e. permanent changes required as part of the Proposed Scheme (and associated traffic modelling);
- Provides details of the traffic modelling undertaken along the route and the outputs from junction modelling undertaken;
- Summarises the land use and land acquisition requirements, includes details of affected landowners and property owners, and provides details of the accommodation works;
- Sets out particular considerations in the context of the urban landscape of the Proposed Scheme, and the criteria influencing the associated design; and
- Sets out the benefits of the Proposed Scheme.

1.8 Preliminary Design Drawings

A set of preliminary design drawings have been prepared to convey the scheme design principles for each discipline and should be read in conjunction with this PDR. The following table provides a description of the drawings and relevant design content displayed in each of the series as applicable for the scheme. The drawings have been included in Appendix B for reference.

Table 1-1 Preliminary Design Drawings

Drawing Series Volume Code	Drawing Series Description / Scale	Design Content
SPW_KP/SPW_ZZ	Site Location Map (1:12500@ A1) and Site Location Plans (1:2500@A1)	Defines the full extent of the works and planning red line boundary. Outlines the scheme chainage structure and provides context for the locality of adjacent Schemes and other notable locations along the route.
SPW_BW	Fencing and Boundary Treatment Plans (1:500@A1)	To be read in conjunction with the GEO_GA General Arrangement series and GEO_CS Typical Cross Section series. Provides an indication of the locations for the proposed boundary modification works along the route.
GEO_GA	General Arrangement Plans (1:500 @ A1)	Displays information for conveying the overarching scheme design intent , providing information on the proposed pedestrian/cycle/ bus/traffic regime, indicative ultimate tree arrangement (existing trees retained and proposed trees), bus stop/shelter locations, key heritage feature locations, parking and loading arrangements, turn bans, side road treatments in addition to identification of specific items of note to the scheme (structures or significant features which may be further described on other drawing series)
GEO_CS	Typical Cross Sections (1:50 @ A1)	To be read in conjunction with the GEO_GA General Arrangement series. Provides an indication of the proposed cross section works in comparison to the existing road geometry. Indicative pavement/kerbing, boundary treatments and key street furniture are also provided for context.

GEO_HV	Mainline Plan and Profile Drawings (1:500@A1)	To be read in conjunction with the GEO_GA General Arrangement series. Provides an indication of the proposed modification works to the mainline vertical alignment with supplementary information on earthworks/retaining walls and other notable structures along the route (as required).
ENV_LA	Landscaping General Arrangement Plans (1:500@A1)	Provides information relating to urban realm and landscaping proposals including: identification of trees to be removed resulting from the arborist assessments, proposed tree/planting regime, proposed footway surface finishes, locations of proposed Sustainable (Urban) Drainage Systems (SuDS) features and proposed boundary treatment and key street furniture notes.
DNG_RD	Proposed Surface Water Drainage Plans (1:500@A1)	Displays information for conveying the design intent for the drainage portion of the works including identification of SuDS measures, requirements for peak discharge management measures (attenuation/detention/flow control) where applicable, catchment assessments and proposed notable trunk network modifications and outline design for the proposed drainage discharge strategy along the route.
UTL_UC	Combined Existing Utilities Record Plans (1:500@A1)	Displays information regarding existing statutory undertakers' records along the length of the scheme with the proposed scheme features shown as background information for context**.**
UTL_UD	Irish Water Foul Sewer Alteration Plans (1:500@A1)	Provides an indication of the existing trunk foul sewer network and proposed indicative modification/diversion works (where identified) along the route. The existing and proposed kerb lines have been displayed for scheme context.
UTL_UW	Irish Water Potable Water Alteration Plans (1:500@A1)	Provides an indication of the existing trunk potable water network and proposed indicative modification/diversion works (where identified) along the route. The existing and proposed kerb lines have been displayed for scheme context.
UTL_UE	ESB Asset Alteration Plans (1:500@A1)	Provides an indication of the existing trunk electrical network (above and below ground) and proposed indicative modification/diversion works (where identified) along the route. The existing and proposed kerb lines have been displayed for scheme context.
UTL_UL	Telecommunications Asset Alteration Plans (1:500@A1)	Provides an indication of the existing trunk telecommunications network and proposed indicative modification/diversion works (where identified) along the route. The existing and proposed kerb lines have been displayed for scheme context.
UTL_UG	Gas Networks Ireland Asset Alteration Plans (1:500@A1)	Provides an indication of the existing trunk gas network and proposed indicative modification/diversion works (where identified) along the route. The existing and proposed kerb lines have been displayed for scheme context.
LHT_RL	Street Lighting Plans (1:500@A1)	Provides an indication of the proposed modification works to the existing street lighting infrastructure along the route in addition to identification of any key heritage light column features.
TSM_SJ	Junction System Design Plans (1:250@A1)	Provides a more detailed overview of the proposed junction arrangements for pedestrians, cyclists, buses and general traffic with an indication of the proposed junction staging and associated signal

		head arrangements for key signalised junctions/signalised crossings along the route.
TSM_GA	Traffic Signs and Road Markings Plans (1:500@A1)	Provides an indication of the proposed key the signage (information/directional/regulatory) design requirements and the design intent for the proposed lane marking arrangements along the route.
PAV_PV	Pavement Treatment Plans (1:500@A1)	Provides an indication of the proposed pavement treatment works along the length of the route
STR_GA	Bridges and Retaining Structures (Varies)	Provides additional details relating to proposed bridge structure/underpass and gantry works, in addition to structural retaining walls along the route.

It should be noted that a significant volume of other drawings and sketches have also been prepared as required to facilitate the design development process. The information shown on the PDR drawings has been deemed sufficient for the purposes of conveying the design intent of the Proposed Scheme in addition to outlining the extent of works in conjunction with the planning red line boundary extents and CPO documentation.

The planning red line boundary has been displayed on the Site Location Plans in drawing series SPW_ZZ as designated by the solid red line 'SITE EXTENTS'. For clarity the various discipline general arrangement drawing series have been displayed with the permanent extent of works boundary line as designated by the solid red line 'SITE BOUNDARY LINE'. Where construction access or accommodation works are required to facilitate the permanent works this has been displayed by the dashed red line 'TEMPORARY LAND ACQUISITION'.

It is noted that the contractor will be restricted to what works can be carried out in the dashed red line areas, i.e. to be limited to access and or accommodation works only. Storage of materials/stockpiling and/or temporary traffic management proposals will not be permitted for extended periods of time in these areas unless otherwise agreed with landowners and the NTA.

Full details of the compulsory land acquisition required to construct the scheme are provided on the various deposit maps, server maps and associated CPO schedules/documentation for the Proposed Scheme as part of the statutory application documentation.

1.9 Report Structure

The structure for the remainder of this report is set out as follows:

- Chapter 2: Policy Context and Design Standards – This chapter briefly identifies the policies and overview of the approach taken for application of design standards which have been applied to the preliminary design.
- Chapter 3: The Proposed Scheme – This chapter provides an overview of the design intent at various locations along the Proposed Scheme, providing a description of the route in more detailed subsections. An outline of the key interactions with other infrastructure projects is also provided.
- Chapter 4: Preliminary Design – This chapter provides an overview of the key design parameters used for the geometric designs and more detailed descriptions of the design elements for pedestrians, cyclists and buses.
- Chapter 5: Junction Layout – The junction design methodology and modelling process is set out for all key junctions along the length of the route in this chapter
- Chapter 6: Ground Investigation and Ground Condition – This chapter provides an overview of the ground investigation process and existing ground conditions
- Chapter 7: Pavement, Kerbs, Footways and Paved Areas – This chapter gives an overview of the existing pavement situation and proposed pavement design for the scheme

- **Chapter 8: Structures** – In this chapter an overview of the structure's strategy is provided, along with a summary of principal and minor structures, retaining walls and embankments, where applicable.
- **Chapter 9: Drainage, Hydrology and Flood Risk** – This chapter is an overview of the drainage strategy includes descriptions of existing watercourses and culverts alongside a summary of the drainage design for each catchment along the scheme, including the consideration of drainage at structures and the maximisation of SUDS features
- **Chapter 10: Services and Utilities** – This chapter shows the Utilities design strategy documents surveys undertaken to date, identifies conflicts and recommends a number of diversions
- **Chapter 11: Waste Quantities** – This chapter provides an overview of the waste quantities for the Proposed Scheme.
- **Chapter 12: Traffic Signs, Lighting and Communications** – In this chapter the design strategy for traffic signs, road markings, lighting and communications equipment is outlined, alongside descriptions of how these elements can be maintained and monitored safety and securely
- **Chapter 13: Land use and Accommodation Works** – This chapter outlines land use and acquisition requirements, affected land and property owners, and proposed accommodation works
- **Chapter 14: Landscape and Urban Realm** – This chapter is an overview of the landscape and urban realm design strategy focussing on the existing trees and proposed mitigation
- **Chapter 15: How are we Achieving the Objectives** – In this chapter benefits provided by the scheme are summarised against the scheme objectives.
- **Appendices** – Various appendices and background information as referenced throughout the report.

2 Policy Context and Design Standards

2.1 Policy Context

The following national, regional and local policies have been reviewed and considered in the development of the Proposed Scheme:

- Project Ireland 2040;
- Department of Transport: Statement of Strategy (2016-2019);
- Smarter Travel: A Sustainable Transport Future (2009-2020);
- National Cycle Policy Framework (2009);
- Road Safety Strategy (2013-2020);
- Building on Recovery: Infrastructure and Capital Investment Plan (2016-2021);
- The Sustainable Development Goals National Implementation Plan (2018-2020);
- Climate Action Plan (2019);
- Eastern and Midland Regional Assembly, Regional Spatial and Economic Strategy (2019-2031);
- Greater Dublin Area Cycle Network Plan;
- Transport Strategy for the Greater Dublin Area (2016-2035);
- DCC Development Plan (2016-2022);
- South Dublin County Council Development Plan (SDCCDP) 2016 - 2022
- Liffey Valley Local Area Plan (extended 2013) (SDCC); and
- Heuston and Environs Local Area Plan (DCC).

For further information on how the Proposed Scheme meets the policies outlined above refer to the Lucan to City Centre Core Bus Corridor Planning Compliance Report.

2.2 Design Standards

Design standards applied on the Proposed Scheme are stated within the applicable chapters of this report. In addition to national design standards the CBC Infrastructure Works has developed the BusConnects Preliminary Design Guidance Booklet (BCPDGB - included in Appendix O), its purpose is to provide guidance for the various design teams involved in CBC Infrastructure Works, to ensure a consistent design approach across the twelve Proposed Schemes.

The BCPDGB complements existing guidance documents relating to the design of urban streets, bus facilities, cycle facilities and urban realm. A non-exhaustive list of these guidelines is as follows:

- The Design Manual for Urban Roads and Streets (DMURS);
- The National Cycle Manual (NCM);
- TII Publications; • The Traffic Signs Manual (TSM);
- Guidance on the use of Tactile Paving;
- Building for Everyone: A Universal Design Approach, and
- Greater Dublin Strategic Drainage Study (GDSDS).

The BCPDGB focuses on the engineering geometry and Proposed Scheme operation. It is recognised that the Proposed Scheme is being planned and designed within the context of an existing city, with known constraints. The BCPDGB provides guidance, however a more flexible approach to the design of the Proposed Scheme, utilising engineering judgement, may be necessary in some locations due to these constraints.

Where it has been necessary to deviate from the parameters set out in the relevant national design standards and the Preliminary Design Guidance, these deviations, relaxations and departures have been noted within Section 4.17.

3 The Proposed Scheme

3.1 Scheme Description

3.1.1 Introduction

The Proposed Scheme, which has an overall length of approximately 9.7 km, commences at Junction 3 on the N4 and it is routed along the R835 Lucan Road from its junction with the R136 Ballyowen Road to the roundabout serving the Lucan Retail Park and also the N4 Lucan Road eastbound on-slip. It is then routed via the N4 (passing the Liffey Valley Shopping Centre) as far as Junction 7 (M50) and via the R148 along Palmerstown bypass, Chapelizod bypass, Con Colbert Road, St John's Road West, ending at Frank Sherwin Bridge, where it will join the prevailing traffic management regime on the South Quays.

The Proposed Scheme is described below, split into three sections to reflect the national, suburban and urban nature of the corridor.

- Section 1: N4 Junction 3 to M50 Junction 7 – N4 Lucan Road;
- Section 2: M50 Junction 7 to R148 Con Colbert Road – Palmerstown bypass and Chapelizod bypass; and
- Section 3: R148 Con Colbert Road to City Centre (Frank Sherwin Bridge) – Con Colbert Road and St John's Road West.

3.1.2 Section 1: N4 Junction 3 to M50 Junction 7 – N4 Lucan Road

This section of the Proposed Scheme runs from Junction 3 on the N4 Lucan Road / Lucan bypass, as far as M50 Junction 7 and, as described below, will include upgrades to the following junctions to provide bus priority and enhanced pedestrian and cyclist facilities:

- R136 Ballyowen Road / R835 Lucan Road;
- R136 Ballyowen Road / N4 Junction 3;
- R136 Ballyowen Road / Hermitage Road;
- N4 Junction 2; and
- N4 / M50 Interchange (Junction 7).

At the start of the Proposed Scheme at Junction 3 on the N4 Lucan Road / Lucan bypass modifications are proposed to the signalised junction at the end of the N4 westbound off-slip, including the removal of the left-turn slip lane. In order to provide priority for buses and maintain adequate junction capacity for general traffic, the existing lane configuration is maintained on the bridge carrying the R136 Ballyowen Road over the N4. A two-way segregated cycle track is proposed on the east side of the R136 Ballyowen Road between R835 Lucan Road and Hermitage Road, including a new pedestrian and cycle bridge across the N4, which will replace the existing pedestrian only bridge at this location.

At the R136 Ballyowen Road junction with the R835 Lucan Road, it is proposed to remove the existing left-turn slip lanes. Additionally, the location of the existing east bound bus stop on the R835 Lucan Road will be moved closer to the junction and will also be increased in length. A continuous bus lane is proposed along the R835 Lucan Road to the roundabout serving the Lucan Retail Park and also on the N4 Lucan Road eastbound on-slip. A segregated two-way cycle track is proposed on the northern side of this section of the R835 Lucan Road which will require land acquisition from the adjacent green space.

On the N4 Lucan Road it is proposed to maintain the existing continuous eastbound and westbound bus lanes over this section of the route with no change to the number of existing general traffic lanes. In addition, the bus lane on the westbound service road Junction 3 will be extended to ensure bus priority is provided on the approach to the junction with R136 Ballyowen Road at the top of the slip road.

A small area of land acquisition will be required from the site of the former Foxhunter public house to facilitate this extended bus lane.

The proposed design provides a significant improvement to the bus stop provision in the vicinity of the Liffey Valley Shopping Centre (LVSC). The bus stops themselves will be moved some 150m further west, increased in length and bus laybys are proposed, segregated from the adjacent N4 Lucan Road carriageway. A small strip of land acquisition is required on the southern side of the N4 adjacent to the car park of the Liffey Valley Office Campus to facilitate the new westbound bus stop arrangement. A retaining wall is proposed for the new boundary at this location.

To better serve the increased bus stop capacity a new pedestrian only bridge is proposed adjacent to the new bus stop locations, some 200m further west from the existing foot / cycle bridge, which will be retained. The position of this new bridge aligns with the new public transport interchange within the LVSC site which is under construction. A small piece of land acquisition is required from the green area adjacent to the shopping centre for the provision of the ramps leading to the new footbridge. Additionally, the speed limit for the bus lanes between N4 junction 2 and the M50 will be reduced from 60km/hr to 50km/hr in the vicinity of the new bus stops.

Between N4 Junction 2 and the M50 on the eastbound approach a change to the lane designation is proposed to separate earlier the general traffic heading towards the M50 northbound and the R148 Palmerstown bypass and provide a continuous bus lane. A new portal gantry is proposed to provide additional lane destination signage. The relocation of the bus stops for LVSC will allow for an increased length for the buses to accelerate and weave with eastbound traffic approaching the M50 interchange, and also an increased weaving length for all westbound traffic exiting the M50 interchange. On the M50 interchange itself it is proposed to provide two general traffic lanes and a continuous bus lane in both directions through the junction.

To provide a continuous facility for the Primary Cycle Route 6 as identified in the GDA Cycle Network Plan, from the roundabout serving the Lucan Retail Park, facilities for cyclists will initially comprise a Quiet Street along the public road providing access to the Hermitage Golf Club.

On the northern side of the N4 between the entrance to the Hermitage Golf Club and Junction 2 of the N4 a segregated two-way cycle track is included in the Proposed Scheme. Land acquisition will be required from the Hermitage Golf Club to provide this cycle track which will connect with the existing foot / cycle bridge over the N4 adjacent to the Mount Andrew estate / St Loman's Hospital access. A piled retaining wall is proposed for the new boundary and 15m high sports netting is proposed adjacent to the relocated boundary for a 130m length opposite Ballyowen Lane, as well as infill planting to the road side boundary and southern edge of the fairway. Eastwards of this location the two-way cycle track continues on the north side of the N4 and will require land acquisition from the Hermitage Medical Clinic. A retaining wall is proposed for the new boundary. The two-way cycle track will then run along the north side of the eastbound off-slip at Junction 2.

From Junction 2 of the N4 the segregated two-way cycle track will be located along the south side of the Old Lucan Road before connecting to the foot / cycle bridge that crosses the M50. The cycle track will be accommodated within the existing road space on the Old Lucan Road, with the lanes for general traffic being narrowed, and traffic calmed to reflect the proposed 30km/hr speed limit. A length of informal parking will be lost along the southern side of this section of Old Lucan Road where the two-way cycle track is provided.

On the south side of the N4 a pedestrian priority zone is provided between Ballyowen Lane and the existing foot / cycle bridge over the N4 adjacent to the Mount Andrew estate. From Ballyowen Lane a Quiet Street is proposed along Hermitage Road to the R136 Ballyowen Road. The provision of the two-way segregated cycle track along the northern side of the N4 and the Quiet Street along Hermitage Road avoids the need for a segregated one-way cycle track on the southern side of the N4, as well as along the westbound service road and off-slip at Junction 3.

3.1.3 Section 2: M50 Junction 7 to R148 Con Colbert Road – R148 Palmerstown bypass and Chapelizod bypass

On this section between M50 Junction 7 and R148 Con Colbert Road – R148 Palmerstown bypass Chapelizod bypass junctions, as described below, it is proposed to upgrade the following junctions to provide bus priority and enhanced pedestrian and cyclist facilities:

- R148 Palmerstown bypass / Kennelsfort Road;

- Old Lucan Road / Kennelsfort Road Lower; and
- R148 Palmerstown bypass / The Oval;

Between the M50 junction and Kennelsfort Road junction, it is proposed to provide a continuous bus lane and two general traffic lanes in the eastbound direction. In the westbound direction, a bus lane and two general traffic lanes are proposed, with the lane designation amended to separate earlier the general traffic heading toward the M50 and the N4 Lucan Road westbound. This arrangement will allow for a continuous westbound bus lane from the Kennelsfort Road junction and through the M50 interchange.

On the R148 Palmerston bypass modifications are proposed to both the Kennelsfort Road and the Old Lucan Road / The Oval junctions to remove the existing left turn slip lanes. In addition, the left turn movement from Kennelsfort Road Lower to the R148 Palmerstown bypass eastbound is to be prohibited to facilitate new signalised crossings on the east side of the Kennelsfort Road junction to serve the enhanced bus stops, the pedestrian demand and to cater for the proposed two-way cycle track that crosses the R148 Palmerstown bypass at this location. Traffic in Palmerstown village wishing to travel east on the R148 towards the city centre will be able to do so by travelling east along the Old Lucan Road to the junction with the Oval.

In addition, at the signalised junction of the R148 with the Old Lucan Road / The Oval a new westbound, bus only, right turn lane is proposed on the R148 Palmerstown bypass to facilitate new bus services through Palmerstown village. A small area of land acquisition will be required from the western edge of the petrol filling station at this location to accommodate this new bus movement. The existing R148 westbound u-turn facility located some 40m east of the junction with the Oval will be closed.

The existing bus stops on the R148 Palmerstown bypass at Kennelsfort Road and The Oval are to be lengthened and relocated to allow the provision of a bus layby in all cases. In addition, it is proposed to rationalise the bus stops within Palmerstown village with new bus stops provided on the Old Lucan Road immediately west of the junction with Mill Lane.

Between the junction with The Oval and the R833 Con Colbert Road junction, it is proposed to maintain a continuous bus lane and two general traffic lanes in each direction, as per the existing arrangement. The existing bus lane and public transport signals on the westbound on-slip from the R112 Kylemore Road will be retained. New bus stops with laybys are proposed where the R148 Chapelizod bypass crosses Chapelizod Hill Road. These will be connected to Chapelizod Hill Road via a combination of steps and ramps. The existing bridge carrying the R148 Chapelizod Bypass over Chapelizod Hill Road will be widened to accommodate the eastbound bus layby and retaining walls are proposed to support the road widening, steps and ramps. Additionally, the speed limit for the bus lanes along the full length of the R148 Chapelizod bypass will be reduced from 80km/hr to 60km/hr.

A segregated two-way cycle track is proposed to run along the north side of the Old Lucan Road from the foot / cycle bridge crossing the M50, all the way through Palmerstown village connecting to the existing pedestrian priority zone at the start of the R148 Chapelizod bypass. A new Toucan crossing is also proposed on the R112 Lucan Road on the approach to Chapelizod village. The cycle track will be accommodated within the existing road space on the Old Lucan Road, with the lanes for general traffic being narrowed and traffic calmed to reflect the existing 30km/hr speed limit. Several lengths of informal parking will be lost along the northern side of the Old Lucan Road between the M50 and Kennelsfort Road Lower where the two-way cycle track is provided.

Along the Old Lucan Road between Kennelsfort Road Lower and the Oval, the existing pay and display parking on the northern side of the road will be lost to accommodate the two-way cycle track. To offset this loss of parking spaces, the existing parallel pay and display parking spaces on the southern side of Old Lucan Road will be replaced with a higher number of perpendicular parking spaces.

In addition, a new segregated two-way cycle track is proposed along the east side of Kennelsfort Road Lower resulting in the loss of a small number of pay and display parking spaces and resulting in the need for a small area of land acquisition from the frontage of the numbers 20 and 22 (the Palmerstown Lodge hotel). The proposed two-way cycle track crosses the R148 Palmerstown bypass via the new signalised cycle crossing on the east side of the junction described above and ends at a new Toucan Crossing on Kennelsfort Road Upper to provide a connection to the existing cycle lanes.

3.1.4 Section 3: R148 Con Colbert Road to City Centre – St John's Road West

On this section between R148 Con Colbert Road – Chapelizod bypass and Frank Sherwin Bridge – St John's Road West junctions, as described below, it is proposed to upgrade the following junctions to provide bus priority and enhanced pedestrian and cyclist facilities:

- R148 Chapelizod bypass / R148 Con Colbert Road
- R148 Con Colbert Road / R839 Memorial Road;
- R148 Con Colbert Road / R111 South Circular Road;
- R148 St John's Road West / R111 South Circular Road;
- R148 St John's Road West / Heuston South Quarter;
- R148 St John's Road West / Military Road;
- R148 St John's Road West / Heuston Station; and
- R148 St John's Road West / Victoria Quay (Frank Sherwin Bridge).

At the R833 Con Colbert Road junction with the R148 Chapelizod bypass the existing left turn slip lane from R833 Con Colbert Road is removed and a segregated cycle track is proposed in each direction. Between the R833 Con Colbert Road junction and the R111 South Circular Road junction the existing continuous bus lanes and two general traffic lanes are maintained and narrowed slightly to facilitate the introduction of a segregated cycle track in each direction.

At the junction between the R148 Con Colbert Road and Memorial Road, the pedestrian crossing will be moved to the east side of the junction to be on the same side of the junction as the bus stops. In addition, while the junction has been designed to tie-in to the existing one-way layout of Memorial Road, consideration has been given to the tie-in with the proposals contained in the Liffey Valley to City Centre CBC, which proposes making Memorial Road two-way. To facilitate this a new eastbound right-turning lane on the R148 Con Colbert Road could be accommodated within the proposed junction layout.

At the R111 South Circular Road junction, there are a number of changes to existing traffic lanes. On the eastbound and westbound approaches to the junction the existing left turn slip lanes will be removed. On the R111 South Circular Road northbound a short right turn lane is provided to facilitate future bus movements and compensate for restricted turns included in the Liffey Valley to City Centre Core Bus Corridor Scheme. In order to improve the standard of pedestrian and cyclist facilities at this junction, the number of general traffic lanes through the junction will be reduced in the eastbound, northbound and southbound directions and the R111 South Circular Road will be widened along the western edge through the junction to facilitate the inclusion of segregated cycle tracks in each direction.

At the R148 St John's Road West / HSQ junction and the R148 St John's Road West / Military Road junction, existing left-turn slip lanes are removed and improved pedestrian and cyclist facilities will be provided, including Toucan crossings of the R148.

On the R148 St John's Road West between the R111 South Circular Road junction and Heuston Station the existing eastbound lane configuration of one bus lane and one single general traffic lane is proposed to be maintained.

In the westbound direction of R148 St John's Road West a continuous bus lane is to be provided instead of one of the two existing general traffic lanes. A segregated cycle track is proposed in each direction along this section. The existing taxi queuing lane on the eastbound direction will be maintained between the Heuston South Quarter junction and Heuston Station, along with the existing taxi rank at the station.

Along the section of the R148 St John's Road West between the Heuston South Quarter junction and Heuston Station some trees will need to be removed and replaced so that the facilities for both taxis and cycles described above can be provided. An urban realm landscaping improvement is therefore proposed along this section of the road. This includes the removal of the pedestrian guard railing and new planting, which will result in a net increase in the number of trees along the road.

In the immediate vicinity of Heuston Station continuous bus lanes and segregated cycle tracks are provided in both directions as far as Frank Sherwin Bridge, which the Proposed Scheme will tie into the existing arrangement at the Victoria Quay junction. It is proposed to upgrade the bus stop provision on

R148 St John's Road West outside the southern façade of the station, with lengthened bus stops and bus laybys provided in both directions. On the southern side of the road this will require some land acquisition from the Health Service Executive's Dr Steevens' Hospital. The extents of this land acquisition have been minimised by the removal of the central kerbed median between the two signalised crossings of the R148 St John's Road West, which will be upgraded to raised Toucan crossings. A detailed urban realm and landscaping proposal has been developed at this location.

A speed limit of 30km/hr is proposed on the R148 St John's Road West between the junction with Military Road and the end of the Proposed Scheme at the junction with Frank Sherwin bridge. This is in recognition of the high amount of pedestrian activity associated with the public transport interchange at Heuston station. While no changes are proposed to the signalised crossing of the Luas Red Line or the platforms for the Luas stop, a minor reduction in height is proposed to the southern end of the rear wall of the eastern Luas platform to provided clearance to the proposed inbound cycle track.

3.2 Associated Infrastructure Projects and Developments

3.2.1 Introduction

There are a number of major infrastructure projects with which the Proposed Scheme will integrate, as well as some planned major developments which will need to integrate with the Proposed Scheme. These are detailed in 3.21 to 3.2.4 below.

3.2.2 Liffey Valley Shopping Centre Expansion

Phase 1 of the Liffey Valley Shopping Centre (LVSC) expansion located adjacent to the Proposed Scheme immediately south-east of the N4 Junction 2, includes a new bus interchange facility with enhanced bus facilities, pedestrian and cycling infrastructure.

The Proposed Scheme includes a significant improvement to the bus stop provision in the vicinity of the LVSC, and to better serve the increased bus stop capacity a new pedestrian only bridge is included in the Proposed Scheme adjacent to the new bus stop locations. This new bridge is approximately 200m further west from the existing foot / cycle bridge, which will be retained. The position of this new bridge aligns with the proposed public transport interchange within the LVSC site.

Phase 2 of the LVSC expansion includes significant redevelopment and expansion including upgrades and signalisation of N4 Junction 2 roundabout junctions and Fonthill Road R133. Permission for the LVSC expansion was granted in December 2021.

3.2.3 Strategic Housing Development

Construction is underway on a strategic housing development (SHD) of 250 no. apartments on the north-west corner of the R148 Palmerstown bypass / Kennelsfort Road Junction, Palmerstown. This will include provision of a left-in left-out, with bollards in the centre of Kennelsfort Road to enforce the left only egress, and segregated pedestrian and cycle access. Service vehicles entering the site will be restricted to one way only traffic movements, with service vehicles entering the subject site from Kennelsfort Road Lower and exiting onto the Old Lucan Road.

The SHD proposal provides for a toucan crossing of Kennelsfort Road Lower. This will need to be modified to provide a central refuge and staggered crossing required for the Proposed Scheme.

3.2.4 Palmerstown Lodge Hotel Development

Permission has been granted for a 53 bedroom boutique hotel to replace the existing 29 bedroom guesthouse located at 20 and 22 Kennelsfort Road Lower in the north-east corner of the R148 Palmerstown bypass / Kennelsfort Road junction. The development proposes replacing the existing two entrance/ exits with one wider pedestrian, cycle and vehicular entrance / exit served by a wider yellow box junction, and realignment of front site boundary, including transfer of land to facilitate the provision of the segregated two-way cycle track and footway in the Proposed Scheme.

3.2.5 Kildare Route Project / Dart+ South West

Irish Rail proposals to upgrade / four-track the Kildare rail line and the reconstruction or refurbishment of existing footbridges along the route. Design development of the scheme is still at an early stage; however, Irish Rail have confirmed their proposed design will stay within the limits of the existing structures at R148 / South Circular Road Junction.

The Proposed Scheme has marginally increased the carriageway set back / protection to the sub-standard bridge parapet at the South Circular Road junction bridge OBC1.

3.3 Integration with Liffey Valley to City Centre Core Bus Corridor Scheme

3.3.1 Introduction

As part of the Preliminary Design of the Proposed Scheme, consideration has been given to the potential coordination required in relation to other Proposed Schemes within the BusConnects CBC Infrastructure Works where relevant. In this regard this section outlines potential interactions of the Proposed Scheme with adjacent scheme(s) and identifies any procedures within the construction strategies that may be required in order to account for various sequencing scenarios in the construction of the schemes. The Proposed Scheme will only interact with the Liffey Valley to City Centre CBC Scheme.

The BCID Infrastructure Team has coordinated the Proposed Schemes designs to ensure a holistic design has been achieved, so that each scheme can be implemented, and integrated, regardless of the sequencing of their construction.

The Liffey Valley to City Centre CBC Scheme (the Liffey Valley Scheme), interfaces with the Proposed Scheme at Con Colbert Road, Memorial Road and South Circular Road.

3.3.2 Con Colbert Road

Figure 3.1 shows an extract of the preliminary design of the Proposed Scheme on the Con Colbert Road which ties in with the existing layout.

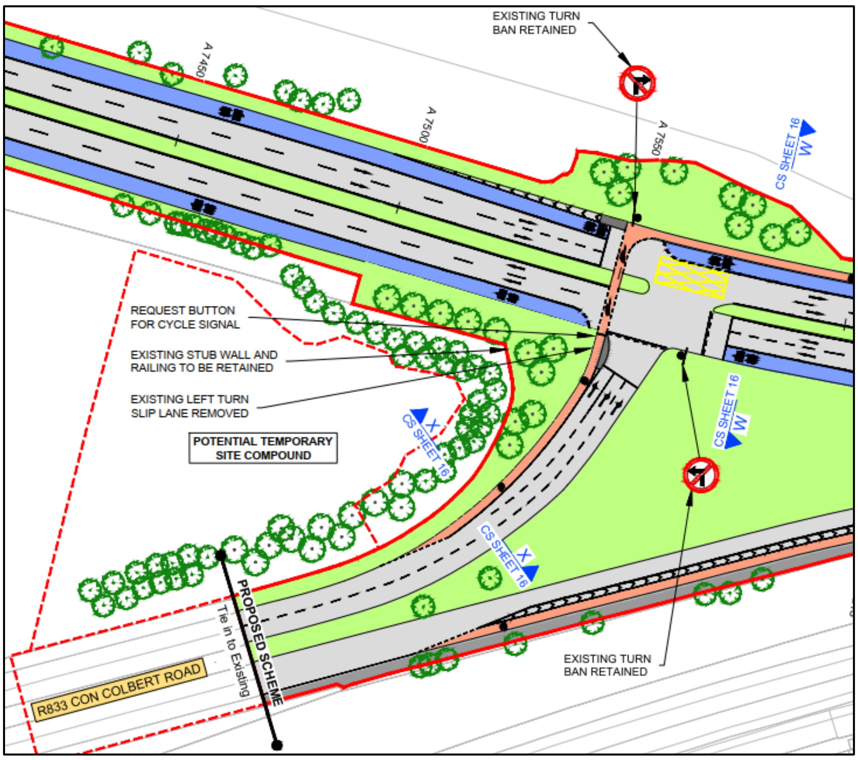

Figure 3-1 Preliminary Design of the Proposed Scheme Tie-in with the Existing Layout

The Proposed Scheme intends to tie-in with the Liffey Valley Scheme at Con Colbert Road in order to provide a cycling connection between the Proposed Scheme and the Liffey Valley Scheme. This cycling connection will provide an alternative segregated cycling facility to the City Centre which follows the secondary Cycle Route 6A in the GDA Cycle Network Plan. Figure 3.2 shows an indicative coordinated design of the expected overall arrangement in a scenario in which both schemes have been implemented.

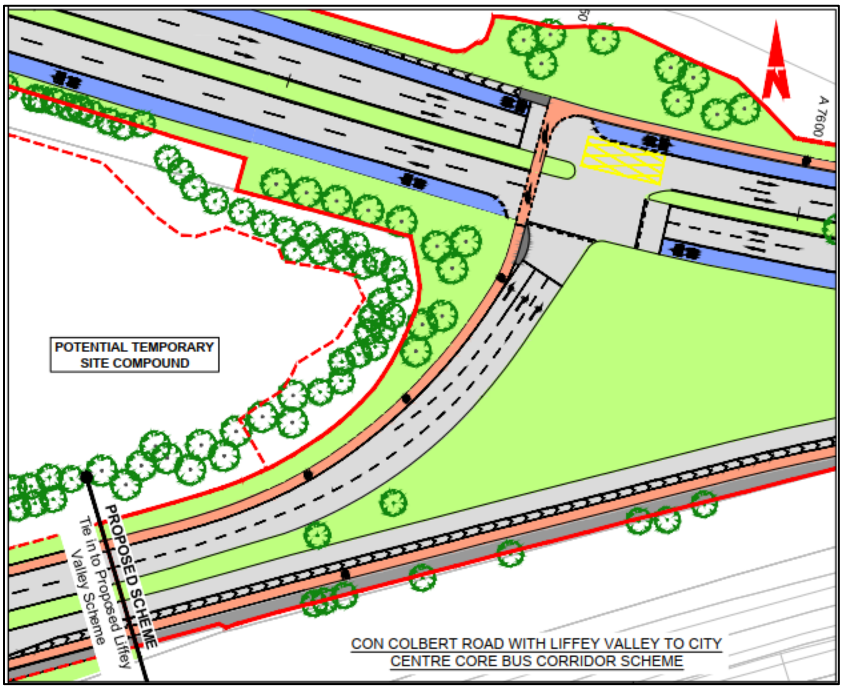

Figure 3-1 Preliminary Design of the Proposed Scheme Tie-in with the Liffey Valley Scheme

Table 3-1 presents a matrix of potential interactions and impacts associated with various potential sequencing scenarios in relation to construction and operation of both schemes.

Table 3-1: Matrix of Potential Interactions and Impacts Associated with Different Sequencing Scenarios

	Liffey Valley Scheme: Not Yet Commenced	Liffey Valley Scheme: Under Construction	Liffey Valley Scheme: Completed
Proposed Scheme: Not Yet Commenced	N/A	Construction of the Liffey Valley Scheme will be carried out in accordance with the Construction Strategy within that scheme's planning application, without any potential interaction with works associated with the Proposed Scheme.	The Liffey Valley Scheme shall be in full operation, designed in accordance with its planning application which will allow for the Lucan Scheme to tie in at a future date.
Proposed Scheme: Under Construction	Construction of the Proposed Scheme shall be carried out in accordance with the Construction Strategy within that scheme's planning application, without any potential interaction with works associated with the Liffey Valley Scheme.	It is not envisaged that both schemes will be under construction at the same time at this location.	The Liffey Valley Scheme will have been completed and the Proposed Scheme will tie into the revised layout on the Con Colbert Road which will provide a cycling connection between the two schemes.

Proposed Scheme: Completed	The Proposed Scheme shall be in full operation, designed in accordance with its planning application which will allow for the Liffey Valley Scheme to tie in at a future date.	The Proposed Scheme will be completed and the Liffey Valley Scheme will tie into the revised layout on the Con Colbert Road. The proposed cycling connection to the Liffey Valley Scheme will be implemented.	The arrangement will be as per Figure 3.2.

3.3.3 Memorial Road

Figure 3.3 shows an extract of the preliminary design of the Proposed Scheme at Memorial Road which ties in with the existing layout.

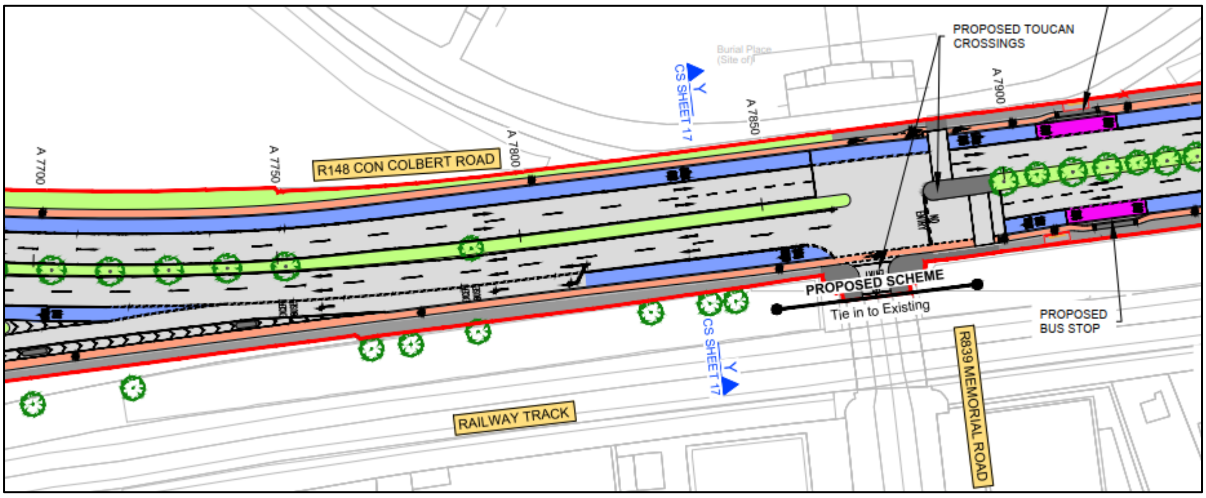

Figure 3-3 Preliminary Design of the Proposed Scheme Tie-in with the Existing Layout

The Proposed Scheme intends to tie-in to the Liffey Valley Scheme at Memorial Road. The Liffey Valley Scheme intends to provide a right turn lane for eastbound traffic on Con Colbert Road to accommodate the proposed revised two-way layout on Memorial Road. Figure 3.4 shows an indicative coordinated design of the expected overall arrangement in a scenario in which both schemes have been implemented.

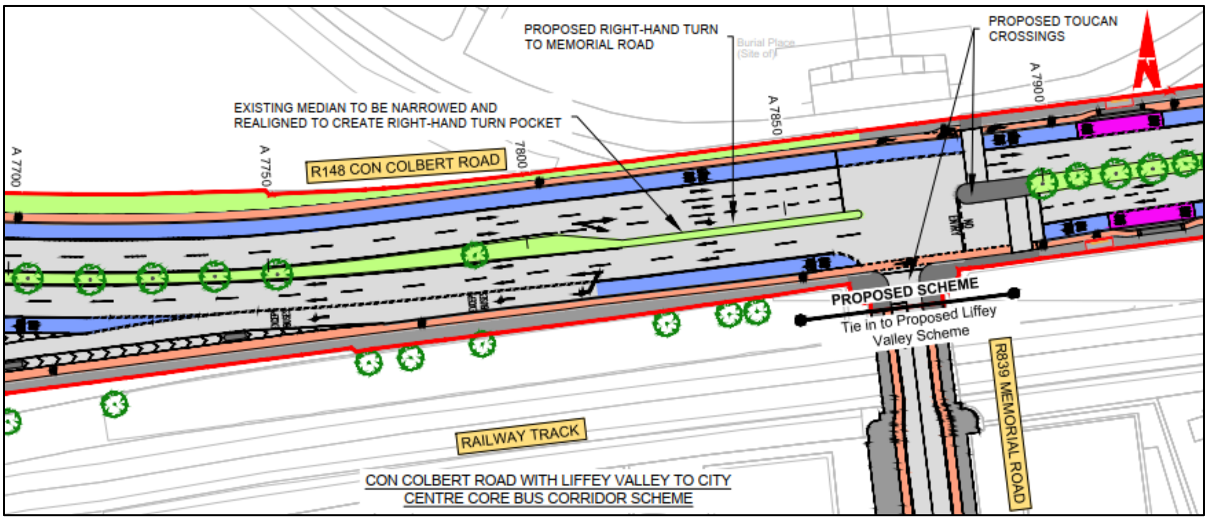

Figure 3-4 Preliminary Design of the Proposed Scheme Tie-in with the Liffey Valley Scheme

Table 3-2 presents a matrix of potential interactions and impacts associated with various potential sequencing scenarios in relation to construction and operation of both schemes.

Table 3-2: Matrix of Potential Interactions and Impacts Associated with Different Sequencing Scenarios

	Liffey Valley Scheme: Not Yet Commenced	Liffey Valley Scheme: Under Construction	Liffey Valley Scheme: Completed
Proposed Scheme: Not Yet Commenced	N/A	Construction of the Liffey Valley Scheme will be carried out in accordance with the Construction Strategy within that scheme's planning application, without any potential interaction with works associated with the Proposed Scheme.	The Liffey Valley Scheme shall be in full operation, designed in accordance with its planning application which will allow for the Lucan Scheme to tie in at a future date.
Proposed Scheme: Under Construction	Construction of the Proposed Scheme shall be carried out in accordance with the Construction Strategy within that scheme's planning application, without any potential interaction with works associated with the Liffey Valley Scheme.	It is not envisaged that both schemes will be under construction at the same time at this location.	The Liffey Valley Scheme will have been completed and the Proposed Scheme will tie into the revised layout on the Con Colbert Road which will provide a cycling connection between the two schemes.
Proposed Scheme: Completed	The Proposed Scheme shall be in full operation, designed in accordance with its planning application which will allow for the Liffey Valley Scheme to tie in at a future date.	The Proposed Scheme will be completed and the Liffey Valley Scheme will tie into the revised layout on the Con Colbert Road. The proposed right turn lane to Memorial Road will be implemented.	The arrangement will be as per Figure 3.4.

3.3.4 South Circular Road Junction

In order to accommodate the movement of some future bus services, the Proposed Scheme includes the removal of the existing right turn ban, and the provision of a new right turn lane, for northbound traffic on the R111 South Circular Road. The Liffey Valley Scheme also includes the same right turn lane for northbound traffic which will provide an alternative route to the City Centre which avoids the Mount Brown bus gate.

Figure 3.5 shows an extract of the preliminary design of the Proposed Scheme at the South Circular Road. This also represents the layout in the scenario where both schemes have been implemented

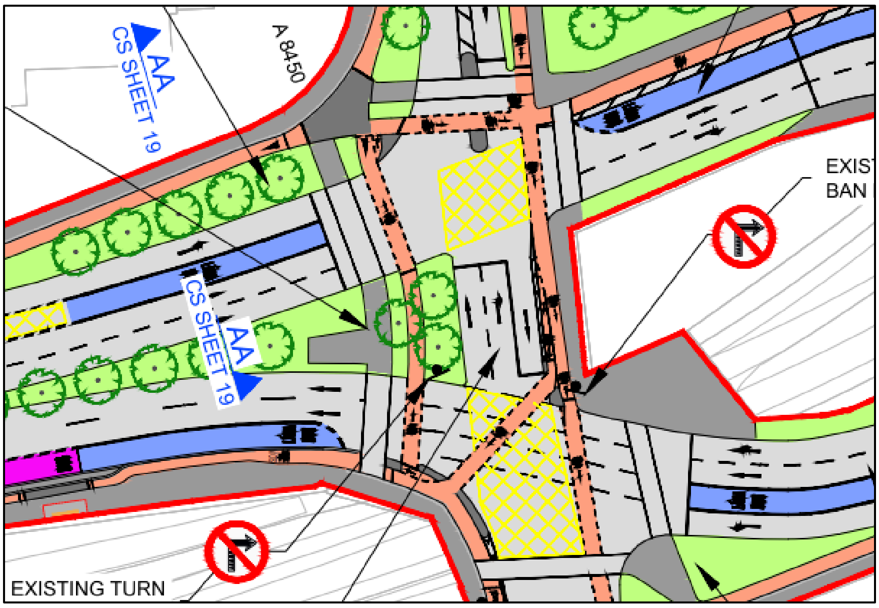

Figure 3-5 Preliminary Design of the Proposed Scheme

Figure 3.6 shows an extract of the preliminary design of the Liffey Valley Scheme at the South Circular Road, where the inclusion of the new right turn lane tie in to DCC's mobility scheme that was constructed in 2021.

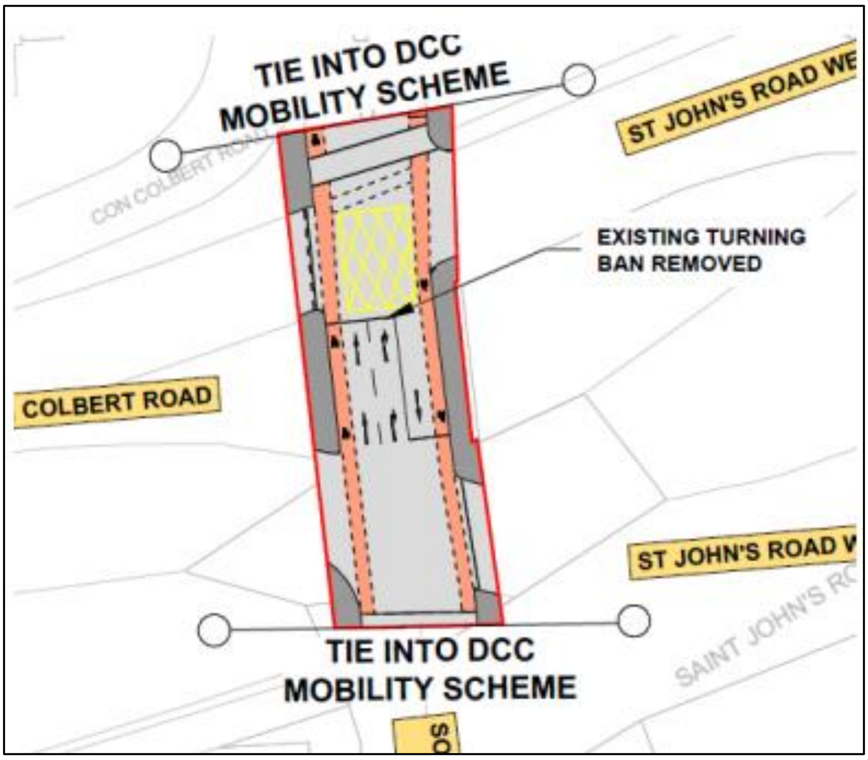

Figure 3-6 Preliminary Design Layout of the Liffey Valley Scheme

Table 3-3 presents a matrix of potential interactions and impacts associated with various potential sequencing scenarios in relation to construction and operation of both schemes.

Table 3-3: Matrix of Potential Interactions and Impacts Associated with Different Sequencing Scenarios

	Liffey Valley Scheme: Not Yet Commenced	**Liffey Valley Scheme: Under Construction**	**Liffey Valley Scheme: Completed**
Proposed Scheme: Not Yet Commenced	N/A	Construction of the Liffey Valley Scheme will be carried out in accordance with the Construction Strategy within that scheme's planning application, without any potential interaction with works associated with the Proposed Scheme.	The Liffey Valley Scheme shall be in full operation, designed in accordance with its planning application which will allow for the Lucan Scheme to tie in at a future date.
Proposed Scheme: Under Construction	Construction of the Proposed Scheme shall be carried out in accordance with the Construction Strategy within that scheme's planning application, without any potential interaction with works associated with the Liffey Valley Scheme.	It is not envisaged that both schemes will be under construction at the same time at this location.	The Liffey Valley Scheme will have been completed and the Proposed Scheme will tie into the revised layout on the South Circular Road which will provide a new right turn lane.
Proposed Scheme: Completed	The Proposed Scheme shall be in full operation, designed in accordance with its planning application. No further works will be required for the Liffey Valley Scheme at this location.	The Proposed Scheme will be completed. No further works will be required for the Liffey Valley Scheme at this location.	The arrangement will be as per Figure 3.5.

4 Preliminary Design

4.1 Principal Geometric Parameters

As a safety improvement, junction improvement and traffic management scheme within an urban area, the Proposed Scheme has generally been designed to urban standards in accordance with the Design Manual for Urban Roads and Streets (DMURS), published by the Department of Transport, Tourism and Sport and the Department of Environment, Community and Local Government in 2013. For the Proposed Scheme the geometric design parameters along the N4 and Chapelizod bypass (R148) are in accordance with the TII DMRB.

DMURS provides guidance in the design of urban roads and streets. DMURS recognises the challenges of fully applying its standards on schemes that involve the retrofitting of new facilities to existing roads and streets, as is the case for this scheme.

The design philosophy adopted for the scheme has applied a balanced and integrated approach to road and street design by applying as far as practicable the four design principles of DMURS, i.e. with respect to connected networks; multi-functional streets; pedestrian focus; and multidisciplinary approach.

In addition to DMURS, criteria from other documents have been considered to provide the most appropriate design application, including the National Cycle Manual, the Transport Infrastructure Ireland (TII) Design Manual for Roads and Bridges (DMRB), Building for Everyone: A Universal Design Approach and the BCPDGB.

A number of published design standards and guides have been utilised to inform the geometrical design of the Proposed Scheme, as listed below:

- TII's Design Manual for Roads and Bridges (DMRB);
- Design Manual for Urban Roads and Streets (DMURS);
- National Cycle Manual (NCM);
- Traffic Sign Manual (TSM);
- Traffic Management Guidelines (TMG);
- NDA's Building for Everyone: A Universal Design Approach;
- Guidance on the use of Tactile Paving Surfaces (UK DfT 2021);
- Construction Standards for Road and Street Works in DCC; and
- BusConnects Preliminary Design Guidance Booklet (BCPDGB) – See Appendix O.

Table 4-1 below details the key design parameters which have been generally adopted to inform the Proposed Scheme design layout. The table describes the relevant geometric features set out in order of functional geometrical requirements for each road user including pedestrians (footways), cyclists (cycle tracks), bus lanes, general traffic lanes, junctions and parking / loading areas. In designing the geometrical elements of the Proposed Scheme a balanced approach to the requirements for each of the road functions from a people movement perspective is needed, noting that the aim of the Proposed Scheme is to provide enhanced walking, cycling and bus infrastructure. It should be noted that the development of the urban realm proposals along the corridor have also informed the key geometrical layouts for the proposed scheme which are further discussed in Chapter 14.

Table 4-1 BusConnects Key Design Parameters

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
All	Road Type	The Proposed Scheme and adjoining street network function in line with DMURS (60km/hr or less)	Varies - Scheme wide	Arterial Link / Link Street / Local Streets	DMURS (Figure 3.3)
		The Proposed Scheme in line with TII Publications Design Standards (80km/hr or more)		National Roads	TII Publications
Footway	Footway Widths	Nominal footway widths in low pedestrian activity areas and pinch point areas.	Varies - Scheme wide	• 2m desirable minimum width • 1.8m minimum nominal width (low pedestrian activity area or localised restrictions) • 1.2m absolute minimum width at pinch points (e.g. trees over 2m length)	NDA[1] (Section 1.5.1) DMURS (Figure 4.34)
		Nominal footway widths in moderate – high pedestrian activity areas		• 2.5m-3m desirable width (moderate to high pedestrian activity area) • 3m-4m desirable width (high pedestrian activity area)	NDA[1] (Section 1.5.1) DMURS (Figure 4.34)
	Footway Longitudinal Gradient	New road sections or new offline Footways		• 0.5% (1 in 200) absolute minimum • 3% (1 in 33) desirable maximum • 5% (1 in 20) absolute maximum (where constrained by road geometry and other factors)	DMURS (Section 4.4.6)
		Existing Footways with localised adjustments		• Generally in line with existing site constraints to a maximum of 5% (1 in 20) gradient with no less than 0.5% (1 in 200)	DMURS (Section 4.4.6)
		Ramp gradients – urban realm		• Nominal gradient of 1 in 25 with landings at maximum 19m intervals and routes with a gradient of 1 in 33 should have landings at no more than 25m intervals with linear interpolation between gradients as required • Desirable max gradient 1 in 20 with 0.45m max rise over 9m length between landings	NDA[1] (Section 1.5.2) DN-STR-03005 (Section 6.9, 6.14, 6.15)
		Ramp gradients – bridge structures		• Desirable max gradient 1 in 20 with 2.5m max rise between landings • Absolute max 1 in 15 – 1 in 12 with 0.65m max rise between landings where 1 in 20 is not practical)	

[1] National Disability Authority: *Building for Everyone: A Universal Design Approach - External environment and approach*

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
	Footway Crossfall Gradient	Fully reconstructed road sections or new offline Footways		• 1 in 50 nominal gradient	NDA[1] (Section 1.5.1.1)
		Existing Footways with localised adjustments		• Generally in line with existing site constraints to a maximum of 3.3% (1 in 33) gradient with no less than 1.5% (1 in 65)	DN-PAV-03026 (Table 2.3)
Cycle Track	Cycle Track Width	Optimum cycle track width (two abreast cycling): single-direction, with-flow, raised-adjacent cycle track		• 2m desirable minimum width	BCPDGB (Section 5)
		Minimum cycle track (single file cycling): single-direction, with-flow, raised-adjacent cycle		• 1.5m minimum width • 1m absolute minimum width at constrained island bus stop locations	BCPDGB (Section 5.3, 11.2)
		Two-way cycle track (single file cycling)		• 3.25m desirable minimum cycle track with additional desirable minimum 0.5m buffer and absolute minimum 0.3m buffer • Using the NCM width calculator, reduction of these desirable minimum widths can be considered on a case-by-case basis, with due cognisance of the volume of cyclists anticipated to use the route as well as the level of service required	BCPDGB (Section 5.3)
		Pedestrian priority zone areas (pedestrian and cyclist) for constrained locations		• 3m minimum width	NCM 1.9.3
	Horizontal Curvature	Minimum horizontal radius (General Alignment)	20 km/h	• 10m radius (urban areas)	NCM 4.10.3
			30 km/h	• 20m	NCM 4.10.3
			40 km/h	• 25m	NCM 4.10.3
		Minimum horizontal radius (island bus stops)		• 4m radius (entry deflection radius) • 6m radius (exit deflection radius)	BCPDGB (Figure 34)
		Nominal deflection – parking and loading bays		• 1 in 3 horizontal taper at cycle protected parking	BCPDGB (Figure 12)
		Nominal deflection – island bus stops		• 1 in 1.5 horizontal taper at island bus stops	BCPDGB (Figure 34)
	Longitudinal Gradient	Acceptable gradient range		• 0.5% to 5.0% (1:200 to 1:20)	NCM 5.2.3.4

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
	Ramps	Transition to cycle track to carriageway		• 60mm drop at 1:20 gradient (2.4m long)	NCM 4.10
		Transition from carriageway to pedestrian priority zone		• 120mm at 1:20 gradient (4.8m long)	NCM 4.10
		Transition from cycle track to pedestrian priority zone		• 60mm rise at 1:20 gradient (2.4m long)	NCM 4.10
	Crossfall Gradient	Acceptable gradient range		• 1.25% to 2.5% (1:80 to 1:40)	NCM 5.2.3.4
Bus Lane	Shared Bus/ Cycle Lane	Lane widths (collector / link roads – low speed) in constrained environments	30-50 km/h	• 3m max width (consideration for cycle and bus (including taxis + other permitted vehicles) volumes required in addition to bus lane operation hours)	NCM 4.3.3
			60 km/hr	• 3.0m width	NCM 4.3.3
	Nominal with Flow Bus Lane Widths	Nominal lane widths adjacent to cycle track / Footway	50 km/h	• 3m min width and lane widening as required by vehicle tracking assessment on tight bends	BCPDGB (Section 5.1)
			60 km/hr	• 3.25m min width and lane widening as required by vehicle tracking assessment on tight bends	BCPDGB (Section 5.1)
			85 km/hr	• 3.0m min width	BCPDGB (Section 5.1)
		Bus lanes adjacent to on street parking (no cycle track / Footway)	30-50 km/h	• 3m min width with consideration for designated buffer zones and delineated parking areas	BCPDGB (Figure 12)
	Design Speed	Design speed for vehicles in bus lane along the Proposed Scheme	30-50 km/h	• See Table 4-1	DMURS (Section 4.1.1 & Table 4.1)
			60 km/hr	• See Table 4-1	DMURS (Section 4.1.1 & Table 4.1)
			85 km/hr	• National Road	TII DN-GEO-03031 (Section 1.1.3-1.3 & Tables 1.2 & 1.3)
	Visibility	Forward Visibility Stopping Sight Distance SSD (Buses and HGV vehicles).	30 km/h	• 24m	DMURS (Table 4.2 – 50km/h)
			50 km/h	• 49m	
			60 km/h	• 65m	

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
			85 km/h	• 160m	TII DN-GEO-03031 (Section 1.3 & Table 1.3)
	Headroom	Headroom vertical clearance for different structures		• Overbridges – 5.3m(new construction), 5.03m (maintained headroom) • Footbridges and sign / signal gantries – 5.7m (new construction), 5.41m (maintained headroom)	DN-GEO-03036 (Table 5.1)
Traffic Lane	Design Speed	Design speed for vehicles in general traffic lanes along the Proposed Scheme	30 km/h	• Local roads	DMURS (Section 4.1.1 & Table 4.1)
			50 km/h	• Link streets / Local streets	
			60 km/h	• Link street / Local streets	
			85 km/h	• 80 km/h speed limit on National Roads / Regional Roads	TII DN-GEO-03031 (Section 1.1.3-1.3 & Tables 1.2 & 1.3)
	Traffic Lane Width	Min carriageway lane width	30 km/h	• 3m min width and lane widening as required by vehicle tracking assessment on tight bends	BCPDGB (Section 5.1)
			50 km/h	• 3m min width and lane widening as required by vehicle tracking assessment on tight bends	
			60 km/h	• 3.25m min width	
			85 km/h	• 3.5m min width	TII DN-GEO-03036-06
	Visibility	Forward visibility Stopping Sight Distance SSD (buses and HGV vehicles).	30 km/h	• 24m	DMURS (Table 4.2 – 50 km/h)
			50 km/h	• 49m	
			60 km/h	• 65m	
		Forward visibility Stopping Sight Distance SSD (cars and smaller vehicles)	30 km/h	• 23m	DMURS (Table 4.2 – 50 km/h)
			50km/h	• 45m	
			60 km/h	• 59m	

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
			85 km/h	• 160m	TII DN-GEO-03031 (Section 1.3 & Table 1.3)
		Visibility to regulatory signage	Up to 50 km/h	• 60m recommended clear	TSM Table 5.1
			60 to 80 km/h	• 75m (or 90m where greater prominence is required) recommended clear	
			81 to 100 km/h	• 90m (or 120m where greater prominence is required) recommended clear	
		Minimum clear visibility distance of gantry sign	60km/h	• 300m minimum clear visibility distance of gantry sign • Directional signage on the approach to a diverge should be located 1km and 500m upstream of the diverge as well as at the start of the nosing of the exit taper	TSM Table 2.3.1
			85km/h [80 km/h speed limit]	• 300m minimum clear visibility distance of gantry sign • Directional signage on the approach to a diverge should be located 1km and 500m upstream of the diverge as well as at the start of the nosing of the exit taper	TSM Table 2.3.1
	Horizontal Curvature	Minimum radius with adverse camber of 2.5%	30 km/h	• 26m	DMURS (Table 4.3)
			50 km/h	• 104m	
			60 km/h	• 178m	
		Minimum radius without elimination of Adverse Camber and Transitions	85 km/h	• 1440m	TII DN-GEO-03031 (Section 1.3 and Table 1.3)
	Vertical Curvature	Crest curve K value	30 km/h	• N/A	DMURS (Table 4.3)
			50 km/h	• 4.7	
			60 km/h	• 8.2	
			85 km/h	• 55	TII DN-GEO-03031 (Section 1.3 and Table 1.3)
		Sag curve K value	30 km/h	• 2.3	DMURS (Table 4.3)

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
			50 km/h	• 6.4	
			60 km/h	• 9.2	
			85 km/h	• 26	TII DN-GEO-03031 (Section 1.3and& Table 1.3)
	Longitudinal Gradient	Longitudinal gradient	30-60 km/h	• 0.5% minimum grade • 5% desirable maximum grade • 8.3% absolute maximum grade	DMURS (Section 4.4.6)
			85 km/h	• 0.5% [minimum grade [may need to be more] • desirable maximum grade – 3% Type 1 dual carriageway – 4% Type 2 and 3 dual carriageway • Maximum gradients hilly terrain – 4% Type 1 dual carriageway – 5% Type 2 and 3 dual carriageway	TII DN-GEO-03031 (Section 4.1.1 and 4.1.2)
	Crossfall	Crossfall	30 – 80 km/h	• 2.5% nominal	DMURS (Section 4.4.6)
			85 km/h	• 2.5% nominal	TII DN-GEO-03031 (Section 3.1 & Table 1.3)
All Junctions	Visibility	Intra-junction visibility envelope	30-100km/h	• 2.5m behind stop lines, inclusive of all signal heads	DN-GEO-03044 (TII DMRB TD50/04) Section 2.10 and 2.14. Figs 2/2 and 2/3.
		Priority junction side road visibility distance (safe gap stopping distance)	30 km/h	• X Value = 2.4m; Y Value 24m SSD (Bus Routes)	DMURS (Figure 4.63)
			50 km/h	• X Value = 2.4m; Y Value 49m SSD (Bus Routes)	DMURS (Figure 4.63 / Para 4.4.4 and 4.4.5)
			60 km/h	• X Value = 2.4m; Y Value 65m SSD (Bus Routes)	

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
			85 km/h	• National Roads / Regional Roads • Desirable Minimum X Value = 3.0m; Y Value 160m SSD	TII DN-GEO-03060 (Section 5.6.3.2 and Table 5.4)
		Visibility to primary traffic signals	30 km/h	• 50m desirable min; 40m absolute min	TSM (Table 9.1)
			50 km/h	• 70m desirable min; 50m absolute min	
			60 km/h	• 90m desirable min; 70m absolute min	
			85 km/h	• 160m desirable min; 120m absolute min	
	Corner Radii	Few larger vehicles (local streets)	Varies - scheme wide	• 1m -3m radius (subject to vehicle tracking assessment and balance of junction form/function)	DMURS (Section 4.4.3)
		Occasional larger vehicles including buses and rigid body trucks (between arterial and or link streets)		• 6m maximum radius (subject to vehicle tracking assessment and balance of junction form/function)	DMURS (Section 4.4.3)
		Occasional larger vehicles including buses and rigid body trucks (arterial/link to local streets)		• 4.5m – 6m radius (subject to vehicle tracking assessment and balance of junction form/function)	DMURS (Section 4.4.3)
		Frequent larger vehicles (industrial estates)		• 9m radius (subject to vehicle tracking assessment)	DMURS (Section 4.4.3)
	Pedestrian Crossings	Rural Areas/ National Roads	85km/h	• Refer to TII DN-GEO-03060 Section 5.6.5 for radius requirements for National Roads	TII DN-GEO-03060 (Section 5.6.5)
		Signalised crossing type / length *(subject to confirmation by traffic modelling and site constraints)*	Varies - scheme wide	• Preferred for all locations: Single stage direct crossing up to 19m length • Alternative for primary / distributor / dual carriageway roads: Two stage staggered crossings with ideally min 3m staggered offset refuge island (ideally stagger to face oncoming traffic) and ideally min 3m (2m absolute min) wide refuge island. • Alternative for primary / distributor / dual carriageway : Two stage crossing in straight crossing with 4m wide refuge island. • Alternative: Single stage direct crossing greater than 19m length (urban centres)	BCPDGB (Section 5) TMG (Section 10.7, Diagram 10.15) DMURS (Section 4.3.2)

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
		Signalised pedestrian / toucan crossing width		• Absolute minimum width 2m • Desirable minimum width 2.4m (4m to be considered for urban centres) • Toucan crossing width minimum 4m	TMG (Section 10.7) DMURS (Section 4.3.2)
Parking/Loading	On-street Parking Dimensions	Accessible parking and child / parent parking	Varies - Scheme wide	• 7m x 3.6m with appropriate drop kerb and tactile paving. • Cycle buffer zone (0.75m preferred)	NDA[1] (Figure 1.4)
		Parallel parking (preferred arrangement)		• 6m x 2.1m desirable minimum. • 6m x 2.4m preferred • Cycle buffer zone (0.75m preferred)	BCPDGB (Section 6) DMURS (Section 4.4.9)
		Angled parking		• 60 degree parking: 4.8m-5m x 2.4m @ 4.2m depth. • 45 degree parking: 4.8m-5m x 2.4m @ 3.6m depth	DMURS (Section 4.4.9)
		Perpendicular parking		• 4.8m – 5m x 2.4m desirable minimum. • Buffer zone (0.3m minimum)	DMURS (Section 4.4.9)
		Loading bay (parallel)		• 6m x 2.8m (large vans) • Cycle buffer zone (0.75m preferred)	DMURS (Section 4.4.9)

4.2 Mainline Cross-section

Utilising Section 4.4.1 of DMURS, and in consultation the NTA, a design strategy was implemented to determine the appropriate cross-section for the scheme, taking account of the design speeds and nature of the locations.

In urban areas traffic lane widths have been considered in line with the guidance outlined in DMURS, with the preferred width of traffic lanes on the Proposed Scheme being:

- 3.0m in areas with a posted speed limit <60km/h, and
- 3.25m in areas with a posted speed limit >60km/h.

Traffic lane widths of 2.75m are permissible but not desirable and only on roads with very low HGV percentage. In some locations these lane widths have been considered for auxiliary turning lanes where appropriate.

The desirable minimum width for a single direction, with flow, raised adjacent cycle track is 2.0m. Based on NCM this allows for overtaking within the cycle track. The minimum width is 1.5m. The desirable width for a 2-way cycle track is 3.25m with a 0.5m buffer between the cycle track and the carriageway. 2.0m is a desirable minimum width for footways with 1.2m being a minimum width at pinch points. A typical CBC cross section is shown on Figure 4-1.

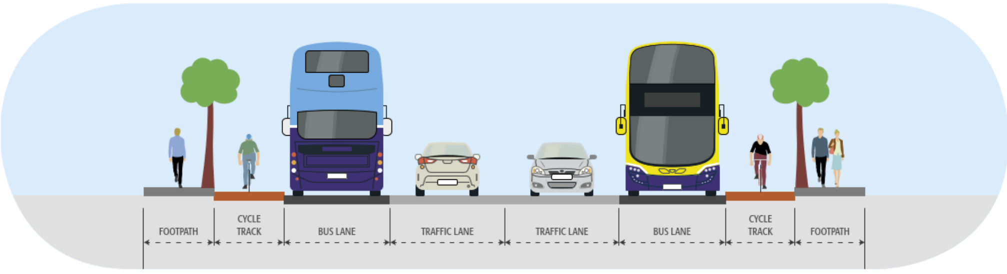

Figure 4-1 Typical CBC Cross Section

On sections of road with a posted speed limit of 80km/h or more, the proposed lane width is 3.5m.

A detailed scheme breakdown of the relevant existing and proposed road cross section elements is provided in Table 4-2. These tables provide information on the existing facilities for pedestrians, cyclists, bus lanes and general traffic lanes between junctions along the route. A detailed description of the existing and proposed junction arrangements is provided in Chapter 5. The table below is intended to provide supplementary information alongside the information presented on the General Arrangement (GEO_GA), Typical Cross Sections (GEO_CS) and Pavement Treatment Plans (PAV_PV) available in Appendix B.

In Table 4-2 the following design alignments are tabulated:

- Alignment A – Follows the route of the CBC along the N4 Lucan Road, the R148 Palmerstown bypass, Chapelizod bypass, Con Colbert Road and St John's Road West;
- Alignment B - R136 Ballyowen Road;
- Alignment C – R835 Lucan Road;
- Alignment D - Hermitage Golf Club access road;
- Alignments E & F – Fonthill Road;
- Alignments G & H – Old Lucan Road (west of M50)
- Alignments I – Liffey Valley SC to Old Lucan Road;
- Alignment J – Old Lucan Road (East of M50)
- Alignments K & L – Kennelsfort Road Lower; and
- Alignment N - N4 Junction 3 off-slip.

Table 4-2 Proposed Scheme vs Existing Nominal Cross Section Widths

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
(Alignment A) N4 Jct 3 Ballyowen Road to Hermitage Golf Course									
CH. A0 to CH. A225	N/A	2m	3.5m	3 x 3.5m lanes	N/A	N/A	N/A	3 x 3.5m lanes	An existing bus lane is provided in the eastbound direction; westbound no bus lane is provided currently. A designated cycle track is provided in the eastbound direction tying into the slip road at Chainage A 220. No cycle facilities are provided in the westbound direction, but an on-road cycle lane is provided along the Jct.3 diverge slip road.
	N/A	2m	3.5m	3 x 3.5m lanes	N/A	N/A	N/A	3 x 3.5m lanes	No changes to the current arrangement.
CH. A225 to CH. A425	N/A	N/A	3.5m	3 x 3.5m lanes	N/A	N/A	N/A	3 x 3.5m lanes	An existing bus lane is provided in the eastbound direction. Westbound no bus lane is provided currently. A shared surface facility is provided along the Jct 3. eastbound slip road continuing adjacent to the carriageway. Eastbound a shared pedestrian / cycle facility is provided adjacent to the carriageway.
	N/A	N/A	3.5m	3 x 3.5m lanes	N/A	N/A	N/A	3 x 3.5m lanes	No changes to the current arrangement, but there are changes at the interface of eastbound and westbound slips necessitating amendments to the tapers and diversions of splitter islands (westbound).
CH. A425 to CH. A500	3.0m shared facility		N/A	4 x 3.5m lanes	1.8m – 2.2m	1.3m-1.5m	N/A	3 x 3.5m and 2.8m lanes segregated by 1.15m buffer from mainline	Eastbound a shared pedestrian / cycle facility is provided adjacent carriageway and bus lane facilities are provided from Chainage A460. Westbound cycle lane (white line segregation) is provided along the lane of the N4 segregated slip road.
	2.0m	N/A	N/A	4 x 3.5m lanes	1.8m – 2.2m	1.3m-1.5m	N/A	3 x 3.5m lanes and 2.8m lane segregated by 1.15m	No changes to the current carriageway arrangement. Changes to slips are documented in separate sections. Eastbound and westbound cyclists are routed down the Hermitage Golf Club Quiet Street and join the proposed two-way cycle track along the front of Hermitage Golf Club.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
								buffer from mainline	
(Alignment A) N4 Hermitage Golf Course to Junction 2 off-slip at Hermitage Medical Centre									
CH. A500 to CH. A700	1.8m shared facility		3.5m	3 x 3.5m lanes	1.8m – 2.2m	1.5m	N/A	3 x 3.5m and 2.8m lanes segregated by 1.15m buffer from mainline	Eastbound a shared cycle / pedestrian facility is provided. Westbound an on-road cycle lane is provided along the lane of the N4 segregated slip-road. Eastbound a sub-optimal lay-by bus stop provided.
	2.0m min.	3.5m	3.5m	3 x 3.5m lanes	1.8m – 2.2m	1.5m	N/A	3 x 3.5m and 2.8m lanes segregated by 1.15m buffer from mainline	A two-way segregated cycle track is provided adjacent to the eastbound bus lane, and westbound the existing on-road cycle lane is to be retained. Pedestrian facilities eastbound are increased to desirable minimum. Land take of ~5.0m and a piled wall retaining up to 3.5m is required to accommodate the proposed eastbound pedestrian and cycle facilities.
CH. A700 to CH. A900	1.8m shared facility		3.5m	3 x 3.5m lanes	1.8m – 2.2m	1.5m	N/A	3 x 3.5m and 2.8m lanes segregated by 1.15m buffer from mainline	Eastbound a shared cycle / pedestrian facility is provided. Westbound cycle lanes (white line segregation) are provided along the lane of the N4 segregated from the mainline.
	2.0m min.	3.5m	3.5m	3 x 3.5m lanes	3.0m-3.5m shared facility		N/A	3 x 3.5m and 3.25m lanes segregated by 1.15m buffer from mainline	A two-way segregated cycle track is provided adjacent to the eastbound bus lane. Pedestrian facilities eastbound are increased to desirable minimum and westbound pedestrian facilities are to become shared with the existing cycle lane removed to accommodate the widening. Land take of ~5.0m is required to accommodate eastbound pedestrian and cycle facilities.
	1.8m shared facility		3.5m	3 x 3.5m lanes	2.8m – 3.5m shared facility		3.5m	3 x 3.5m lanes	Eastbound no existing cycle facilities are provided. Westbound a shared area is provided.

Chainage Reference	Existing Eastbound Carriageway / Proposed Eastbound Carriageway				Existing Westbound Carriageway / Proposed Westbound Carriageway				Existing Conditions Notes / Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
CH. A900 to CH. A1300									In-line bus stop provided westbound and lay-by bus stop provided eastbound.
	2.0m min.	3.5m (additional 0.725m buffer)	3.0m - 3.5m	3 x 3.5m lanes	2.8m – 3.5m	2.8m – 3.5m	3.5m	3 x 3.5m lanes	A two-way segregated cycle track is provided adjacent to the eastbound bus lane. Pedestrian facilities eastbound are increased to desirable minimum and westbound shared facilities are to be retained up to CH. A1150, with the remainder of the section converted to cycle track. Revised lay-by bus stop arrangements are proposed westbound / eastbound within the section. Land take of 10m max. is required to accommodate eastbound pedestrian and cycle facilities.
(Alignment A) N4 Junction 2 off-slip to Junction 2 on-slip									
CH. A1300 to CH. A1800	3.2m	N/A	3.2m	3 x 3.5m lanes	1.8m-3.5m shared facility		3.5m	3 x 3.5m lanes	Westbound cycle and pedestrian facilities are shared, and only pedestrian facilities provided eastbound. Lay-by bus stops are provided in both the Eastbound / westbound direction.
	N/A	N/A	3.2m	3 x 3.5m lanes	N/A	N/A	3.5m	3 x 3.5m lanes	Eastbound / westbound pedestrian and cycle facilities removed (alternative routes provided). Eastbound bus stop removed, and westbound bus stop arrangement revised.
(Alignment A) N4 Junction 2 on-slip to Liffey Valley Interchange									
CH. A1800 to CH. A2250	N/A	N/A	3.5m	3 x 3.5m lanes	N/A	N/A	3.0m	3 x 3.3m lanes	No cycle / pedestrian facilities eastbound or westbound.
	N/A	N/A	3.5m	3 x 3.5m lanes	N/A	N/A	3.0m	3 x 3.3m lanes	LVSC bus stops eastbound / westbound have been relocated east. Pedestrian footbridge and gantry are to be provided at same location. Land take of ~3.0m max required westbound to accommodate bus stop.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
(Alignment A) A4 Liffey Valley Interchange to M50 Junction									
CH. A2250 to CH. A2550	N/A	N/A	4.5m-5.0m	4 x 3.2m-3.8m lanes	N/A	N/A	3.5m – 4.0m	2-3 x 3.5m lanes	Layby bus stops are provided for LVSC eastbound / westbound . Eastbound lanes diverge to continue to City Centre or join M50.
	2.0m	N/A	4.0m – 4.5m	4 x 3.2m-3.8m lanes	N/A	N/A	3.5m – 4.0m	2-3 x 3.5m lanes	Pedestrian facilities provided to access relocated bus stop eastbound. Bus stops eastbound / westbound removed and relocated west. Existing bus stop lay-by to be grassed over and kerb relocated.
(Alignment A) M50 Junction to Chapelizod bypass (Palmerstown)									
CH. A2550 to CH. A3200	N/A	N/A	N/A	2 x 3.4m-3.8m lanes	N/A	N/A	N/A	2-3 x 3.6m lanes	No cycle / pedestrian facilities provided. Bus lanes also not provided.
	N/A	N/A	3.25m – 3.8m	2 x 3.5m lanes	N/A	N/A	3.6m	1-2 x 3.6m lanes	Westbound traffic lanes have been reduced by 1 to accommodate a bus lane. Eastbound the carriageway width has been redistributed and widened (into verge) in areas to maintain 2 traffic lanes and accommodate a bus lane.
(Alignment A) M50/Chapelizod bypass to Kennelsfort Road Junction									
CH. A3200 to CH. A3650	N/A	N/A	3.0m	2-3 x 3.8-4.0m lanes	N/A	N/A	3.0m	2-3 x 3.6m lanes	No cycle and pedestrian facilities provided. Westbound bus lane only runs for 75m, eastbound bus lane commences at the Circle K petrol station.
	N/A	N/A	3.25m	3 x 3.25m lanes	N/A	N/A	3.5m	2 x 3.5m lanes	Eastbound bus lane length provided is lengthened (~125m increase) and 3 traffic lanes retained. To accommodate widening into verge and redistribution of lanes is required. At junction left turn lane is provided widening into the verge (4-lanes provided at junction) along with removal of the island segregating straight on movements from right turners. Westbound bus lane length provided is more extensive (running throughout section), reducing number of traffic lanes by 1.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
(Alignment A) Kennelsfort Road Junction to The Oval									
CH. A3700 to CH. A4000	2.0m	N/A	3.0m	2 x 3.75m lanes	3.0m	N/A	3.0m	2 x 3.8m lanes	No eastbound / westbound cycle facilities provided. Eastbound pedestrian facilities provided to bus stop only and not length of section. In-line bus stops provided eastbound / westbound at CH. A3750.
	2.0m	N/A	3.5m	2 x 3.5m lanes	2.0m – 3.0m	N/A	3.6m	2 x 3.5m lanes	Existing bus stop arrangement revised to lay-by bus stops, footway width behind reduced to 2.0m to accommodate. Additional lay-by bus stops are provided eastbound (CH A3900) / westbound (CH. A3900), widening into verge required. Eastbound a new footway is proposed to access stop and westbound the footway is reduced to 2.0m to accommodate. Land take required westbound for the revised bus stop arrangement.
(Alignment A) The Oval to Chapelizod bypass / R112									
CH. A4000 to CH. A4300	3.0m	N/A	3.0m	2x 3.5m lanes	3.0m	N/A	3.2m	2 x 3.3m lanes	Pedestrian facilities eastbound are detailed Alignment L, pedestrian facilities westbound terminate at CH. A4300. A below standard shared bus / cycle lane is provided on Chapelizod bypass, no other cycle facilities are provided. Inline bus stops are provided eastbound (CH. A4050) / westbound (CH. A4250).
	3.0m	N/A	3.0m	2 x 3.5m lanes	3.0m	N/A	3.5m	2 x 3.3m lanes	Westbound/eastbound shared cycle / bus lanes are no longer for use by cyclists (alternative route detailed in alignment L). Eastbound the inline bus stop is to be removed and relocated to the west. The pedestrian crossing is also to be relocated west to accommodate a right turn lane for buses (median to reduce by ~2.5m locally) to Old Lucan Road. Westbound the bus stop is to be removed (CH. A4250).
CH. A4300 to CH. A4600	2.8m – 4.25m (Shared)		3.0m – 3.3m	2 x 3.2m – 3.5m lanes	N/A	N/A	2.8m	2 x 3.5m-3.8m lanes	A shared bus / cycle lane is provided on Chapelizod bypass. Eastbound a Pedestrian Priority Zone is provided but falls below the required minimum width, and no westbound pedestrian access is provided / granted along Chapelizod bypass.

Chainage Reference	Existing Eastbound Carriageway / Proposed Eastbound Carriageway				Existing Westbound Carriageway / Proposed Westbound Carriageway				Existing Conditions Notes / Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
	4.0m – 4.25m (Shared)		3.0m – 3.25m	2 x 3.5m lanes	N/A	N/A	3.5m	2 x 3.2m lanes	Westbound no changes to arrangement. Eastbound to provide a minimum 4.0m shared area the median is to be reduced by ~1.2m and traffic lanes redistributed. The R112 diverge slip median is also shortened to allow realignment of slip to provide the minimum shared area width. No land take is possible due to constraints /restrictions.
(Alignment A) R112 to Chapelizod Hill Road									
CH. A4600 to CH. A5500	N/A	N/A	3.5m	2 x 3.2m lanes	N/A	N/A	3.5m	2 x 3.2m lanes	Pedestrian access is restricted along this section of the bypass, so no pedestrian facilities are provided. A shared bus / cycle lane is provided on Chapelizod bypass.
	N/A	N/A	3.5m	2 x 3.2m lanes	N/A	N/A	3.5m	2 x 3.2m lanes	Shared bus / cycle lane is to be a bus only lane with cyclists to use the NTA Primary Route 6.
(Alignment A) Chapelizod Hill Road Bus Stops									
CH. A5500 to CH. A5750	N/A	N/A	3.5m	2 x 3.2m lanes	N/A	N/A	3.5m	2 x 3.25m lanes	Pedestrian access is restricted along this section of the bypass, so no pedestrian facilities are provided. A shared bus / cycle lane is provided on Chapelizod bypass.
	N/A	N/A	3.5m	2 x 3.2m lanes	N/A	N/A	3.25m - 3.5m	2 x 3.25m lanes	Shared bus / cycle lane is to be a bus only lane with cyclists to use the NTA Primary Route 6. Eastbound / westbound lay-by bus stops segregated from straight through bus lane by 1.0m-2.5m (eastbound) and 1.5m (westbound) islands along the length of the bus stops. Bus stops provide 3.5m bus stop and 2.0m pedestrian waiting areas. Eastbound the bus stop requires widening the verge and bridge resulting in land take (~8.0m max) either side of Chapelizod Hill Road. Westbound the bus stop requires widening of the verge resulting in land take (~6.0m max) north of Chapelizod Hill Road. Further land take is required to accommodate steps / ramps to the eastbound / westbound bus stops.

<table>
<tr><th rowspan="2">Chainage Reference</th><th colspan="4">Existing Eastbound Carriageway
Proposed Eastbound Carriageway</th><th colspan="4">Existing Westbound Carriageway
Proposed Westbound Carriageway</th><th rowspan="2">Existing Conditions Notes
Proposed Scheme Notes</th></tr>
<tr><th>Footway width (m)</th><th>Cycle Lane/ Track Width (m)</th><th>Bus Lane Width (m)</th><th>Traffic Lane Width (m)</th><th>Footway width (m)</th><th>Cycle Lane/ Track Width (m)</th><th>Bus Lane Width (m)</th><th>Traffic Lane Width (m)</th></tr>
<tr><td colspan="10">(Alignment A) Chapelizod Hill Road to Con-Colbert Road</td></tr>
<tr><td rowspan="2">CH. A5750 to CH. A7550</td><td>N/A</td><td>N/A</td><td>3.5m</td><td>2 x 3.2m lanes</td><td>N/A</td><td>N/A</td><td>3.5m</td><td>2 x 3.2m lanes</td><td>Pedestrian access is restricted along this section of the bypass, so no pedestrian facilities are provided. A shared bus / cycle lane is provided on Chapelizod bypass.</td></tr>
<tr><td>N/A</td><td>N/A</td><td>3.5m</td><td>2 x 3.2m lanes</td><td>N/A</td><td>N/A</td><td>3.0m - 3.5m</td><td>2 x 3.2m lanes</td><td>Shared bus / cycle lane is to be a bus only lane with cyclists to use the NTA Primary Route 6.</td></tr>
<tr><td colspan="10">(Alignment A) Con Colbert Road to Memorial Road</td></tr>
<tr><td rowspan="2">CH. A7550 to CH. A7900</td><td>N/A</td><td>N/A</td><td>3.5m</td><td>2 x 3.2 - 3.8 lanes</td><td>2.6m - 2.8m</td><td>N/A</td><td>3.0m – 3.6m</td><td>2 x 3.2m lanes</td><td>No cycle facilities are provided eastbound / westbound. Pedestrian facilities are only provided westbound heading along Con Colbert Road.</td></tr>
<tr><td>N/A</td><td>2.0m</td><td>3.2m</td><td>2 x 3.25m lanes</td><td>2.0m – 2.8m</td><td>1.5m</td><td>3.0m</td><td>2 x 3.2m lanes</td><td>Eastbound / westbound segregated cycle tracks are provided. Westbound cycle facilities continue down Con Colbert Road. Pedestrian facilities westbound have been reduced to the desirable minimum (2.0m) in areas to accommodate the cycle track and eastbound the central median narrowed and lanes rationalised / narrowed to provide the cycle track within the existing cross section limits.

Eastbound an additional right turn lane is provided (for Memorial Road) reducing the median to 1.5m and requiring the relocation of the pedestrian crossing facilities to the east. All lanes reduced to 2.8m – 3.0m at junction.</td></tr>
<tr><td colspan="10">(Alignment A) Memorial Road to South Circular Road</td></tr>
<tr><td rowspan="2">CH. A7900 to CH. A8400</td><td>2.0m</td><td>N/A</td><td>4.0m</td><td>2 x 3.2 – 3.4 lanes</td><td>2.4m</td><td>N/A</td><td>3.8m</td><td>2 x 3.5m lanes</td><td>No cycle facilities are provided eastbound / westbound . Eastbound / westbound bus stops provided at CH. A8000 and CH. A8300.</td></tr>
<tr><td>2.0m</td><td>2.0m</td><td>3.0m</td><td>2 x 3.0m lanes</td><td>2.4m</td><td>2.0m</td><td>3.0m</td><td>2 x 3.0m lanes</td><td>Eastbound / westbound cycle tracks provided. Traffic lanes and bus lanes narrowed to accommodate cycle tracks.

CH. A8000 Eastbound / westbound bus stops relocated west. CH. A8300 bus stops relocated to the east and layout revised.</td></tr>
</table>

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
									Toucan crossing relocated at Military Road junction and median widened to allow adequate crossing facilities.
(Alignment A) South Circular Road to St John's Road West									
CH. A8400 to CH. A8550	1.8m- 2.5m	1.2m	N/A	3 x 3.2m lanes	2.4m – 5.0m	N/A	N/A	3 x 3.2m 3.5m lanes	Eastbound cycle facilities provided are below absolute minimum and only provide white line segregation from the adjacent traffic lanes. Westbound no cycle facilities are provided. No bus lanes are provided eastbound / westbound.
	2.0m	2.0m (1.0m buffer where applicable)	3.0m	2 x 3.0m lanes	2.0m – 4.0m	1.5m – 2.0m	3.0m	3 x 3.0m lanes	Eastbound / westbound cycle tracks are provided to SCR with left turn slips removed to accommodate movements. Eastbound a cycle lane is provided to connect with the cycle track on St John's Road West with a 1.0m buffer to segregate from adjacent traffic lanes. Eastbound / westbound routes at junction are widened to facilitate left turns (left turn slips removed). Westbound widening into verge to provide bus lane required.
(Alignment A) South Circular Road to HSQ									
CH. A8550 to CH. A9050	2.0m – 2.75m	1.2m	2.4m – 4.75m	3.2m – 3.8m lane	2.25m – 4.0m	N/A	3.0m	2 x 3.0m lanes	Eastbound cycle lane segregated by white line only is only provided for a short length within the section (CH. A8550 – CH. A8650). Westbound no cycle facilities are provided. Eastbound a taxi waiting area (1.7m wide) for Heuston station is provided.
	2.0m – 2.75m	2.0m	3.25m	3.25m lane	1.8m – 4.0m	1.5m – 1.8m (0.5m buffer where applicable)	3.25m	3.25m lane	Eastbound bus and traffic lanes are reduced to 3.25m to facilitate 2.0m protected cycle track. Westbound the number of traffic lanes are reduced to one, allowing a protected (0.5m segregation with bollards) cycle lane to be provided. At CH. A8600 eastbound traffic lanes are reduced to one, widening the median (reducing the carriageway width). Eastbound taxi waiting area is to be removed.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
(Alignment A) HSQ to Memorial Road									
CH. A9050 to CH. A9300	1.2m – 4.0m	N/A	3.5m	3.2m lane	2.4m (0.7m – 5.0m)	1.5m	N/A	2 x 3.5m lanes	Eastbound no cycle facilities are provided and footway is reduced to 1.2m in areas. Westbound a cycle lane is provided segregated by white line only. No bus lane is provided westbound. Eastbound a taxi waiting (2.0m wide) is provided.
	1.2m – 3.6m	1.5m - 2.5m	3.25m	3.0m lane	2.0m	1.75 – 2.0m	3.0m	3.0m lane	Eastbound / westbound a protected cycle track is provided. To provide the cycle facilities and retain the taxi waiting area the medium is relocated towards the westbound route and reduced in width (1.3m min.). Eastbound 1.2m pedestrian facilities are to be kept as existing to retain trees. Westbound a bus lane is provided reducing traffic lanes to one. Stairs, planters, and parking in front of GHQ are to be removed to provide width for complete cross section. Westbound electric parking facilities are relocated to GHQ. Land take (4.5m max) required in front of GHQ.
(Alignment A) Memorial Road to Steeven's Lane									
CH. A9300 to CH. A9600	2.0m min.	1.25m	3.0m	3.0m lane	2.5m – 3.5m	1.0m	N/A	2 x 3.0m lanes	Eastbound / westbound cycle facilities are provided, , providing suboptimum facilities (cycle track with white line segregation). Lay-by (non-standard) bus stops are provided eastbound / westbound . At taxi rank is provided for Heuston Station eastbound. Westbound electric charging points are provided at Dr Steevens' Hospital.
	2.0m min.	1.75m (0.5m at taxi rank)	3.0m	3.0m lane	2.0m min.	2.0m	3.0m	3.0m lane	Eastbound cycle lane widened and protected with bollards. Westbound protected cycle track provided. Westbound bus lane provided replacing inside traffic lane. Eastbound bus stop reconfigured, and lay-by provided. Westbound new bus stop provided at Dr Steevens' Hospital and electric charging points

Chainage Reference	Existing Eastbound Carriageway / Proposed Eastbound Carriageway				Existing Westbound Carriageway / Proposed Westbound Carriageway				Existing Conditions Notes / Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
									relocated. Existing westbound bus stop reconfigured. Taxi rank is to be retained widened to 2.4m. To accommodate changes central median has been relocated and changes to width have been made. Land take (max 15.5m) required at Dr Steevens' hospital required.
(Alignment A) Steeven's Lane to Frank Sherwin Bridge									
CH. A9600 to CH. A9694	N/A	1.0m	N/A	2 x 3.0m – 4.5m lanes	3.0m – 6.6m	N/A	N/A	2 x 3.2m – 4.2m lanes	Westbound no cycle facilities are provided. Eastbound cycle facilities provide suboptimum facilities (cycle track with white line segregation). No pedestrian facilities are provided eastbound. Eastbound / westbound no bus lanes are provided.
	N/A	1.5m (0.5m buffer)	3.6m – 3.8m	3.6m - 4.4m lane	2.0m – 6.6m	1.5m – 2.0m	3.2m – 3.8m	3.3m – 4.4m lane	Eastbound / westbound cycle facilities provided. Eastbound bollards are provided where the cycle lane is 1.5m in width. Eastbound / westbound bus lanes replace a traffic lane. Eastbound left slip is removed and replaced with left turn lane. Central median relocated and reconfigured. Land take required to reconfigure Luas platform.
Hermitage Road (CH A0000 to A630)									
CH. A0000 to CH. A630	1.8m – 2.0m	N/A	N/A	3.2m lane	1.8m – 2.0m	N/A	N/A	3.6m - 3.8m lane	No cycle / bus facilities eastbound / westbound .
	1.8m – 2.0m	N/A	N/A	3.2m lane	1.8m – 2.0m	N/A	N/A	3.6m -3.8m lane	Hermitage Road is to become Quiet Street to be shared with traffic. No other changes to arrangement are to be made.
Hermitage Park (Ch A630 to A700)									
	2.5m - 2.8m	N/A	N/A	N/A	2.5m - 2.8m	N/A	N/A	N/A	Footway through Hermitage Park is provided.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
CH. A630 to CH. A700	3.5m	N/A	N/A	N/A	3.5m	N/A	N/A	N/A	Footway through Hermitage Park is to be widened and become pedestrian priority zone to allow access to the proposed Quiet Street.
Ballyowen Lane (Ch A700)									
CH. A700	1.8m – 2.4m	N/A	N/A	2.75 – 3.5m lane	1.6m – 3.2m	N/A	N/A	2.75 – 3.5m lane	No cycle / bus facilities eastbound / westbound .
	1.8m – 2.4m	N/A	N/A	2.75 – 3.5m lane	1.6m – 2.7m	N/A	N/A	2.75 – 3.5m lane	Ballyowen lane is to become Quiet Street to be shared with traffic. No other changes to arrangement are to be made. Parking to be retained opposite the recently completed residential development.
R113 (CH A1650 to A1800)									
CH. A1650 to CH. A1800	1.3m – 1.5m	N/A	N/A	2 x 3.5m reduced to 1 x 4.0m) lanes	N/A	N/A	N/A	N/A	No cycle or bus facilities provided eastbound. Pedestrian facilities separated from carriageway by verge.
	N/A	N/A	N/A	2 x 3.5m (reduced to 1 x 4.0m) lanes	N/A	N/A	N/A	N/A	Pedestrian facilities removed alternative route provided at CH. F100. No other changes to arrangement are to be made.
Kennelsfort Road Lower (CH A3670)									
CH. A3670	3.4m – 7.0m	N/A	N/A	3.6m	1.5m - 3.4m	N/A	N/A	3.0m - 3.7m	No cycle or bus facilities provided eastbound / westbound . Inline bus stop provided eastbound. Westbound right turn lane provided at junction.
	3.4m – 7.0m	N/A	N/A	3.6m – 4.0m lane	1.7m – 2.5m	3.0m - 3.5m	N/A	3.0m – 3.25m lane	Westbound two-way cycle track provided. Parking to be removed and land take (~3.7m) required to facilitate changes.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
									Eastbound bus stop to be removed. Road widened eastbound at junction to facilitate left turning from Chapelizod bypass. Westbound right turn lane retained.
Kennelsfort Road Upper (CH A3670)									
CH. A3670	N/A	1.2m	N/A	2 x 2.5m – 3.0m lanes	1.8m - 2.0m	1.2m	N/A	2.8m lane	Westbound / eastbound cycle facilities provide suboptimum facilities (cycle track with white line segregation).
	N/A	3.0m	N/A	2 x 3.0m lanes	2.0m	1.2m – 1.5m	N/A	3.25m – 5.0m lane	Eastbound/ westbound cycle facilities replaced by two-way cycle track segregated by a verge, alongside a 2.0m pedestrian facility. Left slip removed and replaced with a left turning lane eastbound. Westbound cross section reduced by 0.5m – 1.5m.
The Oval (CH A4000)									
CH. A4000	2.2m – 3.0m	N/A	N/A	2 x 3.0m lanes	3.0m – 3.6m	N/A	N/A	5.5m – 6.5m lane	No cycle or bus facilities eastbound / westbound .
	2.2m – 7.25m	N/A	N/A	2 x 3.25m lanes	3.0m – 9.25m	N/A	N/A	3.25m – 3.6m lane	Corner radii tightened (~6.5m) eastbound / westbound , increasing footways at corners.
Palmerstown Drive (CH A4000)									
CH. A4000	1.2m	N/A	N/A	2 x 2.8m lanes	1.2m	N/A	N/A	N/A	No cycle or bus facilities eastbound / westbound . Pedestrian facilities below 1.8m min. eastbound and westbound. Beyond private entry (Shaw Tree Services) two-way road is provided.
	2.0m shared facility		N/A	2 x 3.5m lanes	2.0m shared facility		3.5m	N/A	Westbound a traffic lane is to be provided for buses only (access from Shaw Tree Services maintained). Eastbound a traffic lane is to be retained to be retained splitting into 2 lanes. Widening into petrol station is required. Eastbound and westbound shared facilities are to be maintained.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
									Land take required for widening (additional vehicle lane / footway) of cross section (~5.0m).
R112 (CH A4450 – A4700)									
CH A4450 to A4700	3.0m – 5.0m	N/A	N/A	3.5m – 4.25m lane	N/A	N/A	N/A	N/A	Section eastbound only. No cycle or bus facilities provided eastbound. Pedestrian Priority Zone provides suboptimum conditions in regard to width.
	4.0m – 5.0m	N/A	N/A	3.5m – 4.25m lane	N/A	N/A	N/A	N/A	Pedestrian Priority Zone widened to 4.0m min. R112 realigned and median between mainline and R112 shortened to accommodate. No changes to alignment beyond Ch. A4500.
Chapelizod Hill Road (CH A5640)									
CH A5640	2.0m	N/A	N/A	2.6m – 5.5m lane	2.2m – 2.4m	N/A	N/A	N/A	No cycle or bus facilities provided eastbound / westbound . Section is one way only east-bound, road narrows at end of two-way section to 2.6m.
	2.0m	N/A	N/A	2.6m lane	2.0m – 2.4m	1.5m (0.75m buffer)	N/A	N/A	West-bound cycle lane provided with buffer and bollards; one-way carriageway reduced to 2.6m for traffic calming. Footway widened into carriageway in east/west directions to accommodate stair / ramp arrangement for Chapelizod bypass bus stops. Land take required for stair / ramp configuration and proposed bridge widening (covered in mainline chainage CH. A5500 to CH. A5750)
Con Colbert Road Eastbound tie-in to Liffey Valley Scheme (CH A7500 -A7550)									
CH. A7500 to CH. A7550	N/A	N/A	N/A	3 x 3.7m lanes	N/A	N/A	N/A	N/A	No cycle / bus / pedestrian facilities provided. Eastbound only carriageway connecting to the future Liffey Valley scheme.

Chainage Reference	Existing Eastbound Carriageway **Proposed Eastbound Carriageway**				Existing Westbound Carriageway **Proposed Westbound Carriageway**				Existing Conditions Notes **Proposed Scheme Notes**
	Footway width (m)	**Cycle Lane/ Track Width (m)**	**Bus Lane Width (m)**	**Traffic Lane Width (m)**	**Footway width (m)**	**Cycle Lane/ Track Width (m)**	**Bus Lane Width (m)**	**Traffic Lane Width (m)**	
	N/A	2.0m	N/A	3 x 3.0m lanes	N/A	N/A	N/A	N/A	Eastbound only cycle lane provided. Island provided at Con Colbert Road/ Chapelizod bypass junction for protection for cyclists from left turning vehicles. Traffic lanes reduced to 3.0m to accommodate. Left turn slip removed; left turn lane provided.
Con Colbert Road Westbound tie-in to Liffey Valley Scheme (CH A7500 -A7700)									
CH. A7650 to CH. A7700	N/A	N/A	N/A	N/A	2.2m	2.0m (2.0m buffer)	N/A	3.2m	No bus facilities provided. Cycle lane provided with 2.0m buffer to carriageway. Westbound carriageway only.
	N/A	N/A	N/A	N/A	2.2m	2.0m (2.0m buffer)	N/A	3.2m	No changes to current arrangement
CH. A7500 to CH. A7650	N/A	N/A	N/A	N/A	2.2m – 2.8m	N/A	N/A	7.0m	No cycle or bus facilities provided. Wide single lane splits to 2 lanes at tie into Liffey Valley scheme.
	N/A	N/A	N/A	N/A	2.2m – 2.8m	2.0m (1.5m buffer)	N/A	3.6m	Cycle lane with buffer provided. Traffic lane narrowed to provide cycle facilities.
South Circular Road - North of junction with Con Colbert Road/ St John's Road West (CH A8470)									
CH. A8470	3.4m	1.0m – 1.2m	N/A	2 x 3.0m lanes	2.4m – 3.4m	1.5m	N/A	6.0m lane	No Eastbound / westbound bus lane in the existing conditions, with suboptimum cycle/ped facilities eastbound (cycle track with white line segregation). Eastbound suboptimum cycle lane shared with traffic lane.
	3.4	2.0m	N/A	2 x 3.0m lanes	3.0m – 3.4m	2.0m	N/A	3.2m lane	Road widening into verge area and narrowing of traffic lanes allowing wider eastbound and westbound cycle lanes. Westbound footway widened to facilitate anticipated higher pedestrian volumes.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
Military Road (CH A9300)									
CH. A9300	N/A	N/A	N/A	2 x 3.0m lanes	2.2m – 6.5m	N/A	N/A	3.5m lane	No cycle or bus facilities provided eastbound / westbound .
	N/A	1.75m	N/A	2 x 3.0m lanes	1.8m – 5.0m	1.5m	N/A	3.5m lane	Cycle lanes provided eastbound and westbound. Eastbound cycle lane protected by bollards. Widening into footway to provide Eastbound / westbound cycle lanes. Remaining footway is to be beyond the redline boundary.
(Alignment B) R136 Ballyowen Road (CH B0 to B254)									
CH. B0 to CH. B100	N/A	N/A	3.35m	3.0m lane	3.0m	N/A	N/A	2 x 3.3m lanes	No cycle facilities provided eastbound / westbound . Pedestrian facilities are provided over a footbridge only. No bus facilities provided westbound, eastbound a bus lane is provided.
	N/A	N/A	3.35m	3.0m lane	2.5m	3.6m	N/A	2 x 3.3m lanes	Carriageway to remain unchanged. New footbridge is to be provided with two-way cycle facilities and pedestrian facilities with white line segregation.
CH. B100 to CH. B254	N/A	1.2m	3.0m	3.3m lane	3.3m	1.25m	3.0m	3.25m lane	No westbound bus lane in the existing conditions, with suboptimum cycle facilities Eastbound / westbound (cycle track with white line segregation). No eastbound pedestrian facilities provided.
	N/A	N/A	3.2m	3.25m lane	2.0m	3.25m (0.5m – 1.5m buffer)	N/A	3.25m lane	Segregated two-way cycle lane provided (segregated by buffer and islands/bollards). Footway width reduced to help accommodate. Westbound bus facilities removed.
(Alignment B) R136 Ballyowen Road South of N4 Junction 3 (CH B1 0 to CH B 1 200)									
CH. B1 0 to CH. B1 140	N/A	N/A	4.0m	3.0m – 3.5m lane	2.7m	1.6m	3.0m	3.5m lane	No eastbound cycle facilities provided. Westbound a cycle lane is provided (white line segregation only). Eastbound no pedestrian facilities are provided.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
	N/A	N/A	3.5m	3.0m – 3.5m lane	2.7m	3.0m (0.5 - 1.25m buffer)	3.0m	3.0m lane	Two-way cycle lane provided westbound with 0.5m buffer and bollards / islands for protection. Traffic/bus lane widths reduced the accommodate change.
CH. B1 140 to CH. B1 200	N/A	N/A	N/A	2 x 3.0m/4.0 m lanes	2.7m	1.6m	3.0m	3.5m lane	No eastbound cycle facilities provided. Westbound a cycle lane is provided (white line segregation only). Eastbound no pedestrian facilities are provided. No bus lane provided eastbound left turn only except buses provided.
	N/A	N/A	N/A	2 x 3.0m/4.0 m lanes	2.7m	3.0m (0.5m buffer)	N/A	4.0m – 5.2m lane	Two-way cycle lane provided westbound with 0.5m buffer and bollards for protection. Bus lane removed, widened traffic lane provided only to accommodate proposed changes.
(Alignment C) R835 Lucan Road (CH C0 to CH C288)									
CH. C0 to CH. C100	2.0m	N/A	3.0m	3.2m lane	2.0m (Segregated by grass verge)	N/A	N/A	3.0m – 3.5m lane	No Eastbound / westbound cycle facilities provided. Two traffic lanes provided eastbound at junction for right hand turn both reduced to 2.8m. Bus lane provided eastbound segregated through junction by island (max 2.0m wide).
	2.0m	2.0m	3.0m-3.2m	3.0m - 3.2m lane	2.0m (Segregated by grass verge)	1.5m – 1.75m	N/A	3.0m – 5.5m lane	Eastbound segregated cycle track provided with widening to 2.7m at CH. C100 to provide right-turn pocket along with 1.0m wide protection island. An Westbound cycle track is partially provided along the section joining with the main carriageway at CH. C50. Westbound the left turn slip from R136 Ballyowen Road is to be removed requiring the widening of the traffic lane to accommodate turning vehicles. Eastbound the island running alongside the bus lane is to be removed to allow the through movement of eastbound vehicles. Widening of existing cross section into verge eastbound is required to accommodate changes.
	1.6m – 2.0m	N/A	3.0m	3.15m lane	2.0m	N/A	N/A	3.15m – 4.5m lane	No Eastbound / westbound cycle facilities provided. Bus lane provided in eastbound direction only with bus stop at CH. C100.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
CH. C100 to CH. C288	1.8m – 2.0m	3.25m	3.0m	3.15m lane	2.0m	N/A	N/A	3.0m lane	Segregated two-way cycle track provided adjacent to eastbound bus lane. Pedestrian facilities widened to the required 1.8m min. Eastbound the bus stop has been relocated and revised. Land take is required eastbound (~3.0m) to accommodate two-way cycle track and min footway requirements.
(Alignment D) Hermitage Golf Club Access Road (CH D0 to CH D300)									
CH. D0 to CH. D280	3.0m	N/A	N/A	5.5m – 6.5m lane	N/A	N/A	N/A	N/A	No dedicated bus or cycle facilities are provided. N4 cycle track (eastbound) terminates at Ch. D0. A suboptimum shared footway is provided eastbound.
	2.0m	N/A	3.0m	3.5m lane	N/A	N/A	N/A	N/A	Footway no longer shared; cycle facilities are provided along an alternative Quiet Street. Bus facilities are provided, requiring widening into verge, relocation of stone wall, reduction in traffic lane width and footway width. A 1.8m segregation island is provided between the traffic lane and bus lane.
(Alignment E) R113 Fonthill Road (N4 Junction 2 Off-slip) (CH E 0 to E305)									
CH. E0 to CH. E305	1.5m	1.2m	2.2m	3.5m lane	N/A	N/A	N/A	N/A	Suboptimum cycle facilities (cycle track with white line segregation).No westbound facilities. Inline bus stop provided on slip road.
	2.0m	2.0m	3.0m	3.0m lane	N/A	N/A	N/A	N/A	Two-way cycle track provided, and pedestrian facilities widened to desirable minimum. To facilitate widening into verge/dense foliage is required along with narrowing of traffic and bus lanes. Inline bus stop layout revised.
(Alignment F) R113 Fonthill Road (N4 Junction 2 Off-slip) to Old Lucan Road (West of M50) (CH F0 to F149)									
CH. F0 to CH. F75	1.2m	N/A	N/A	2 x 4.8m lanes	1.3m	N/A	N/A	2 x 4.8m lanes	Eastbound / westbound no cycle facilities provided. Suboptimum pedestrian facilities are provided Eastbound / westbound with a verge buffer provided.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
	2.0m	3.25m	N/A	2 x 4.8m lanes	3.6m	N/A	N/A	2 x 4.8m lanes	Eastbound two-way cycle track provided. Pedestrian facilities eastbound widened to desirable minimum. Widening into verge required. Westbound footway widened into the verge to provide shared area.
CH. F75 to CH. F100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No facilities provided.
	2.0m	3.0m	N/A	N/A	N/A	N/A	N/A	N/A	Two-way cycle track and pedestrian facilities provided to link R113 to Old Lucan Road.
(Alignment G) Old Lucan Road (West of M50) (CH G 0 to G522)									
CH. G0 to CH. G250	1.5m	N/A	N/A	3.75 – 4.5m lane	N/A	N/A	N/A	3.75m – 4.5m lane	No cycle facilities are provided eastbound / westbound . Suboptimum pedestrian facilitates are provided eastbound (verge segregation provided). No pedestrian facilities are provided westbound.
	2.0m	N/A	N/A	2.75m lane	N/A	3.0m	N/A	2.75m lane	Two-way cycle track provided westbound. Traffic lanes narrowed to provide cycle facilities. Pedestrian facilities widened into segregating verge to provide desirable minimum width.
CH. G250 to CH. G300	1.4m – 2.0m	N/A	N/A	3.8m lane	1.6m – 2.2m	N/A	N/A	3.8m lane	No cycle facilities are provided eastbound / westbound . Suboptimum pedestrian facilitates are provided eastbound / westbound .
	1.8m – 3.0m	N/A	N/A	3.5m lane	1.8m – 2.2m	3.0m	N/A	N/A	Two-way cycle track provided westbound. Traffic lanes reduced to one in a 'yield arrangement'. Pedestrian facilities westbound / eastbound widened into carriageway to provide the minimum width.
CH. G300 to CH. G522	1.8m- 2.5m	N/A	N/A	4.0m lane	2.0m – 2.8m	N/A	N/A	4.0m lane	No cycle facilities are provided eastbound / westbound . Informal parking facilities westbound.
	2.0m – 2.4m	N/A	N/A	2.75m lane	2.0m	3.0m	N/A	2.75m lane	Two-way cycle track provided westbound. Traffic lanes narrowed and informal parking facilities removed to provide cycle facilities.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
									Pedestrian facilities widened into carriageway to provide the desirable minimum width.
(Alignment H) Old Lucan Road (West of M50) (CH H0 to H295)									
CH. H0 to CH. H200	2.0m – 2.5m	N/A	N/A	2.5m lane	N/A	N/A	N/A	2.5m lane	No cycle / bus facilities provided eastbound / westbound . Pedestrian facilities westbound are not provided. A parallel parking strip is provided westbound.
	2.0m – 2.5m	N/A	N/A	2.5m lane	N/A	3.0m	N/A	2.5m lane	Two-way cycle facilities are provided westbound. Removal of parallel parking strip is required to facilitate the cycle track. Verge to be widened to fill remaining space.
CH. H200 to CH. H295	2.0m	N/A	N/A	5.5m lane	2.0m	N/A	N/A	3.0m lane	No cycle / bus facilities provided Eastbound / westbound as the public road ends at CH. H295. Informal on-street parking eastbound / westbound .
	2.0m	N/A	N/A	3.0m lane	2.0m	N/A	N/A	3.0m lane	Formal parking Eastbound / westbound provided. Eastbound lane to be narrowed to provide parallel parking spaces.
(Alignment I) LVSC to Old Lucan Road (East of M50) (CH I 0 to I883)									
CH. I 0 to CH. I883	1.6m - 2.2m	1.8m – 3.0m	N/A	N/A	N/A	N/A	N/A	N/A	Two-way cycle track and footway provided. 1.5m verge segregation provided between carriageway and footway.
	1.6m – 2.2m	1.8m – 3.0m	N/A	N/A	N/A	N/A	N/A	N/A	No changes to alignment.
(Alignment J) Old Lucan Road (East of M50) to Kennelsfort Road Lower (CH J 0 to J886)									
CH. J0 to CH. J886	1.8m – 5.5m	N/A	N/A	4.2m lane	1.6m - 3.5m	N/A	N/A	4.2m lane	No cycle facilities are provided eastbound / westbound . No bus lane are provided eastbound / westbound. Two eastbound bus stops (CH. J275 and CH. J660) and two westbound bus stops (CH. J180 and CH. J625) are provided.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
	1.8m – 5.5m	N/A	N/A	3.0m lane	1.6m – 3.5m	N/A	N/A	3.0m lane	Two-way cycle track is to be provided eastbound. Traffic lane / footway widths are to be reduced to accommodate the change. Two eastbound bus stops (CH. J275 and CH. J660) and two westbound bus stops (CH. J180 and CH. J625) are to be removed.
(Alignment K) Kennelsfort Road Lower to Palmerstown drive (CH K 0 to K275)									
CH. K0 to CH. K275	2.0m – 6.8m	N/A	N/A	3.0m – 6.25m lane	1.6m – 5.0m	N/A	N/A	3.0m – 6.0m lane	No cycle facilities provided eastbound / westbound . No bus facilities provided eastbound / westbound . Westbound pedestrian facilities vary with substantial areas below the minimum required width. Parallel parking facilities provided eastbound and westbound.
	1.8m – 5.5m	2.5m – 3.0m	N/A	3.0m lane	2.2m – 4.6m	N/A	N/A	3.0m lane	Two-way cycle track provided eastbound. Traffic lanes and footway reduced to accommodate. Eastbound parking (including 1 disabled parking space) removed to accommodate cycle track. 38 perpendicular parking spaces provided (replacing existing parallel spaces) to replace loss of eastbound parking spaces, and relocation of disabled space. Requires reduction in traffic lane widths to accommodate. Eastbound (CH. K90) and westbound (CH. K100) new bus stops are to be provided.
(Alignment L) Kennelsfort Road Lower to Palmerstown Drive (CH L 0 to L326)									
CH. L0 to CH. L326	4.5m – 5.5m shared facility		N/A	N/A	N/A	N/A	N/A	N/A	Shared Pedestrian/ cycle facility is provided only.
	2.0m	3.25m	N/A	N/A	N/A	N/A	N/A	N/A	2 -Way Cycle track is provided as an offline route. Pedestrian footway is reduced and widening into the verge in locations along the section is required to accommodate.

Chainage Reference	Existing Eastbound Carriageway Proposed Eastbound Carriageway				Existing Westbound Carriageway Proposed Westbound Carriageway				Existing Conditions Notes Proposed Scheme Notes
	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Footway width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	
(Alignment N) N4 Junction 3 off-slip (CH N 0 to N368)									
CH. N0 to CH. N368	N/A	N/A	N/A	N/A	2.0m	1.5m	N/A	2 x 3.0m	Suboptimum cycle facilities (cycle track with white line segregation) provided as far as the bus stop after which the 2.0m wide footway is designated a shared surface, but there is no ramp or transition to route cyclists to the shared facility. With signage, street furniture and the presence of a bus stop, the shared facility is also suboptimal. With the exception of a bus stop, there is no other bus lane provision westbound.
	N/A	N/A	N/A	N/A	2.0m – 3.0m	N/A	3.2m	2 x 3.0m	The bus lane on the westbound off-slip at Junction 3 will be extended to ensure bus priority is provided on the approach to the junction with R136 Ballyowen Road at the top of the slip road. The existing dedicated cycle lane provision on the segregated westbound service road terminates at Chainage N 0 and cyclists will share the Bus lane. In addition to removing the existing sub-optimal cycle lane, widening into the verge/ footway (0.4m max) and onto the off-slip embankment (1.6m max) is required to facilitate the provision of the addition of a bus lane. A low proprietary retaining wall system will be required to facilitate encroaching on the embankment.

4.3 Design Speed

The design speed to which the horizontal and vertical alignment of the Proposed Scheme has been developed has been governed by DMURS and the guidance provided by the Department of Transport, Tourism and Sport (DTTAS) in the document Guidelines for Setting and Managing Speed Limits in Ireland.

As outlined in DMURS '*Design Speed is the maximum speed at which it is envisaged / intended that the majority of vehicles will travel under normal conditions*' for the urban road sections. DMURS recommends that "*in most cases the posted or intended speed limit should be aligned with the design speed"and* that the design speed of a road or street must not be "*up-designed*" so that it is higher than the posted speed limit. DMURS sets out that designers *"must balance speed management, the values of place and reasonable expectations of appropriate speed according to context and function"*.

Consideration for selection of an appropriate design speed is undertaken in light of the "Function and Importance of Movement" and "Context" of the street network, as explained further in DMURS Section 3.2. The "Design Speed Selection Matrix" as shown in Figure 4-2 below is also used to inform the appropriate design speed, extracted from DMURS Chapter 4.

However, the above does not include the following sections of the Proposed Scheme:

- The N4 from Junction 3 to Junction 2 in-bound;
- The N4 from the M50 interchange to Junction 3 out-bound; and
- The R148 Chapelizod bypass, where the speed limit for the general traffic is 80kph, (the bus lane speed limit along these sections is generally 60kph).

The above sections of the Proposed Scheme are governed by the design standard in the TII Publication (DN-GEO-03031 (NRA TD 9) – "Rural Road Link Design").

PEDESTRIAN PRIORITY VEHICLE PRIORITY

FUNCTION					
ARTERIAL	30-40 KM/H	40-50 KM/H	40-50 KM/H	50-60 KM/H	60-80 KM/H
LINK	30 KM/H	30-50 KM/H	30-50 KM/H	50-60 KM/H	60-80 KM/H
LOCAL	10-30 KM/H	10-30 KM/H	10-30 KM/H	30-50 KM/H	60 KM/H
CONTEXT	CENTRE	N'HOOD	SUBURBAN	BUSINESS/ INDUSTRIAL	RURAL FRINGE

Figure 4-2 DMURS Design Speed Selection Matrix

The design speeds used for the existing and proposed mandatory speed limits on the Proposed Scheme are detailed in Table 4-3 below. The Proposed Scheme will introduce a 30km/hr speed limit on the Old Lucan Road west of the M50, which will be narrowed, and traffic calmed to accommodate a cycle track within the existing road space. Speed limits for the bus lanes for a section around the proposed bus stops at LVSC between N4 Junction 2 and M50 Junction 7 will be reduced to 50km/hr from 60km/hr eastbound, and 80km/hr westbound. Similarly, speed limits for the bus lanes along the full length of the R148 Chapelizod bypass will be reduced from 80km/hr to 60km/hr.

The Proposed Scheme will also adopt a reduced speed limit from 50km/h to 30km/h for St John's Road West from Military Road to the tie-in at Victoria Quay as proposed by the DCC Special Speed Limit Bye-Laws, April 2021.

Table 4-3 Existing and Proposed Design Speeds

Chainage reference	Road/Junction Name	DMURS Road Function	DMURS Place Context	Existing Speed Limit (km/h)	Proposed Design Speed (km/h)	Proposed Posted Speed Limit (km/h)
A700	Ballyowen Lane	Local	Neighbourhood	50	30	30
G50 – H295	Old Lucan Road	Local	Neighbourhood	50	30	30
A2050 – A2250	N4 (Eastbound Bus Lane only)	Arterial	Business/ Industrial	60	50	50-60
A2280 – 2060	N4 (Westbound Bus Lane only)	Arterial	Business/ Industrial	80	50	50-80
A4600 – A7450	R148 Chapelizod bypass (Bus Lanes only)	Arterial	Rural Fringe	80	60	60 [80 gen traffic lanes]
A 9250 to end of scheme	St John's Road West Military Road to Victoria Quay	Arterial/ Link	Centre	50	30	30

4.4 Alignment Modelling Strategy

The 3D model design, including the horizontal and vertical alignments, 3D modelling corridors and the associated design features has been developed using the Autodesk Civil 3D software in accordance with the BCID BIM Execution Plan. The models have been developed for the purposes of informing the scheme extents and informing the preliminary design for the requirement for any significant earthworks / retaining structures along the Proposed Scheme.

As part of the alignment design process, the horizontal and vertical design has been optimised to minimise impact to the existing road network and adjoining properties where feasible. Horizontal and vertical alignments have been developed to define the road centrelines for the proposed route layout while also taking cognisance of the existing road network. In terms of the horizontal alignments, due consideration has been given to aligning the centrelines as close to existing as practicable. However, the over-riding determining factor for locating the horizontal alignment is to ensure it is positioned in the centre of the proposed carriageway. This is ideally along a central lane marking on the carriageway, in order to minimise rideability issues for vehicles crossing the crown line.

In the case of developing the vertical alignment along the route, a refinement process has been undertaken to minimise impacts to the existing road network and develop the proposed carriageway levels as close to existing as practicable. In most circumstances however, due to a change in cross-section, due consideration is given to the resulting level difference at the outer extents of the carriageway, particularly through urban areas where a difference in existing and proposed footway levels will require additional temporary land-take to facilitate tie-in.

Existing ground levels have been determined using the existing ground model produced for the Proposed Scheme from the topographical survey. This existing ground model informs the differences in levels between proposed and existing along the route, while at junctions it is also used to determine dwell area gradients and lengths to facilitate junction realignment.

The developed alignment design sets parameters for development of other design elements such as drainage, determination of earthworks, utility / services placement etc.

4.5 Summary of Horizontal Alignment

Existing alignments and crossfalls along the Proposed Scheme have been generally retained wherever practical. DMURS provides the following guidance in relation to modifications of existing arterial and link road geometry:

> *Designers should avoid major changes in the alignment of Arterial and Link streets as these routes will generally need to be directional in order to efficiently link destinations.*
>
> *Major changes in horizontal alignment of Arterial and Link streets should be restricted to where required in response to the topography or constraints of a site.*

In some areas, minor adjustments will be required to the horizontal alignment to deliver the requisite width to ensure the provision of the necessary traffic lanes, bus lanes, cyclist and pedestrian facilities which would also allow the drainage of surface water into new / relocated road gullies.

In areas where road widening and minor changes to the horizontal alignment will not be practicable due to constraints (environmental, residential, geometrical etc.), new construction has been provided through greenfield areas to ensure the provision of continuity of design throughout the scheme.

In light of the above the horizontal and vertical alignment of the mainline are generally as per the existing parameters and surveys. The alignment of the scheme is generally compatible with the selected design speed and associated safe stopping sight distances.

Minor changes in horizontal alignments include:

- N4 Jct.3 on-slip Chainage A200 – A450 – a change to the cross section width to provide a new bus lane. The cross section is widened into the verge and existing traffic lane narrowed with a splitter island provided between the traffic and bus lane.
- N4 Jct.2 off-slip Chainage A1050 to A1400 – a change to upgrade the off-slip layout to facilitate a continuous bus lane, widening required for upgraded slip and new 2-way cycle track.
- R148 Eastbound Chainage A2800 to A3100 – a minor horizontal change provided within the existing cross section to retain 2 traffic lanes and provide a new bus lane, existing hatched road marks reduced in width to facilitate.
- Old Lucan Road Chainage A4000 – widening into Applegreen petrol station land to provide an additional traffic lane for straight on and left movements from Old Lucan Road and upgraded shared facilities adjacent to the petrol station boundary.
- R148 Chainage A 4300 to A4450 – minor change to provide continuity in pedestrian priority shared surface, encroaching in central median, whilst maintaining existing boundary to designated SAC;
- St John's Road West Chainage A 9100 to A9694 – minor change to facilitate cycle tracks and offline bus stops; and
- R148 Lucan Road Chainage C0 to C100 Lucan Road – widening into verge to accommodate cycle track and upgraded traffic and bus lane widths.

4.6 Summary of Vertical Alignment

Due to the nature of the proposed design, with the majority of the design proposals involving widening of the existing roadway in order to accommodate additional facilities, every effort has been made to ensure the vertical alignment adheres as closely as practicable to the existing arrangement.

DMURS defines the vertical alignment of a road as follows:

> *"A vertical alignment consists of a series of straight-line gradients that are connected by curves, usually parabolic curves. Vertical alignment is less of an issue on urban streets that carry traffic at moderate design speeds and changes in vertical alignment should be considered at the network level as a response to the topography of a site."*

With the exception of several existing isolated locations, visibility concerns associated with adverse vertical crest and sag curves have generally not been identified on the Proposed Scheme due to the nature of the existing urban road network. Notwithstanding, the vertical alignment of the proposed road development has also been assessed to ensure hard standing areas have been designed above the minimum gradient of 0.5% to mitigate localised surface water ponding and facilitate surface run-off drainage measures.

4.7 Forward Visibility

Forward visibility is the distance along the street ahead of which a driver of a vehicle can see. The minimum level of forward visibility required along a street for a vehicle to stop safely, should an object enter its path, is based on the Stopping Sight Distances (SSD).

The SSD is the theoretical minimum forward sight distance required by a driver travelling at free speed (i.e. not influenced by other drivers) in order to stop the car when faced with an unexpected hazard on the carriageway. This is calculated as the total distance it takes the driver driving at the design speed to stop safely. It is measured along the centreline of the lane in which the vehicle is travelling, and the design guidance assumes that a driver sitting in a low vehicle (eye height 1.05m) must be able to see an object which is 0.26m high from the SSD distance.

The SSD = perception distance + reaction distance + braking distance.

The SSD standards which have been applied to the proposed design have been provided in Table 4-1 and are in accordance with the design guidance given within DMURS as shown in Table 4-4.

For sections of the Proposed Scheme with a speed limit of 80km/h, SSD requirements are set out in TII publication DN-GEO-03031 (Section 1.3 and Table 1.3) SSD required for general traffic lanes is 160m; however, in bus lanes the speed is limited to 60km/h, and a SSD of 120m is required.

With the exception of the following locations, the desirable minimum forward visibility requirements were achieved for the Proposed Scheme:

- N4 Mainline EB – Ch. A1400 to Ch. A2400;
- N4 Mainline EB – Ch. A2480 to Ch. A2570;
- R148 Palmerstown bypass EB – Ch. A2850 to Ch. A3000; and
- R148 Chapelizod bypass WB – Ch. A4925 to Ch. A4980.

Refer to Section 4.17 for details of any required deviations, relaxations or departures.

Table 4-4 DMURS SSD Design Standards

SSD STANDARDS

Design Speed (km/h)	SSD Standard (metres)
10	7
20	14
30	23
40	33
50	45
60	59

Forward Visibility

Design Speed (km/h)	SSD Standard (metres)
10	8
20	15
30	24
40	36
50	49
60	65

Forward Visibility on Bus Routes

4.8 Corner Radii and Swept Path

In line with the aim of the Proposed Scheme of providing enhanced infrastructure for walking and cycling, corner radii along the route are to be reduced where appropriate in order to lower the speed at which vehicles can turn corners and increase inter-visibility between users.

Junctions are where the actual and perceived risk to both cyclists and pedestrians are highest and usually represent the most uncomfortable parts of any journey. In order to provide a design whereby vehicles navigate through turns at a reduced speed, thereby reducing the risk of serious collisions, kerb and footway buildouts have been included on the majority of the designed junctions along the route thus adhering to design guidance given within the DMURS document where it is stated:

> *"Build-outs should be used on approaches to junctions and pedestrian crossings in order to tighten corner radii, reinforce visibility splays and reduce crossing distances."*

The corner radius in urban settings is often determined by swept path analysis. Whilst swept path analysis should be considered, the analysis may overestimate the amount of space needed and / or the speed at which the corner is taken. The design of the Proposed Scheme has balanced the size of the corner radii with user needs, pedestrian and cyclist safety and the promotion of lower operating speeds. In general, on junctions between Arterial and / or Link streets a maximum corner radius of 6m has been applied. 6m will generally allow larger vehicles, such as buses and rigid body trucks, to turn corners without crossing the centre line of the intersecting road.

A suite of vehicles was collated for consideration in assessment of alignment / junction designs and entrances to private properties as shown below in Figure 4-3.

Name	Width	Length	W/W Rad
'Standard' Articulated Bus	2.520	18.020	11.400
15m 6WS Luxury Coach	2.500	15.000	12.490
DB32 Fire Appliance	2.180	8.680	8.821
DB32 Private Car	1.715	4.223	6.207
DB32 Refuse Vehicle	2.400	7.900	10.323
Double Decker City Bus	2.520	10.704	10.856
Double Decker Regional Bus	2.550	14.145	12.150
FTA Design Articulated Vehicle (1998)	2.550	16.480	7.314
FTA Design Drawbar Vehicle (1998)	2.550	18.751	10.708
Low Entry Regional Commuter Bus	2.550	13.490	12.200
Rigid Truck	2.500	12.000	12.677
Single Deck City Bus	2.445	11.505	11.948
Single Deck Midi Bus	2.445	10.280	11.577

Figure 4-3 Standard Suite of Vehicles Used for Assessment of the Proposed Scheme

In general vehicle tracking / swept path analysis was carried out using the following principles:

- DB32 Private Car – Analysis undertaken at impacted private residential properties /car parking areas;
- DB32 Refuse Vehicle – Analysis undertaken to ensure refuse vehicles can make turns in / out of all side roads and entries concerning residential / commercial properties;
- 14.1m Double Decker Regional Bus – Analysis undertaken along the main alignment of the route concerning bus lanes, including the bus interchange area and at junctions;
- Rigid Truck – Analysis undertaken along the main alignment of the route; and
- FTA Design Articulated Vehicle (1998) – Analysis undertaken along the regional roads of the Proposed Scheme.

At the following locations it was deemed appropriate to provide a set-back stop line to facilitate turning movements at junctions:

- Ch. A8460, South Circular Road - St John's Road West (westbound) to South Circular Road (southbound),
- Ch. A9300, Military Road – St John's Road West (westbound) to Military Road (southbound).

4.9 Kerbing

The kerbing type selected along the Proposed Scheme is primarily dependent upon the presence of a cycle track alongside the carriageway. Where cycle tracks will be present adjacent to the carriageway, the cycle track will be separated by the typical 250mm wide BusConnects kerb, which will have a 120mm upstand to the carriageway and a 60mm upstand to the cycle track (120mm upstand where cycle track is not raised) as shown in Figure 4-4.

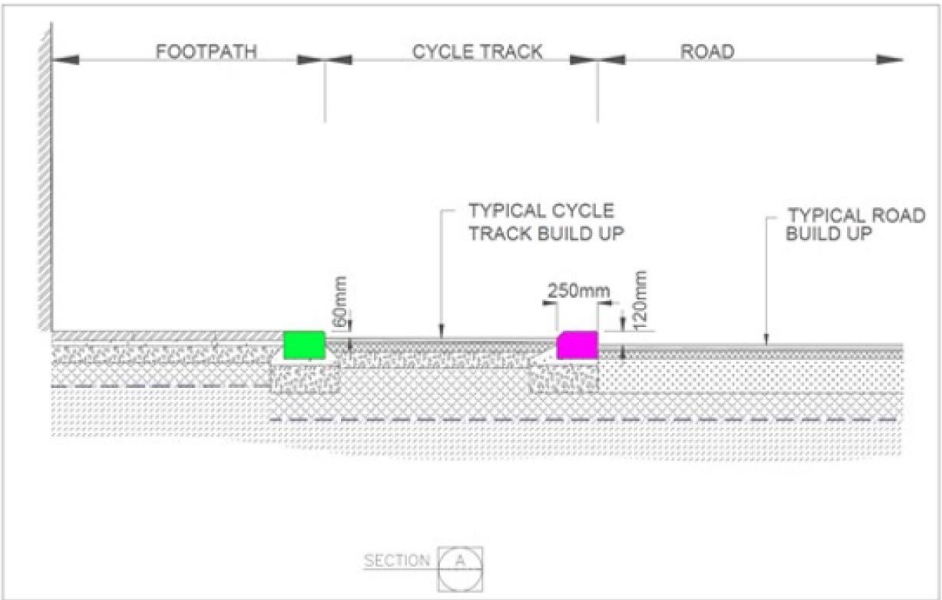

Figure 4-4 Typical Kerb Arrangement

Where this kerb will cross at an uncontrolled junction and at direct accesses, the Raised Table Priority Junction Treatment (Figure 4-5) will be implemented at the majority of locations. At these locations, the kerb will be lowered to a 60mm upstand while the cycle track will be raised throughout. At some locations, where it is necessary to retain the cycle track at carriageway level (e.g. due to cobblestone heritage feature), the kerb will transition to carriageway level and / or terminate as required.

At controlled and signalised junctions, the cycle track will be ramped down to the carriageway level and the kerb will be transitioned to carriageway level and terminated.

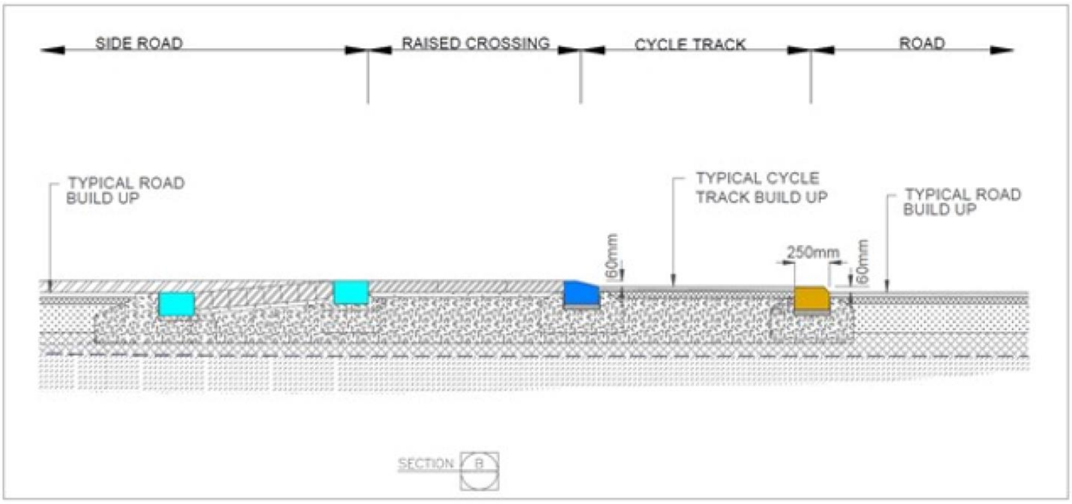

Figure 4-5 Kerb Treatment at Raised Table Priority Junction

At locations where a footpath will be located adjacent to a cycle track, a half battered kerb with a 60mm upstand is proposed. This 60mm high vertical kerb will be required to ensure that the kerb is properly detectable by visually impaired pedestrians using the footpath.

At locations where a cycle track is not present, and the footpath is adjacent to the carriageway, a standard 125mm upstand is proposed. Dropped and transition kerbs will be provided at driveways and pedestrian crossings.

Where levels and proposed carriageway cross-sections will not change across major overbridge structures along the Proposed Scheme, it is proposed to retain the existing kerb provisions.

At the existing N4 Junction 3 westbound off-slip and the eastbound approach to the R112 Lucan Road it is proposed to use a trief kerb due to carriageway widening, in order to minimise the extent of change to footpath crossfall.

4.10 Pedestrian Provision

DMURS defines the footway cross section by three distinct areas. The 'footway' area is designated as the main throughfare within the footway designated for pedestrian movement along the street. The 'verge' area provides an area that can be used for street furniture as well as an overflow area for pedestrian movement. In some circumstances the verge area can also provide a buffer for high speed traffic, however for the majority of the Proposed Scheme a cycle track will perform a similar function for separation from motorised traffic. The 'strip' area is designated as a specific location for which retail / commercial / private premises may undertake certain outdoor activities including dining, stalls or outdoor seating etc. These areas often have specific licenses or agreements in place with the Council or have dedicated legal interests (private landings) over this area of the footway. The assessment of these areas are further discussed in Chapter 13.

Figure 4-6 below provides an extract from DMURS demonstrating the relevant components of the footway.

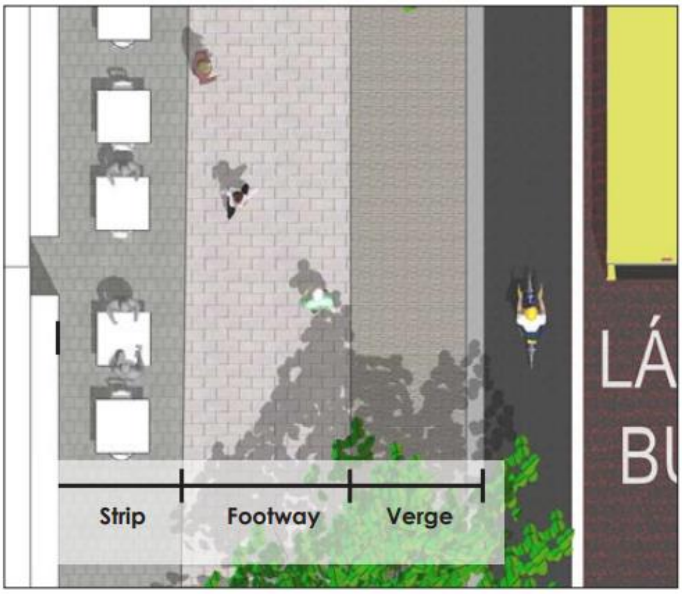

Figure 4-6 Key Components of the Footway

4.10.1 Footway Widths

The adopted footway design width parameters have been provided in Table 4-1.The desirable minimum footway width for the Proposed Scheme is 2m and an absolute minimum width of 1.8m has been adopted at constrained sections. This width should be increased in areas catering for significant pedestrian volumes where space permits or in areas where designated additional outdoor functionality has been determined to increase the overall footway regime.

At specific pinch points, Building for Everyone: A Universal Design Approach, defines acceptable minimum footway widths as being 1.2m wide over a 2m length of path.

In line with the Road User Hierarchy designated within DMURS, at pinch points, the width of the general traffic lane should be reduced first, then the width of the cycle track should be reduced before the width of the pedestrian footway is reduced. For the majority of the Proposed Scheme extents minimum lane widths have been adopted throughout.

Throughout the scheme, footway widths of 2.0m or wider have been proposed, with the exception of a limited number of stretches where a width of 1.8m or greater is proposed due to the presence of localised space constraints. The existing and Proposed Scheme nominal footway widths over the length of the corridor have been provided in Table 4-2.

4.10.2 Footway Crossfall

The adopted footway design crossfall parameters have been provided in Table 4-5.The footway crossfall is recommended to be 2% - 3.3% as per DN-PAV-03026, Figure 2.3.

Table 4-5 DN-PAV-03026, (Figure 2.3 Geometric Parameters for Footways)

Parameter	Recommended Limits	Extreme Limits
Longitudinal gradient (normally the same as adjacent highway)	1.25% to 5%	8% maximum*
Width	2m minimum	1.3m minimum
Crossfall	2% to 3.3%	1.5% minimum to 7% maximum at crossings

Note: *In some cases it may be necessary to construct a footway with a gradient of more than 8 per cent. Provision of a handrail is recommended if site constraints necessitate a gradient steeper than 10 per cent.

Building for Everyone: A Universal Design Approach recommends that cross falls should ideally be limited to 1:50 or 2% gradient as steeper gradients can tend to misdirect prams, pushchairs and wheelchairs. This approach has been generally adopted to within the constraints of the existing footway extents.

4.10.3 Longitudinal Gradient

The adopted footway design longitudinal grading parameters have been provided in Table 4-1. The footway longitudinal gradient follows the gradient of the proposed carriageway. DN-PAV-03026, Table 2.3 shown in Table 4-5 recommends a longitudinal gradient of 1.25%-5%.

Similar to cycle tracks throughout the scheme, longitudinal gradients of footways are likely to be constrained by the longitudinal gradient of the adjacent carriageway with little scope to vary the footway separately.

Designated ramps to the proposed bus stops at Chapelizod Hill Road are proposed at a maximum slope of 1 in 15 for sections of 5m, complying with Building Regulations Technical Guidance Documents K and M.

4.10.4 Pedestrian Crossings

The adopted pedestrian crossing design parameters have been provided in Table 4-1. Where practicable, DMURS recommends that designers provide pedestrian crossings that allow pedestrians to cross the street in a single, direct movement. To facilitate road users who cannot cross in a reasonable time, the desirable maximum crossing length without providing a refuge island is 18m. This may be increased to 19m as an absolute maximum. This is applicable at stand-alone pedestrian crossings as well as at junctions.

Refuge islands should be a minimum width of 2m. Larger refuge islands should be considered by designers in locations where the balance of place and movement is weighted towards vehicle movements, such as areas where the speed limit is 60kph or greater, in suburban areas or where there is an increased pedestrian safety risk due to particular traffic movements. Straight crossings can be provided through refuge islands only where the island is 4m wide or more. Islands of less than 4m in width should provide for staggered crossings.

Where space allows, crossing lengths can be minimised by accommodating a suitable landing area for pedestrians between the road carriageway and cycle track, with the cycle track crossing controlled by mini-zebra markings. This reduced pedestrian crossing distance will have the added benefit of improving overall junction performance due to reduced intergreen times.

Along the Proposed Scheme, pedestrian crossings varying from 2.4m and 4m in width have been incorporated throughout the design. Larger pedestrian crossing widths have been allocated in areas that are expected to accommodate a high number of non-motorised users.

At signalised junctions and standalone pedestrian crossings, the footway is to be ramped down to carriageway level to facilitate pedestrians who require an unobstructed crossing. At minor junctions, raised tables are provided to raise the road level up to footway level and facilitate unimpeded crossing. Tactile paving is provided at the mouth of each pedestrian crossing and is to be designed in accordance with standards. Audio units are to be provided on each traffic signal push button.

Formal crossing points are to be provided on the upstream side of bus stop islands, consisting of an on-demand signalised pedestrian crossing with appropriate tactile paving, push buttons and LED warning studs. A secondary informal crossing should be provided on the desire line on the downstream side of the island.

4.11 Accessibility for Mobility Impaired Users

One of the aims of the Proposed Scheme is to provide enhanced walking, cycling and bus infrastructure along the corridor. In achieving this aim, the Proposed Scheme has generally been developed in accordance with the principles of DMURS and Building for Everyone: A Universal Design Approach.

The following non exhaustive list of relevant standards and guidelines have been informed the approach to Universal Design in developing the Proposed Scheme:

- Preliminary Design Guidance Booklet for BusConnects Core Bus Corridors (NTA 2020);
- Building for Everyone: A Universal Design Approach (NDA 2020);
- How Walkable is Your Town (NDA 2015);
- Shared Space, Shared Surfaces and Home Zones from a Universal Design Approach for the Urban Environment in Ireland (NDA 2012);
- Best Practice Guidelines, Designing Accessible Environments. Irish Wheelchair Association;
- DfT Inclusive Mobility (UK DfT 2005);
- UK DfT Guidance on the use of tactile paving surfaces (UK DfT 2021); and
- BS8300:2018 Volume 1 Design of an accessible and inclusive built environment. External Environment - code of practice (BSI 2012).

The Disability Act 2005 places a statutory obligation on public service providers to consider the needs of disabled people. A specialist consultant was engaged to undertake an Accessibility Audit of the existing environment and proposed draft preliminary design for the corridor. The Audit provided a description of the key accessibility features and potential barriers to disabled people based on the Universal Design standards of good practice listed above. A copy of the Audit has been provided in Appendix I. It should be noted that the audit was undertaken in the early design stages with the view to implementing any key measures identified as part of the design development process.

The audit provided a description of the key accessibility features and potential barriers to mobility impaired people based on good practice and considered the following general design issues.

- Accessible Parking - On-street Disabled Parking Space layout should be to the appropriate standard, with dropped kerb access between the parking space and footpath;
- Access Routes on Footpaths - Width of footpaths should be clear of clutter, such as street furniture, and allow unimpeded access for the mobility impaired, and in doing so, meet the minimum standards for widths;
- Drainage - All footpaths should have sufficient cross-fall for drainage purposes but without affecting the ability of mobility-impaired people to move safely along the corridor;
- Guardrails - Guardrails should be located only where needed for safety purposes – and care should be taken not to create narrow spaces which create difficulties for movement;
- Pedestrian Crossing Points - Pedestrian crossing points should be laid out in accordance with standards and make it convenient and safe for mobility impaired users to negotiate crossing of carriageways;

- Controlled and Uncontrolled Crossings - Controlled and Uncontrolled Crossings should have tactile paving laid out correctly to provide tactile and visual assistance to mobility-impaired users approaching crossing points;
- Changes in Level - Any changes in level should be addressed in the design process to ensure that all changes in level, where practicable, comply with standards;
- Shared pedestrian/cyclist areas - Shared pedestrian/cyclist areas should be well laid out, with clear visual and tactile elements included, to ensure that these areas are safe for mobility-impaired users, pedestrians and cyclists;
- Surface Material - Footpath materials should be selected to ensure surfaces are free of undulations, with no trip hazards where there is a transition between surface materials – or where the Proposed Scheme ties into the existing infrastructure; and
- Street Furniture - All poles for signs and street lighting should be carefully located to minimise the effect on the safe and convenient passage of pedestrians and cyclists, with due cognisance to the safe movement of mobility impaired users.

The audit also provided recommendations for consideration when developing the design and noted that in general the Proposed Scheme is likely to improve the street environment meeting current Universal Design good practice standards or at least make it no worse than the current situation. However, in a small number of cases, where road space is limited, the audit noted that the improvements for cyclists had the potential to make the pedestrian environment more complex for vulnerable pedestrians, including people with vision impairments.

The audit also noted that the Proposed Scheme has the opportunity to address many of the existing barriers to accessibility. For example; although the majority of the footways appear to be in a reasonable state of repair and the majority of crossings have dropped kerbs and tactile paving there is the opportunity to address any gaps in the current provision within the Proposed Scheme; in general, there will be an increase in the number of controlled pedestrian crossings along the route improving the experience for pedestrians.

The audit noted that a new at grade pedestrian crossing is proposed at the R148 / Kennelsfort Road junction, as an alternative to using the existing pedestrian/cycle bridge which has steep curved ramps and does not meet good practice standards, although these are likely to have met the design standards when constructed.

The audit noted the following specific potential issues for further consideration:

- that the design proposals include a small number of bus stops with shared pedestrian/cycle areas on the approach to the bus boarding areas which could be problematic for vulnerable pedestrians, with a recommendation to explore every opportunity to design out shared spaces;
- The ramps proposed to provide access to the new bus stops on the Chapelizod Bypass are unlikely to meet the needs of many disabled people, with a recommendation to revisit the potential access options at the next stage; and
- The cycle facilities proposed at the St John's Road West/Con Colbert Road / South Circular Road junction potentially create a complex pedestrian environment, with a to design out potential areas of conflict between pedestrians and cyclists at the next design stage.

A detailed scheme breakdown of the relevant existing and proposed footways has been provided in Table 4-2. In achieving the enhanced pedestrian facilities there has been a concerted effort made to provide clear segregation of modes at key interaction points along the corridor which was highlighted as a potential mobility constraint in the Audit of the existing situation, particularly for people with vision impairments. In addressing one of the key aspects to segregation, the use of the 60mm set down kerb between the footway and the cycle track is of particular importance for guide dogs, whereby the use of white line segregation is not as effective for establishing a clear understanding of the change of pavement use and potential for cyclist / pedestrian interactions.

One of the other key areas that was focused on was the interaction between pedestrians, cyclists and buses at bus stops. The Proposed Scheme has implemented the use of island bus stops to manage the interaction between the various modes with the view to providing a balanced safe solution for all modes. This is further discussed in Section 4.13.

4.12 Cycling Provision

One of the objectives of the Proposed Scheme is to enhance the potential for cycling by providing safe infrastructure for cycling, segregated from general traffic wherever practicable. Physical segregation ensures that cyclists are protected from motorised traffic as well as independent of vehicular congestion, thus improving cyclist safety and reliability of journey times for cyclists. Physical segregation can be provided in the form of vertical segregation, (e.g. raised kerbs), horizontal segregation, (e.g. parking / verge protected cycle tracks), or both.

The 'preferred cross-section template' developed for the Proposed Scheme consists of protected cycle tracks, providing vertical segregation from the carriageway to the cycle track and vertical segregation from the cycle track to the footway.

The principal source for guidance on the design of cycle facilities is the National Cycle Manual (NCM) published by the National Transport Authority, and the BCPDGB. The design parameters for cycling facilities have been provided in Table 4-1.

The desirable minimum width for a single-direction, with-flow, raised-adjacent cycle track is 2.0m. This arrangement allows for two-abreast cycling. Based on the NCM Width Calculator, this allows for overtaking within the cycle track. The minimum width is 1.5m, which based on the NCM Width Calculator, allows for single file cycling. Localised narrowing of the cycle track below 1.5m may be necessary over very short distances to cater for local constraints (e.g. mature trees).

The desirable minimum width for a two-way cycle track is 3.25m. In addition to this, a buffer of 0.5m should be provided between the two-way cycle track and the carriageway. Using the NCM width calculator, reduction of these desirable minimum widths can be considered on a case-by-case basis, with due cognisance of the volume of cyclists anticipated to use the route as well as the level of service required.

The Proposed Scheme is approximately 9.7km long and includes 7.5km+ of new cycle tracks. The preliminary design drawings included within Appendix B show the improved extent of cycle provision, which is summarised below:

- 30.5% Existing cycle priority (westbound) (12.5% mandatory cycle lane, 8% advisory, 10% cycle-track)
- 21% Existing cycle priority (eastbound) (0.6% mandatory cycle lane, 11% advisory, 10% cycle-track)
- 90.5% Proposed cycle priority (westbound) (85% cycle track, 5.5% advisory cycle lane, [3.6% Quiet Street not included]
- 90.5% Proposed cycle priority (eastbound) (87% cycle track, 3.5% advisory cycle lane, [3.6% Quiet Street not included]

The cycle provision figures relate to the sections of the GDA Cycle Network Plan along the route of the Proposed Scheme and do not include the significant additional provision feeding into this route from secondary cycle routes on side roads. In accordance with the GDA Cycle Network Plan there is no cycle provision proposed along the Chapelizod bypass.

4.12.1 Segregated Cycle Track

A Cycle Track is a segregated cycle lane which is physically segregated from the adjacent traffic lane and / or bus lane horizontally and / or vertically as shown in Figure 4-7 below, taken from the BCPDGB.

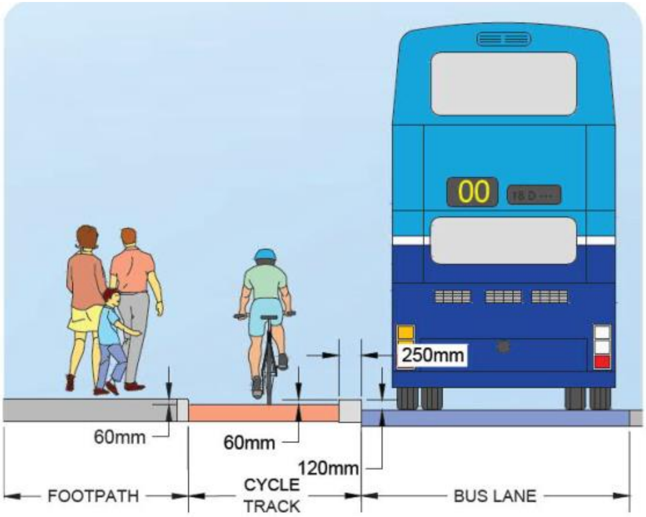

Figure 4-7 Fully Segregated Cycle Track

Wherever practicable, the Proposed Scheme design has endeavoured to incorporate segregated cycle tracks, and has done so in the following locations:

- R136 Ballyowen Road from Ch. B1 0 to Ch. B254 (two-way cycle track adjacent to southbound lane including N4 overbridge);
- Lucan Road from Ch. C0 to Ch. C288 (two-way cycle track from Ch. C100, adjacent to eastbound carriageway);
- N4 Junction 3 to Junction 2 from Ch. A 450 (two-way cycle track, adjacent to eastbound carriageway.) to Ch. E305 (N4 Junction 2 off-slip);
- Old Lucan Road east and west of M50 from Ch. G0 crossing over the M50 to Ch. L300 beyond Applegreen Petrol Station. Protective cycle tracks also provided along Kennelsfort Road (linked with Old Lucan Road (Ch. A3650); and
- Con Colbert Road from Ch. A7550 to St John's Road West Ch. A9570 (single cycle tracks in both eastbound / westbound directions).

4.12.2 Cycle Lane

Cycle lanes are designated lanes on the carriageway that are reserved either exclusively or primarily for the passage of cyclists. Standard cycle lanes include Mandatory Cycle Lanes and Advisory Cycle Lanes. Mandatory Cycle Lanes are marked by a continuous white line which prohibits motorised traffic from entering the lane, except for access. Parking is not permitted on Mandatory Cycle lanes. Mandatory Cycle Lanes are 24 hour unless time plated in which case, they are no longer cycle lanes. Advisory Cycle Lanes are marked by a broken white line which allows motorised traffic to enter or cross the lane. They are used where a Mandatory Cycle Lane leaves insufficient residual road space for traffic, and at junctions where traffic needs to turn across the cycle lane. Parking is not permitted on Advisory Cycle Lanes other than for set down and loading. Advisory Cycle Lanes are 24-hour unless time plated.

Cycle tracks are the preferred cycling infrastructure proposed along the length of the Proposed Scheme wherever practicable. Where necessary the use of cycle lanes have been limited to the following locations typically along the route:

- Transitions to existing cycle lanes, typically on side roads of the main corridor alignment;
- At grade junction crossings; and
- For side road crossings where the cycle track is locally reduced to road level.

4.12.3 Offline Cycle Track

Offline cycle tracks are fully offset from the road carriageway, providing a greater level of protection and comfort to cycle users. Offline sections of cycle track are provided at the following locations:

- East side of R136 Ballyowen Road, Ch. B100 to Ch. B0, two-way cycle track provided over the N4 (via proposed new pedestrian / cycle bridge);
- Northern roundabout of N4 Junction 2, Ch. F90 to Ch. F149, two-way cycle track provided as alternative route for cyclists, avoiding the navigation of the roundabout and improving directness to Old Lucan Road;
- Ch. H175 to Ch. I150 two-way cycle track proving continuation of cycle route from ramp of existing bridge to the existing two-way cycle track adjacent to the M50 Northbound slip road;
- Old Lucan Road west of the M50, Ch. I550 to Ch. I883, existing two-way pedestrian / cycle bridge retained to navigate over M50;
- Kennelsfort Road Upper, Ch. A3700, connectivity and directness between signalised crossings; and
- Ch. L0 to Ch. L300, OLR to R112 Lucan Road, continuation and enhancement of existing shared cycle / pedestrian facilities to two-way cycle track and segregated footway.

4.12.4 Quiet Street Treatment

Where the roadway widths cannot facilitate cyclists without significant impact on bus priority, alternative cycle routes are explored for short distances away from the Proposed Scheme bus route. Such offline options may include directing cyclists along streets with minimal general traffic other than car users who live on the street. Guidance in this regard has been provided within the BCPDGB which states:

> *"Diversions of proposed cycle facilities on to quieter parallel routes, to avoid localised narrowing of cycle tracks on the main CBC route, is to be considered in the context of the CBC route being listed as a primary cycle route as per the Greater Dublin Area Cycle Network Plan. These diversions, however, may also be considered where appropriate cycle facilities cannot be provided along the CBC route without significant impact."*

They are called Quiet Streets due to the low amount of general traffic users travelling at low speed and are deemed suitable for cyclists sharing the roadway with the general traffic without the need to construct segregated cycle tracks or painted cycle lanes. The Quiet Street treatment would involve appropriate advisory signage and lane marking for both the general road users and cyclists.

Quiet Street treatment has been proposed along the access road to the Hermitage Golf Course, Ballyowen Lane, and Hermitage Road with a view to providing an alternative route for cyclists.

Additional traffic calming measures (speed ramps and raised uncontrolled pedestrian crossing ramps) have been proposed at all of the above locations.

4.12.5 Treatment of Constrained Areas

At some locations along the scheme, due to site constraints such as the Memorial Gardens, the Royal Hospital Kilmainham, the Kildare rail line, the desirable minimum cycle track width cannot be achieved, and localised narrowing is required. These locations are recorded in the Deviations Report in Appendix C.

At these locations, owing to the local constraints providing land take to achieve the desirable minimum width is not practicable. Due to the high foot traffic in these areas, it is preferable to provide a reduced cycle track / cycle lane width. The proposed single cycle track / cycle lane width is reduced to the minimum permitted in the NCM (1.5m) at the following locations:

- Parallel service road on the N4 between Jct.3 and Jct.2 westbound between A-425 to A-650;
- R148 Con Colbert Road eastbound between A-7800 to A-7900;
- R111 South Circular Road southbound at A-8500
- R148 St John's Road West westbound between A-8500 to A-8550
- R148 St John's Road West westbound between A-8675 to A-8625;
- R148 St John's Road West eastbound between A-9100 to A-9260; and
- Victoria Quay westbound at A-9694

A reduced single cycle track / lane width of 1.75m is proposed at the following locations:

- R148 Con Colbert Road westbound between A-7775 to A-7875;
- R148 St John's Road West eastbound between A-9260 to A-9300; and
- R148 St John's Road West westbound between A-9175 to A-9250.

It is also noted that single cycle tracks narrow to minimum 1.5m width to slow flow of cyclists when approaching mini-bus islands and 1.0m at the bus stop island.

The width of the existing two-way cycle track to be retained at N4 / M50 Junction 7, between Ch I-150 to I-883 varies from 2.5 to 1.5m.

The width of proposed two-way cycle tracks is reduced to 3.0m (>the minimum permitted in the NCM (2.25m) at the following locations:

- Old Lucan Road (west of M50) between G-0 to H-150;
- Old Lucan Road (east of M50) between J-0 to K-275; and
- Kennelsfort Road at A-3675.

4.12.6 Cycle Parking Provision

The existing cycle parking at the following locations will be retained:

- R136 Ballyowen Road / R835 Lucan Road junction;
- Old Lucan Road, Palmerstown village;
- R148 Palmerstown bypass / Kennelsfort Road Lower junction; and
- Heuston Station

Additional cycle stands will be provided at the following locations:

- Old Lucan Road at the proposed bus stops for Liffey Valley Shopping Centre;
- Old Lucan Road, Palmerstown village; and
- Chapelizod Hill Road at the proposed bus stops on the Chapelizod Bypass.

4.13 Bus Provision

The Preferred Route is approximately 9.7km long from end to end. The updated scheme design drawings show the improved extent of bus provision:

- 67% Existing bus priority (westbound);
- 77% Existing bus priority (eastbound);
- 89% Proposed bus priority (westbound); and
- 95% Proposed bus priority (eastbound).

The Bus provision figures reported follows the C-spine route including using the off-slip and on-slip eastbound at N4 Junction 2, and does not include the provision on Ballyowen Road or Old Lucan Road (Route 80) at Palmerstown.

4.13.1 Bus Priority

Bus priority for the Proposed Scheme is based on provision of a dedicated lane within the carriageway for the bus to travel unhindered by the general traffic along the road corridors between junctions. At junctions, bus lane provision can be provided up to the stop line wherein adaptive signalling solutions could request a green signal for buses or similarly a short, generally less than a 20m section of shared bus/traffic lane in advance of the junction stop line can be provided and configured in a similar manner using adaptive signalling methods to communicate the arrival of a bus on approach to the junction. Both methods provide a high level of bus priority, with the latter solution implemented where left turning traffic volumes are relatively low and/ or scenarios where less stages / phases are more desirable for junction capacity and bus priority in a fixed time cycle approach where adaptive bus signalling solutions are not appropriate. This is further discussed in Chapter 5 and Chapter 11.

The width of the bus lane provision along the route varies depending on the design speed as noted in Table 4-1, with 3.0m, 3.25m and 3.5m wide lanes provided for bus and other authorised vehicle use only. Larger lane widths are needed in some instances where the swept path of the bus needs more space.

Where this full priority cannot be provided due to cross-section constraints, measures such as signal controlled priority and bus gates may be utilised to retain bus priority.

4.13.2 Signal Controlled Priority

Signal Control Priority uses traffic signals to enable buses to get priority ahead of other traffic on single lane road sections, but it is only effective for short distances. This typically arises where the bus lane cannot continue due to obstructions on the roadway. An example might be where a road has pinch-points where it narrows due to existing buildings or structures that cannot be demolished to widen the road to make space for a bus lane. It works through the use of traffic signal controls (typically at junctions) where the bus lane and general traffic lane must merge ahead and share the road space for a short distance until the bus lane recommences downstream. The general traffic will be stopped at the signal to allow the bus pass through the narrow section first and when the bus has passed the general traffic will then be allowed through the lights. In considering Signal Controlled Priority it is necessary to look at the traffic implications both upstream and downstream of the area under consideration. For the Signal Controlled Priority to operate successfully queues or tailbacks on the single (shared bus / traffic) lane portion cannot be allowed to develop as this will result in delays on the bus service.

There are no sections of Signal Controlled Priority proposed as part of the Proposed Scheme.

4.13.3 Bus Gate

A Bus Gate is a sign-posted short length of stand-alone bus lane. This short length of road is restricted exclusively to buses, taxis and cyclists plus emergency vehicles. It facilitates bus priority by removing general through traffic along the overall road where the bus gate is located. General traffic will be directed by signage to divert away to other roads before they arrive at the Bus Gate.

There are no Bus Gates proposed as part of the Proposed Scheme.

4.14 Bus Stops

The flow chart below outlines the process for examining the Proposed Scheme and assessing and reporting on the bus stops along the route, as shown in Figure 4-8 below.

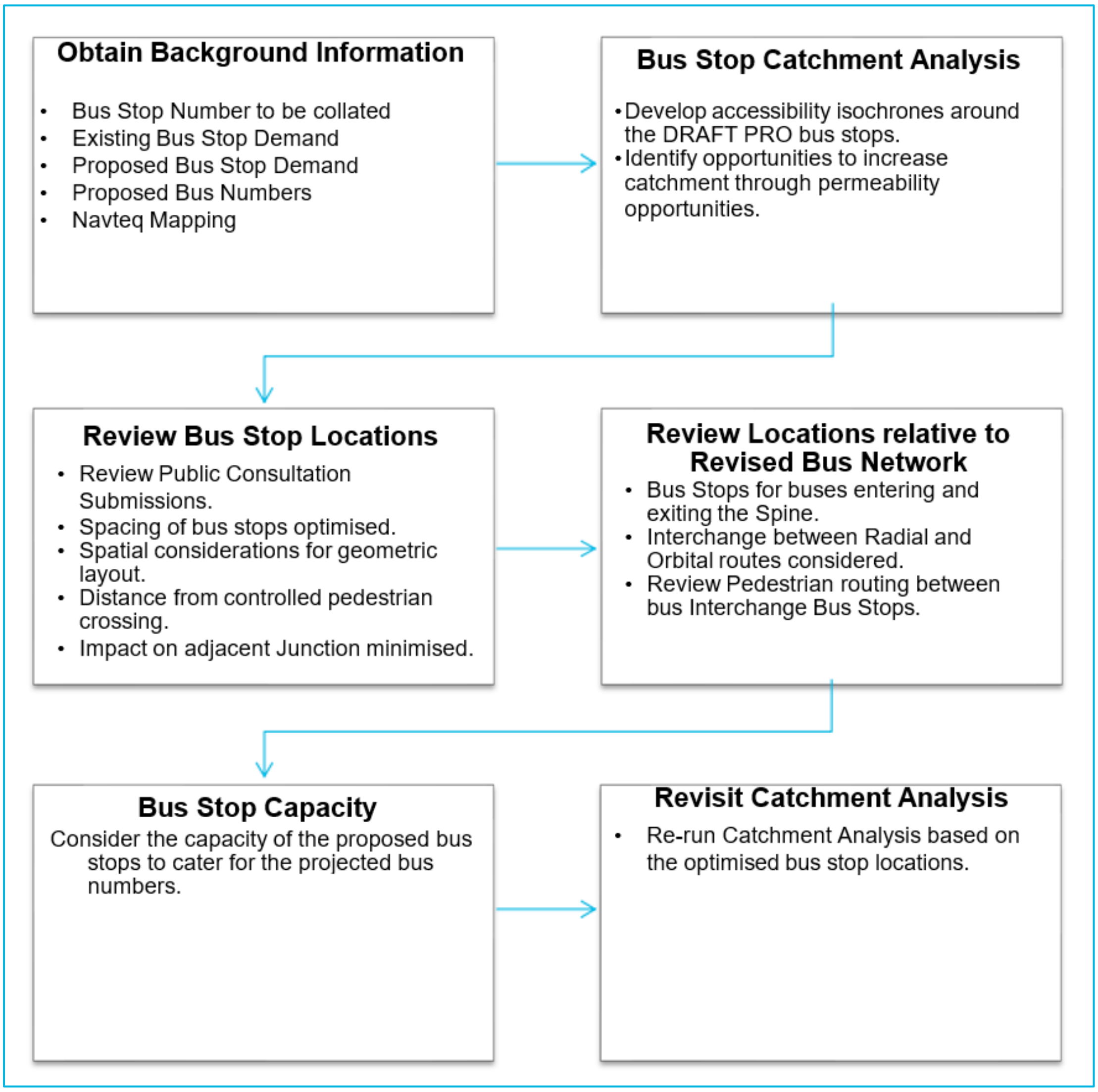

Figure 4-8 Bus Stop Location Assessment Process

The procedure for the assessment undertaken was set out in the Bus Stop Review Methodology document provided in Appendix H.1.

The basic criteria for consideration when locating a bus stop are as follows:

- Driver and waiting Passengers are clearly visible to each other;
- Location close to key facilities;
- Location close to main junctions without affecting road safety or junction operation;
- Location to minimise walking distance between interchange stops;
- Where there is space for a bus shelter;
- Location in pairs, ‘Tail to tail’ on opposite sides of the road;
- Close to (and on exit side of) pedestrian crossings;
- Away from sites likely to be obstructed; and
- Adequate footway width.

The Core Bus Network Report concluded that increasing spacing between bus stops was part of the solution to reduce delays along the corridors. For BusConnects it is proposed that bus stops should be spaced approximately 400m apart on typical suburban sections on route, dropping to approximately 250m in urban centres. This spacing should be seen as recommended rather than an absolute minimum spacing.

Where the Proposed Scheme is located on the N4 and R148 Palmerstown bypass / Chapelizod bypass / St John's Road West, bus stops are generally dictated by key facilities or proposed strategic access points.

It is important that bus stops are not located too far from pedestrian crossings as by nature pedestrians will take the quickest route. This may be hazardous and include jaywalking. Locations with no or indirect pedestrian crossings should be avoided. Their optimum location is a short distance from a controlled crossing point.

Pedestrian barriers or suitable planting is proposed at a number of locations to discourage jaywalking.

4.14.1 Bus Stop Summary

There are 22 existing bus stops on the route of the CBC and the majority of these (15) are proposed to be retained at, or very close to, their existing locations. The following five bus stops are relocated or removed:

- N4 Lucan Road Liffey Valley Shopping Centre eastbound and westbound (relocated approximately 150m further west with new footbridge provided);
- R148 Palmerstown bypass / the Oval eastbound (relocated to the west of the junction);
- R148 Chapelizod bypass westbound at Circle K (removed); and
- R148 St John's Road West westbound at Heuston station (relocated to outside Dr Steevens' Hospital).

Two new bus stops are proposed on the R148 Chapelizod bypass at Chapelizod Hill Road (eastbound and westbound).

In addition, in Palmerstown village the existing bus stops on Kennelsfort Road Lower will be removed and two new bus stops will be provided at the Old Lucan Road / Mill Lane junction (eastbound and westbound).

A more detailed breakdown of the bus stop review in addition to the catchment analysis outputs is provided in Appendix H.2. Where specific feedback in relation to bus stops from the public consultation process has been provided, this has been acknowledged in the assessment also.

Table 4-6 below provides an overview of the key changes to the locations for bus stops along the route of the CBC and along the Old Lucan Road / Kennelsfort Road Lower in Palmerstown village.

Table 4-6 Lucan to City Centre Bus Stop Summary

Eastbound							
Existing				Proposed			
No.	Bus Stop No.	Chainage	Distance between Stops (meters)	No.	Bus Stop No.	Chainage	Distance between Stops (meters)
1	2234	C170	N/A	1	2234	C150	N/A
2	2236	A980	898	2	2236	A980	918
3	5056	E250	570	3	5056	E250	570
4	2239	A2359	809	4	2239	A2300	750
5	4359	J275	N/A	5	New	K100	N/A
6	4360	J650	375	6	2241	A3750	1450
7	2212	J886	300	7	2242	A3950	200
8	2241	A3750	1391	8	New	A5650	1700
9	2242	A4060	310	9	7435	A7925	2275
10	7435	A7970	3910	10	2722	A8325	400
11	2722	A8240	270	11	4413	A9540	1215
12	4413	A9540	1300				
		Average Distance	1013			Average Distance	1053

Westbound							
Existing				Proposed			
No.	**Bus Stop No.**	**Chainage**	**Distance between Stops (meters)**	**No.**	**Bus Stop No.**	**Chainage**	**Distance between Stops (meters)**
1	2637	A9440	N/A	1	New	A9550	N/A
2	2721	A8310	1130	2	2637	A9425	75
3	7012	A7970	340	3	2721	A8400	1025
4	2201	A4220	3750	4	7012	A7925	475
5	7239	A3930	290	5	New	A5600	2325
6	4401	A3730	200	6	7239	A3930	1670
7	4316	K0	N/A	7	New	K100	N/A
8	7165	J625	260	8	4401	A3730	200
9	4357	J180	445	9	2213	A2150	1580
10	2213	A2300	1430	10	2214	A1790	360
11	2214	A1790	510	11	2215	A1100	690
12	2215	A1100	690	12	2216	A650	450
13	2216	A650	450	13	4599	N350	600
14	4599	N350	600				
		Average Distance	**842**			**Average Distance**	**860**

4.14.2 Island Bus Stops

The preferred bus stop arrangement for the Proposed Scheme is the island bus stop arrangement as shown below in Figure 4-9.

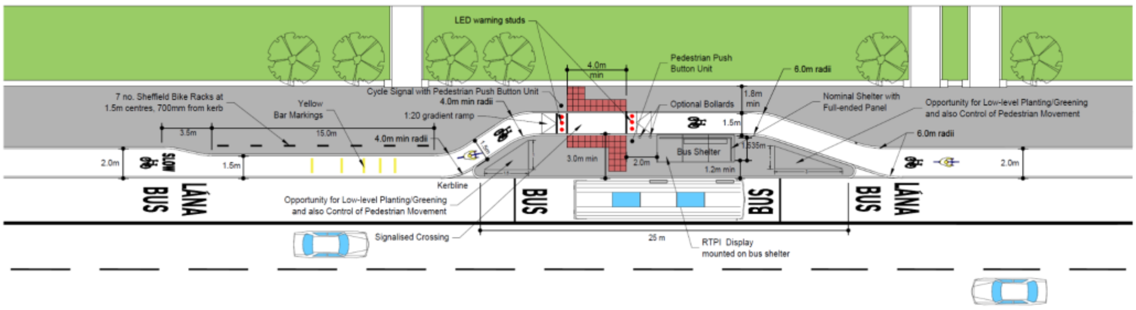

Figure 4-9 Example of an Island Bus Stop

This arrangement will reduce the potential for conflict between pedestrians, cyclists and stopping buses by deflecting cyclists behind the bus stop, thus creating an island area for boarding and alighting passengers. On approach to the bus stop island the cycle track is intentionally narrowed with yellow bar markings, also used to promote a low speed single file cycling arrangement on approach to the bus stop. Similarly, a 1 in 1.5 typical cycle track deflection is implemented on the approach to the island to reduce speeds for cyclists on approach to the controlled pedestrian crossing point on the island. To address the pedestrian / cyclist conflict, a pedestrian priority crossing point is provided for pedestrians accessing the bus stop island area. At these locations a 'nested Pelican' sequence similar to what has been provided on the Grand Canal Cycle Route is introduced so that visually impaired or partially sighted pedestrians may call for a fixed green signal when necessary and the cycle signal will change to red. Where the pedestrian call button has not been actuated the cyclists will be given a flashing amber signal to enforce the requirement to give way to passing pedestrians. A schematic outline of the nested pelican sequence is provided below in Figure 4-8. Audible tactile units will also be a featured at the crossing points.

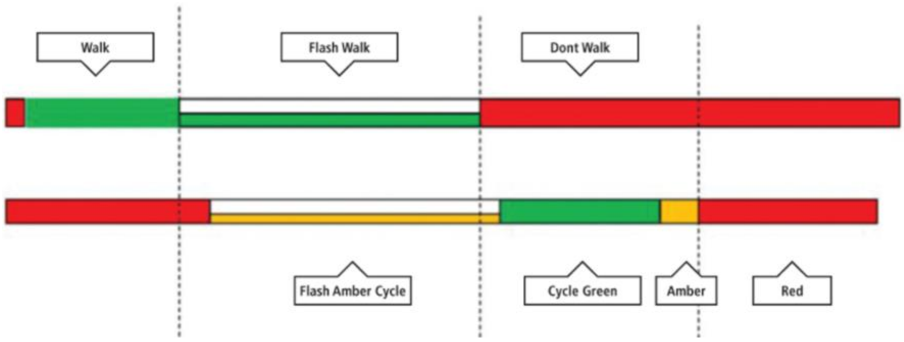

Figure 4-10 Example of Nested Pelican Sequence

A 1:20 ramp is provided on the cycle track to raise the cycle track to the level of the footway / island area onto a 4m wide crossing. Suitable tactile paving is also provided at the crossing point. In addition a series of LED warning studs are provided at the crossing location which are actuated by bus detector loops in the bus lane. The exit taper for the bus stop has been designed at 1 in 3 to provide for the gradual transition to the cycle track.

The desired minimum island width of 3m has been developed to accommodate the provision of a full end panel shelter and nominal length of 25m to accommodate a 19m typical bus cage arrangement and adjusted to suit the site constraints (e.g. between driveway entrances). The residual bus stop triangular island arrangements can also be used for areas of planting or SuDS as these areas are not intended for pedestrian circulation and will also help promote directing pedestrians towards the designated crossing point in addition to improving the passenger waiting area environment. Bike racks should also be located in the immediate vicinity as shown in Figure 4-7 to promote the use of sustainable mode interchange at bus stops for longer distance trips.

Figure 4-11 Example Landscaping Arrangement at Island Bus Stops on Oxford Road Manchester (source: Google Street View 2021)

The island bus stop design is used for the majority of the bus stops along the Proposed Scheme, additional information on the island bus stop design principles can be found in the BCPDGB. Table 4-7 below provides a summary of the proposed island bus stop locations.

Table 4-7 List of Island Bus Stops

Eastbound / Westbound	Bus Stop Name	Bus Stop No.	Chainage	Bus Stop Type
Eastbound	Lucan Retail Park	2234	C 150	Island Bus Stop
Eastbound	Mill Lane, Old Lucan Road	New Bus Stop	K 100	Island Bus Stop

Eastbound	Islandbridge, Memorial Gardens entrance gate	7435 (Relocated Bus Stop)	A 7925	Island Bus Stop
Westbound	Memorial Gardens	7012 (Relocated Bus Stop)	A 7925	Island Bus Stop
Eastbound	Kilmainham Jail, Islandbridge, Memorial Park	2722 (Relocated Bus Stop)	A 8325	Island Bus Stop
Westbound	Islandbridge / SCR, Chapelizod bypass	2721 (Relocated Bus Stop)	A 8400	Island Bus Stop
Westbound	Outside Heuston Train Station / Heuston St	2637	A 9425	Island Bus Stop
Westbound	Dr Steevens' Hospital	New Bus Stop	A 9540	Island Bus Stop / Lay-by
Eastbound	Heuston Station, Saint John's Road West	4413	A 9550	Island Bus Stop / Lay-by
Eastbound	Lucan Retail Park	2234	C 150	Island Bus Stop
Eastbound	Mill Lane, Old Lucan Road	New Bus Stop	K 100	Island Bus Stop
Eastbound	Islandbridge, Memorial Gardens entrance gate	7435 (Relocated Bus Stop)	A 7925	Island Bus Stop
Westbound	Memorial Gardens	7012 (Relocated Bus Stop)	A 7925	Island Bus Stop
Eastbound	Kilmainham Jail, Islandbridge, Memorial Park	2722 (Relocated Bus Stop)	A 8325	Island Bus Stop
Westbound	Islandbridge / SCR, Chapelizod bypass	2721 (Relocated Bus Stop)	A 8400	Island Bus Stop
Westbound	Outside Heuston Train Station / Heuston St	2637	A 9425	Island Bus Stop
Westbound	Dr Steevens' Hospital	New Bus Stop	A 9540	Island Bus Stop / Lay-by
Eastbound	Heuston Station, Saint John's Road West	4413	A 9550	Island Bus Stop / Lay-by

4.14.3 Shared Bus Stop Landing Zone

Where space constraints do not allow for an island bus stop, an option consisting of a shared bus stop landing zone will be considered. The principles of this arrangement are similar to those described in Section 4.14.2. The use of corduroy tactile paving on the cycle track is additional in this arrangement to help facilitate awareness and reduce speeds in lieu of the 1:1.5 deflection provision for the island bus stop. The cycle track will also be narrowed when level to the footway, and tactile paving provided to prevent pedestrian / cyclist conflict. An example of a shared bus stop landing zone is shown in Figure 4-10.

The design of the Proposed Scheme does not include any shared bus stop landing zones.

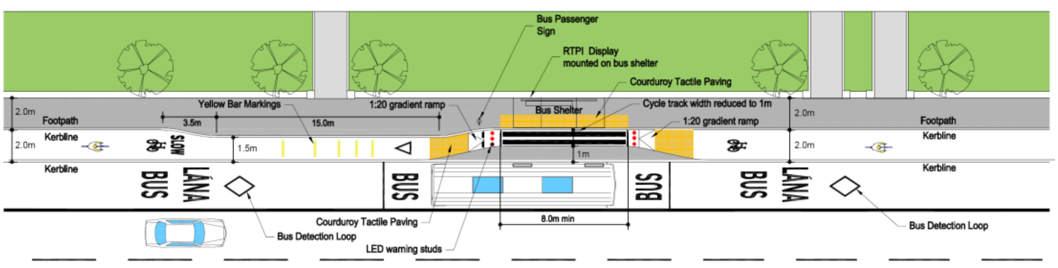

Figure 4-12 Example of a Shared Bus Stop Landing Zone

4.14.4 Inline Bus Stop

Inline bus stops are generally only provided in areas of low-medium flow. Cyclists will generally have to yield when a bus is stationary at the stop to avoid collisions with the bus as it pulls away. Therefore, the option is to be generally avoided due to cyclist conflicts.

Inline bus stops are used on the Proposed Scheme at locations of offline cycle facilities, at the following locations listed in Table 4-8.

Table 4-8 List of Inline Bus Stops

Eastbound / Westbound	Bus Stop Name	Bus Stop No.	Chainage	Bus Stop Type
Westbound	Ballyowen, Slip Road onto the N4	4599 (Relocated Bus Stop)	N300	Inline Bus Stop
Westbound	Mill Lane, Old Lucan Road	New Bus Stop	K100	Inline Bus Stop
Eastbound	Hermitage Clinic (ii)	5056	E250	Inline Bus Stop

4.14.5 Layby Bus Stops

Layby bus stops can provide an effective solution for coaches with long dwell times at bus stops. However as stated in the BCPDGB; urban area bus stop laybys can present significant operational problems and negative impacts for bus users, and should only be used where there are compelling safety or road capacity reasons.

An example of a layby landing zone bus stop arrangement is shown below.

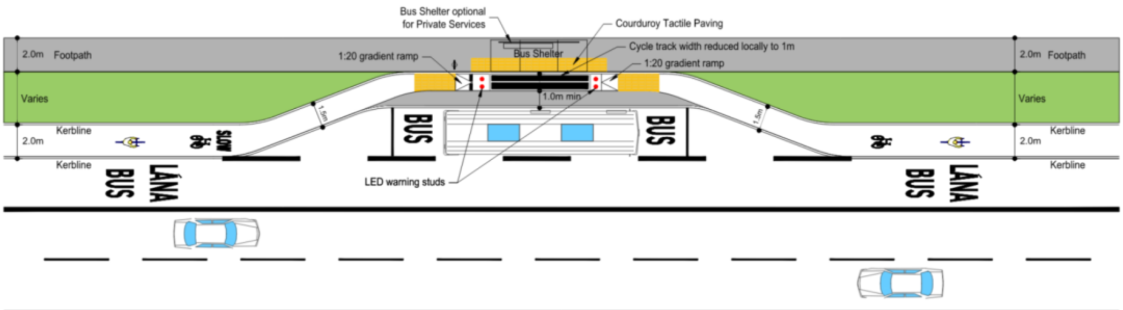

Figure 4-13 Example of a Layby Bus Stop

Layby bus stops are used at the following locations along the Proposed Scheme listed in Table 4-9.

Table 4-9 List of Layby Bus Stops

Eastbound / Westbound	Bus Stop Name	Bus Stop No.	Chainage	Bus Stop Type
Westbound	Ballyowen Lane	2216	A650	Layby Bus Stop
Eastbound	Ballyowen Lane (near Hermitage Golf Club)	2236	A1000	Layby Bus Stop
Westbound	St Loman's Hospital	2215	A1100	Layby Bus Stop
Westbound	Clarion Hotel	2214	A1790	Layby Bus Stop
Eastbound	Liffey Valley, Kings Hospital	2239 (Relocated Bus Stop)	A2150	Layby Bus Stop

Eastbound / Westbound	Bus Stop Name	Bus Stop No.	Chainage	Bus Stop Type
Westbound	Liffey Valley	2213 (Relocated Bus Stop)	A2150	Layby Bus Stop
Eastbound	Chapelizod bypass at Kennelsfort Road	2241	A3750	Layby Bus Stop
Westbound	Chapelizod bypass at Kennelsfort Road	4401	A3750	Layby Bus Stop
Eastbound	Palmerstown, Lucan Road (The Oval)	2242 (Relocated Bus Stop)	A3950	Layby Bus Stop
Westbound	The Oval	7239	A3950	Layby Bus Stop
Eastbound	Chapelizod bypass (over Chapelizod Hill Road)	New Bus Stop	A5650	Layby Bus Stop
Westbound	Chapelizod bypass (over Chapelizod Hill Road)	New Bus Stop	A5600	Layby Bus Stop
Westbound	Dr Steevens' Hospital	New Bus Stop	A 9540	Island Bus Stop / Layby
Eastbound	Heuston Station, Saint John's Road West	4413	A 9550	Island Bus Stop / Layby

4.14.6 Bus Shelters

Bus shelters provide an important function in design of bus stops. The shelter will offer protection for people from poor weather, with lighting to help them feel more secure, Seating is provided to assist ambulant disabled and older passengers and accompanied with Real Time Passenger Information (RTPI) signage to provide information on the bus services. The locations of the bus shelters have been presented on the GEO_GA General Arrangement drawing series in Appendix B. The optimum configuration that provides maximum comfort and protection from the elements to the traveling public is the 3-Bay Reliance 'mark' configuration with full width roof. This shelter is a relatively new arrangement which has been developed by JCDecaux in conjunction with the NTA. The shelter consists mainly of a stainless-steel structure with toughened safety glass and extruded aluminium roof beams. Figure 4-12 below provides an example image of the preferred full end panel shelter arrangement. The desirable minimum footway / island widths required to accommodate the full end panel shelter is 3.3m with an absolute minimum width of 3m to facilitate a minimum 1.2m clearance at the end panel for pedestrians. Alternative arrangements for more constrained footway widths are considered in the following sections.

Figure 4-14 Example of a 3-Bay Reliance Full End Panel Bus Shelter (Source: JCDecaux)

The cantilever shelter using full width roof and half end panel arrangement provides a second alternative solution for bus shelters in constrained footway locations. Figure 4-13 below provides an example of this type of shelter. Advertising panels in this arrangement are normally located on the back façade of the shelter compared to the full end panel arrangement. The desirable minimum footway / island widths required to accommodate the full end panel shelter is 2.75m with an absolute minimum width of 2.4m to facilitate a minimum 1.2m clearance at the end panels for pedestrians.

Figure 4-15 Example of a 3-Bay Reliance Cantilever Shelter with Full Width Roof and Half End Panels (Source: JCDecaux)

Two alternative narrow roof shelter configurations are also available which offer reduced protection against the elements compared to the full width roof arrangements. These shelter configurations are not preferred but do provide an alternative solution for particularly constrained locations where cycle track narrowing to min 1m width has already been considered, and 2.4m widths cannot be achieved to facilitate the full width roof with half end panel shelter, or for locations where the surrounding environment may offer protection against the elements. The desirable minimum footway widths for the narrow roof configuration are 2.75m (with end panel) and 2.1m (no end panel). The absolute minimum footway widths for these shelters are 2.4m (with end panel), and 1.8m (no end panel) to facilitate requirements for boarding and alighting passengers in consideration of wheelchair, pram, luggage and other such similar spatial requirements.

Figure 4-16 Example of a 3-Bay Reliance Cantilever Shelter with Narrow Roof Configuration with and without Half End Panels (Source: JCDecaux)

The siting of bus shelters also requires due consideration on a case by case basis. Ideally bus shelters should be located on the island bus stop boarding / alighting area where space permits. Where this is not feasible, the shelters should be located parallel to the island to the rear of the footway. Where bus shelters cannot be located directly on the dedicated island or parallel to the island due to spatial and or other constraints, they should ideally be located downstream of the stop area. This will inherently promote eye to eye contact between boarding passengers and oncoming cyclists and buses when signalling the bus, and also improve the courtesy arrangement for segregation of boarding and alighting passengers. Examples from each of these scenarios are shown below.

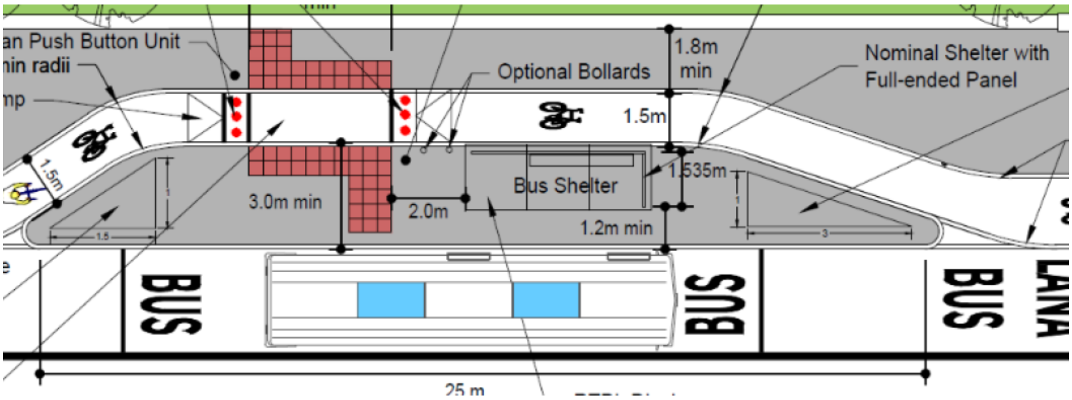

Figure 4-17 Preferred Shelter Location (On island)

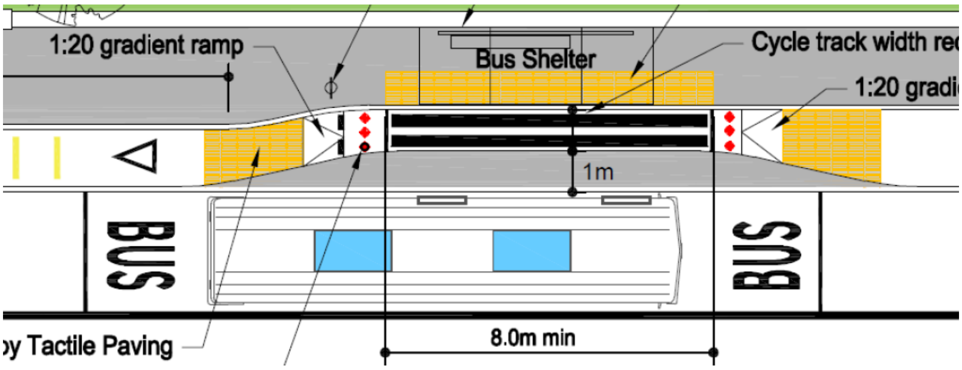

Figure 4-18 Alternative Shelter Location Back of Footway (Narrow Island with Adequate Footway Widths)

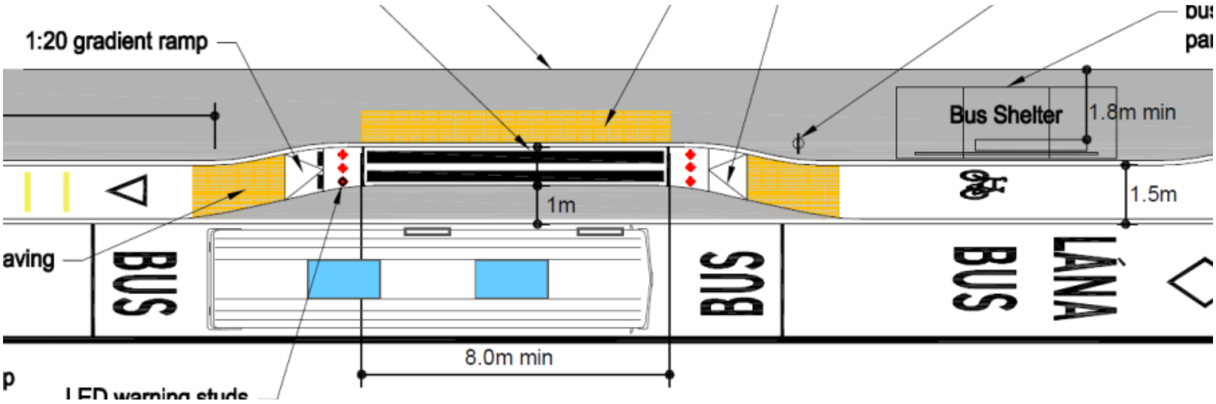

Figure 4-19 Alternative Shelter Downstream of Island (Narrow Island with Narrow Footway Widths at Landing Area)

4.15 Parking and Loading

As part of the assessment of existing conditions to support the development of the engineering design along the Proposed Scheme, a parking survey assessment was undertaken to assess the existing loading and parking arrangements and potential alternatives along the Proposed Scheme. Appendix G provides the details of the Parking and Loading Report.

The report was prepared in the absence of full parking occupancy data, which could not be obtained due to movement restrictions as a result of the Covid-19 pandemic. Quantification of the number of existing parking spaces and their potential removal along the scheme is an important task, as removal of parking without provision of viable replacement options may result in a reduction in the cross sectional width of the design.

Below is an overview of the methodology in assessing the parking impacts along the Proposed Scheme:

- Review the existing parking arrangements on the road network or immediately adjacent to the proposed scheme;
- Assess the impacts associated with the current design proposals;
- Identify possible mitigation measures / alternative parking arrangements;
- Analyse mitigation measures to inform the optimum recommendation; and
- Provide recommendations and identify residual parking impacts.

In assessing the Proposed Scheme the following parking / loading classifications were adopted:

- Designated Paid Parking;
- Permit Parking;
- Disabled Permit Parking;
- Loading / Unloading (in designated Loading Bays);
- Loading / Unloading (outside designated Loading Bays);
- Taxi Parking (Taxi Ranks);
- Commercial vehicles parked for display (car sales); and
- Illegal Parking.

In addition to the above consideration for other parking, usage/ behaviour has been analysed under the following classifications:

- Informal Parking: On-street parking in which spaces may or may not be marked and in which the Local Authority does not charge for use, and
- Adjacent Parking: Parking which is located in close proximity to the street. This parking includes free and pay parking, and also highlights car parks which may be affected by future design proposals.

4.15.1 Summary of Parking Amendments

The locations for existing and proposed parking / loading modifications in line with the Proposed Scheme have been identified on the GEO_GA General Arrangement drawings Appendix B, and further discussed in detail in the Parking Survey Report Appendix G. The following table provides a summary of the key residual parking/ loading impacted areas along the Proposed Scheme.

The proposed changes in parking provision are summarised in Table 4-10 below.

Table 4-10 Summary of parking amendments

Location	Parking type	Existing Parking Provision	Proposed Parking Provision	Change
Ballyowen Lane	Informal Parking	5	4	-1
Old Lucan Road, west of M50 at the Deadman's Inn	Adjacent Parking	50	50	0
	Informal Parking	78	17	-61
Old Lucan Road between Deadman's Inn and M50	Informal parking	81	34	-47
Old Lucan Road between the M50 and Palmerstown village centre	Designated Paid Parking	6	6	0
	Informal Parking	194	88	-106
	Adjacent Parking	151	151	0
Kennelsfort Road Lower and Old Lucan	Designated Paid Parking	81	63	-18

Location	Parking type	Existing Parking Provision	Proposed Parking Provision	Change
Road, Palmerstown village centre to Applegreen	Disabled Permit Parking	3	2	-1
St John's Road West between Heuston South Quarter and Heuston station	Designated Paid Parking	3	0	-3
	Permit Parking (Electric Vehicles)	2	2	0
	Taxi Parking (Taxi Ranks)	18	18	0
	Taxi queuing lane	43	23	-20
	Informal Parking	10	0	-10

4.15.2 Summary of Parking Impact and Mitigation

With the Proposed Scheme in place, the impacts of the change in on-street parking have been considered and are itemised below (in summary); the associated mitigation effects and other measures are also summarised:

On Old Lucan Road (west of M50) near The Deadman's Inn, the reallocation of road space reduces informal parking outside businesses / commercial land; however, desktop studies show the car park of the Deadman's Inn not operating at full capacity, so it is recommended that businesses be directed to use their respective car parks.

Along Old Lucan Road between the Deadman's Inn and the M50 near LVSC bus stops, the reallocation of road space reduces informal parking spaces on both sides of the road. It is recommended that any parking in association with shopping is to be directed to LVSC car parks.

Along Old Lucan Road (east of M50), due to the reallocation of road space, parking is to be prohibited along the majority of the northern section of the road. The current provision of parking on the southern side of the road will be retained and is expected to accommodate vehicles using the northern side.

Due to the reallocation of road space at Kennelsfort Road Lower in Palmerstown, there is the loss of 3 paid parking spaces and a disabled space. Additional parking and disabled parking will be provided east of Kennelsfort Road Lower on Old Lucan Road.

Due to reallocation of road space on Old Lucan Road in the centre of Palmerstown Village, there is the loss of existing pay and display parking and a single disabled parking space on the northern side of the road. To reduce the number of lost parking spaces, existing parallel pay and display parking on the southern side of the road will be replaced by perpendicular pay and display parking, including disabled parking provision, where the road width permits. This provides an additional 14 spaces on the southern side of the road.

Along St John's Road West, the section of the existing taxi queuing lane to the west of the HSQ car park entrance (20 spaces) is proposed to be removed to accommodate the new segregated cycle track. The taxi queuing lane and taxi rank to the east of the HSQ car park entrance will remain. It is considered that these will be adequate for the taxi demand observed.

The 8 informal parking spaces immediately west of the HSQ car park entrance and outside the Eir building are to be removed. The two electric vehicle parking spaces opposite Heuston station are to be removed to accommodate the revised bus stop arrangements and will be relocated to outside the Eir building.

4.16 Turning Bans and Traffic Management Measures

Speed limits, turning bans and restricted movements along the route are shown on the General Arrangement Drawings within Appendix B.

A summary of the turning bans along the Proposed Scheme are shown in Table 4-11.

Table 4-11 Summary of Turning Bans

Chainage	Minor Road	Major Road	Existing / Proposed	Turning Ban	Notes
B75	N4 Junction 3 off-slip eastbound	R136 Ballyowen Road	Existing	No right or left turn onto off-slip	Existing Turn Ban used to regulate Traffic flow
B1 200	N4 Junction 3 off-slip westbound	R136 Ballyowen Road	Existing	No right or left turn onto off-slip	Existing Turn Ban used to regulate Traffic flow
A300	N4 Junction 3 on-slip eastbound	N4 Lucan Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
A700	Ballyowen Lane	N4 Lucan Road (westbound service road)	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
A1200	Saint Loman's Hospital	N4 Lucan Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
A1500	R113 Fonthill Road (westbound)	N4 Lucan Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
A1500	R113 Fonthill Road (westbound)	N4 Lucan Road	Existing	No left turn onto minor road	Existing Turn Ban used to regulate Traffic flow
A1700	R113 Fonthill Road (eastbound)	N4 Lucan Road	Existing	No left turn onto minor road	Existing Turn Ban used to regulate Traffic flow
A1750	R113 Fonthill Road (eastbound)	N4 Lucan Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
A3700	Kennelsfort Road Lower	R148 Palmerstown bypass	Proposed	No left turn onto major road	Proposed Turn ban used to regulate Traffic flow following introduction of new signalised pedestrian crossing of Palmerstown bypass
A3975	Old Lucan Road	R148 Palmerstown bypass	Existing	No left turn onto minor road	Existing Turn Ban used to regulate Traffic flow
A4000	Old Lucan Road	R148 Palmerstown bypass	Proposed	No straight through road onto minor road except buses	Existing Turn Ban revised to facilitate proposed bus movements along Old Lucan Road
A4000	Old Lucan Road	R148 Palmerstown bypass	Proposed	No right turn onto minor road except buses	Existing Turn Ban revised to facilitate proposed bus movements along Old Lucan Road
A5650	n/a	Chapelizod Hill Road	Existing	No entry (road one way)	Existing No Entry used to maintain one-way Traffic flow.
A7550	R833 Con Colbert Road	R148 Con Colbert Road	Existing	No right turn onto minor road	Existing Turn Ban used to regulate Traffic flow
A7550	R833 Con Colbert Road	R148 Con Colbert Road	Existing	No left turn onto major road	Existing Turn Ban used to regulate Traffic flow
A7875	R839 Memorial Road	R148 Con Colbert Road	Existing	No left turn onto minor road	Existing Turn Ban used to regulate Traffic flow

A8450	R111 South Circular Road southbound	R148 St John's Road West	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
A8475	R111 South Circular Road northbound	R148 St John's Road West westbound	Existing	No left turn onto major road	Existing Turn Ban used to regulate Traffic flow
A8475	R111 South Circular Road northbound	R148 St John's Road West eastbound	Proposed	Right turn onto major road	Existing Turn Ban removed to facilitate future bus service movements
A9075	HSQ	St John's Road West	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
A9300	Military Road	St John's Road West	Existing	No right turn onto minor road	Existing Turn Ban used to regulate Traffic flow
A9600	Steeven's Lane	St John's Road West	Existing	No right turn onto minor road	Existing Turn Ban used to regulate Traffic flow
A9600	Victoria Quay	St John's Road West	Existing	No left turn onto minor road	Existing Turn Ban used to regulate Traffic flow
A9600	Victoria Quay	Steeven's Lane	Existing	No straight through road onto minor / major road except trams	Existing Turn Ban used to regulate entry to Luas tracks.

4.17 Relaxations, Departures and Deviations

The terms relaxation and departure are derived from TII requirements for national roads projects. As defined in GE-GEN-01005, a Departure from Standard shall mean any of the following:

- A Departure from any of the mandatory requirements of TII Publications (Standards);
- The use of technical design standards and / or specifications other than those in TII Publications (Standards);
- The use of a set of requirements or additional criteria for any aspect of the Works for which requirements are not defined in the Contract;
- The use of a technical design standard or technical specification in a manner or circumstance which is not permitted or provided for in such directive or specification; and
- A combination of any of the criteria specified above.

The following are variations that are not considered as constituting a Departure from Standard:

- Suggestions / Recommendations within TII Publications (Standards), and
- Relaxations – these need to be recorded in the Departures Report, but a formal application does not need to be completed.

For urban renewal schemes DN-GEO-03030 provides suitable guidance on the application of DMURS for the design of all urban roads and streets with a 60km/h or less speed limit. A scheme that is being designed in accordance with DMURS shall require a Design Report. Any deviations from the requirements or guidance set out in DMURS shall be detailed in the Design Report. Notwithstanding the above, schemes that are being designed in accordance with DMURS shall comply with relevant TII Specifications with regards to materials, standard construction details and maintenance requirements.

The Design Report for schemes designed in accordance with DMURS shall contain a DMURS Compliance Statement. This statement shall include a table demonstrating compliance with the four Core Design Principles.

- Design Principle 1: To support the creation of integrated street networks which promote higher levels of permeability and legibility for all users, and in particular more sustainable forms of transport;

- Design Principle 2: The promotion of multi-functional, place-based streets that balance the needs of all users within a self-regulating environment;
- Design Principle 3: The quality of the street is measured by the quality of the pedestrian environment; and
- Design Principle 4: Greater communication and co-operation between design professionals through the promotion of a plan-led, multidisciplinary approach to design.

For sections of the Proposed Scheme with a speed restriction of 60km/hr or less, a DMURS Design Compliance Statement is provided Section 4.17.1 below.

For sections of the Proposed Scheme with a speed restriction of 80km/hr or more, details of Departure and Relaxations in line with TII Publications (Standards) are provided in Section 4.17.2 below.

4.17.1 DMURS Design Compliance Statement

The Proposed Scheme has been designed in line with the principles and guidance outlined within the DMURS 2019. The scheme proposals have been developed in direct response to the aim and objectives as set out in Section 1.2, which have common synergies with the Core Design Principles of DMURS.

The adopted design approach successfully achieves the appropriate balance between the functional requirements of different network users whilst enhancing the sense of place. The implementation of enhanced pedestrian, cycling and bus infrastructure actively manages movement by offering real modal and route choices in a low speed high-quality mixed-use self-regulating environment. Specific attributes of the Proposed Scheme design which contribute to achieving this DMURS objective include:

- Prioritising pedestrians and cyclists through the implementation of designated footways, and cycle tracks, and limiting vehicles' speed through the use of tight kerb radii on all internal junctions within the Proposed Scheme;
- Provision of cycle protected junctions will control speed at which vehicles can travel through the junction and incorporates tight kerb radii to limit vehicles' speed but also allow occasional larger vehicles to manoeuvre safely through the junction, while also reducing pedestrian crossing distances;
- The inclusion of new and enhanced pedestrian crossing facilities will promote increased pedestrian activity along the scheme, providing safe desire lines for pedestrians to / from all directions. The Proposed Scheme also removes the existing lengthy uncontrolled crossings and the associated safety risks that they present to pedestrians at these vehicle dominated locations;
- Introduction of designated cycle protected parking along the scheme will improve the interaction between parked vehicles, pedestrians and cyclists; and
- The implementation of traffic calming measures and side entry treatments promote pedestrian activity on the junction side arms.

The scheme proposals are the outcome of an integrated urban design and landscaping strategy to enhance the function and place for the surrounding area and thereby facilitating a safer environment for pedestrians and cyclists.

The design has been progressed in accordance with the design standards within Section 4.1 as far as practicable, but in some instances it has been necessary to deviate away from these. A schedule of identified deviations relating to the road geometry, alongside those identified for other technical design elements, is included within Table 4-12. Locations where the Proposed Scheme does not amend the existing roadway cross-section or road geometry are not included in Table 4-12.

Table 4-12 Summary of Deviations

Chainage	Major Road	Minor Road	Description of Deviation	Standard Required	Justification of Deviation
A300 - A550	N4 Westbound	N/A	Lane width = 2.5 - 3.0 m	Lane width = 3.0 m	Existing traffic lane width retained on service road running adjacent to the N4 westbound carriageway

Chainage	Major Road	Minor Road	Description of Deviation	Standard Required	Justification of Deviation
A420-A650	N4	N/A	Cycle Lane width = 1.5m	Cycle Track Width = 1.75m	Existing cycle lane facilities have been retained with an alternative route proposed as part of the design as an offline route. The alternative route will provide a Quiet Street along Ballyowen Lane and Hermitage Road to access Ballyowen Road from the N4 Footbridge (Ch. A900).
A3675	Kennelsfort Road Lower	N/A	Footway width = 1.7m - 1.8m	Footway width = 1.8m	Footway width reduced over 5m to facilitate a turning pocket for right turning vehicles as part of Palmerstown Lodge planning application.
A3700	R148 Palmerstown bypass	Kennelsfort Road Lower	Corner Radii = 18.0m	Corner radii = 9.0m	Significant HGV movement from Palmerstown bypass to Kennelsfort Road Lower. Higher radii required to facilitate safe movement of HGVs.
A3700	R148 Palmerstown bypass	Kennelsfort Road Upper	Corner Radii = 20m	Corner radii = 9.0m	Significant HGV movement from Chapelizod bypass to Kennelsfort Road Upper. Higher radii required to facilitate safe movement of HGVs.
A7800 - A7900	Con Colbert Road Eastbound	N/A	Cycle track width = 1.5m	Cycle Track Width = 1.75m	Cycle track is tapered down to 1.5m to accommodate minimum width footway, existing traffic lanes and proposed right turn lane. No further road space is available, as the highway boundary borders the Irish National War Memorial Park.
A7850 - A7900	Con Colbert Road Westbound	N/A	Footway width = 1.65 m	Footway width = 1.8	Footpath narrowed locally to facilitate proposed cycle track
A7880 - A7885	Con Colbert Road Eastbound	N/A	Footway width = 1.4 m	Footway width = 1.8	Footpath reduced over 6m length to accommodate the jug right turn for cyclists
A8450	R148 Con Colbert Road	R111 South Circular Road	Corner Radii = 13.5m	Corner radii = 9.0m	Corner radii increased to facilitate movement of left turning HGV's.
A8475	R111 South Circular Road	N/A	Cycle track width = 1.2m - 1.4m	Cycle Track Width = 1.5m	15.0m right turn lane only, concrete protection island is to be provided at stop line for further protection and reduce risk of cyclist/vehicle collision.
A8500 - A8550	R148 St John's Road West Westbound	N/A	Cycle track width = 1.5m	Cycle Track Width = 1.75m	Cycle track width reduced to retain vehicle/bus lane widths and to provide 1.8m min footway width .
A8625 - A8700	R148 St John's Road West Westbound	N/A	Cycle track width = 1.5m	Cycle Track Width = 1.75m	Cycle track width is below standard to retain vehicle/bus lane widths and to provide a minimum 1.8m footway width due to minimum road space available.
A9000 - A9060	R148 St Johns Road West	HSQ entrance	Lane width = 2.8m - 2.9 m	Lane width = 3.0 m	Straight on and right turn lanes reduced to below 3.0m to accommodate cycle track while retaining existing trees within verge. Widening into the median has been discounted due to the substantial works required to setback the existing retaining wall/reinforced earth works.

Chainage	Major Road	Minor Road	Description of Deviation	Standard Required	Justification of Deviation
A9100 - A9250	R148 St. John's Road West	N/A	Footway width = 1.2m-1.6m	Footway width = 1.8m	Existing substandard footway to be retained to retain existing trees.
A 9307 - A9320	St John's Road West Eastbound	N/A	Footway width = 1.7 m	Footway width = 1.8	Footpath reduced to facilitate proposed cycle track which includes the provision of waiting area for right turning cyclists without impeding on going cyclists
B1 025	R136 Ballyowen Road	Hermitage Road	Corner radii = 10m - 12m	Corner radii = 9.0m	Tightened from existing radii. Higher radii retained to facilitate the safe movement of larger vehicles.
B225	R136 Ballyowen Road	N/A	Footway width = 1.5m-1.8m	Footway width = 1.8m	Reduction in width over a length of max. 5.0m. Reduction required to facilitate 2-way cycle track and retain existing vehicle movements onto Ballyowen Road. Cross-section constrained either side of carriageway.
I0 to I883	M50 Bridge	N/A	Footway width = 1.6m-2.2m	Footway width = 1.8m	Existing bridge/conditions are to be retained. Significant works required to facilitate widening of existing bridge required to facilitate NCM requirements.
I625-I883	M50 bridge	N/A	Cycle track width = 1.5-2.5m	Cycle Track Width = 2.65m	Existing bridge/conditions are to be retained. Significant works required to facilitate widening of existing bridge required to facilitate NCM requirements.

4.17.2 TII Departures and Relaxations

A schedule of departures and relaxations from TII Design Standards relating to the individual aspects of Road Geometry is included within Appendix C. For ease of reference, combinations of Departures and Relaxations from Standards have not been considered. Locations where the Proposed Scheme does not amend the existing roadway cross-section or road geometry are not included in Appendix C.

4.18 Road Safety and Road User Audit

Road Safety Audits have been undertaken at various stages throughout the design development process. The TII GE-STY-01024 document provides an outline of the typical stages for road safety audits and further noted below as follows:

- **Stage F**: Route selection, prior to route choice;
- **Stage 1**: Completion of preliminary design prior to land acquisition procedures;
- **Stage 2**: Completion of detailed design, prior to tender of construction contract. In the case of Design and Build contracts, a Stage 2 audit shall be completed prior to construction taking place;
- **Stage 1 and 2**: Completion of detailed design, prior to tender of construction contract, for small schemes where only one design stage audit is appropriate;
- **Stage 3**: Completion of construction (prior to opening of the scheme, or part of the scheme to traffic wherever practicable); and
- **Stage 4**: Early operation at 2 to 4 months' post road opening with live traffic.

In line with the above a Desktop Safety Review (broadly following the requirements of a Stage F Road Safety Audit (RSA)) was undertaken as part of the Emerging Preferred Route Selection process, and Stage 1 Road Safety Audits (RSA) were undertaken as part of the Preliminary Design development at an intermediate stage and towards the end of the Preliminary Design. All 3 RSA's have been included in Appendix M, complete with the proposed designer's responses.

The Desktop Safety Review was reviewed in light of the scheme development and had identified various elements of the EPR scheme that were subsequentially improved with design development.

The Stage 1 RSA represents the response of an independent audit team to various aspects of the scheme. The recommendations contained within the document are the opinions of the audit team and are intended as a guide to the designers on how the scheme as constructed can be improved to address issues of road safety. The Stage 1 RSA recommended protecting junctions, further segregation of cycle tracks, shortening pedestrian crossing distances and tie-ins for cycle infrastructure on side roads. These recommendations informed and improved the design development. Further observations are to be considered at detailed design stage.

5 Junction Design

5.1 Overview of Transport Modelling Strategy

The design and modelling of junctions has been an iterative process to optimise the number of people that can pass through each junction, with priority given to pedestrian, cycle and bus movements.

The design for each junction within the Proposed Scheme was developed to meet the underlying objectives of the project and to align with the geometric parameters set out in Section 4.1 in conjunction with the junction operation principles described in the BCPDGB. Various traffic modelling tools were used to assess the impact of the proposals on a local, corridor and surrounding road network level which is further described in Section 5.4.

A traffic impact assessment has been undertaken for the Proposed Scheme in order to determine the predicted magnitude of impact Proposed Scheme measures may have against the likely receiving environment. The impact assessments have been carried out using the following scenarios:

- Do Minimum' (DM) – This scenario represents the likely conditions of the road network with all major committed transportation schemes in place that will impact on the use of public transport and private car, without the Proposed Scheme, and
- Do Something' (DS) – This scenario represents the likely conditions of the road network with all major committed transportation schemes in place that will impact on the use of public transport and private car, with the Proposed Scheme (i.e. the 'DM' scenario with the addition of the Proposed Scheme).

Both scenarios above comprised of an assessment at opening year (2028) and opening year +15 years (2043). In developing the design proposals for the Proposed Scheme, the 2028 year flows were determined to provide the higher volume of traffic flows for the most part and as such has been generally adopted as the design case scenario for junction development.

Where design flows from the 2028 DS model were not deemed appropriate for a specific location the flows associated with the DM and or base 2019 survey flows have been considered. Similarly, the final junction designs have been supplemented with additional cycle volumes to ensure a minimum 10% cycle mode share in terms of people movement at each junction can be achieved in line with the National Cycle Policy Framework (NCPF).

5.2 Overview of Junction Design

The purpose of traffic signals is to regulate movements safely with allocation of priority in line with transportation policy. For the Proposed Scheme, a key policy is to ensure appropriate capacity and reliability for the bus services so as to maximise the overall throughput of people in an efficient manner. The junctions will provide safe and convenient crossing facilities for pedestrians with as little delay as practicable. Particular provisions are required for the protection of cyclists from turning traffic, as well as ensuring suitable capacity for a rapidly increasing demand by this mode.

The design of signalised junctions, or series of junctions, as part of the Proposed Scheme has been approached on a case-by-case basis. There have been a number of components of the design development process that have influenced the preliminary junction designs including:

- The junction operational and geometrical principles described in the BCPDGB;
- Integration of pedestrian and cycle movements at junctions;
- Geometrical junction design for optimal layouts for pedestrians, cyclists and bus priority whilst minimising general traffic dispersion where practicable;
- People Movement Signals Calculator (PMSC) to inform junction staging and design development;
- LINSIG junction modelling to assess junction design performance and refinement;
- Micro-Sim modelling to assess and refine bus priority designs; and
- Cyclist quantification.

5.3 Junction Geometry Design

5.3.1 Pedestrians

The junction design approach is to minimise delay for pedestrians at junctions, whilst ensuring high quality infrastructure to ensure pedestrians of all ages including vulnerable users can cross in a safe and convenient manner. Pedestrian crossings have been placed as close to pedestrian desire lines as practicable. Where pedestrians are required to cross a cycle track, this is proposed to be controlled by traffic signals to manage potential conflicts.

The preferred arrangement for pedestrians at junctions is to have a wrap-around pedestrian signal stage at the start of the cycle. In some instances, this has not been feasible, i.e. due to crossing distances and the associated intergreen time for pedestrians to safely clear the junction. A “walk with traffic” system is therefore proposed at certain junctions, in particular where refuge islands have been introduced for a two-stage pedestrian crossing. At these locations, ‘walk with traffic’ is proposed where the pedestrian movements are permitted to run simultaneously with non-conflicting traffic movements. This has a beneficial effect on junction and people movement capacities. This facility has the advantage to allowing pedestrians to cross during the cycle whilst having less effect on traffic capacity.

The Proposed Scheme will enhance pedestrian crossing facilities in particular all existing left turn slip lanes has been removed, and wherever practicable straight through crossings have been provided. In these instances the cycle times have been increased to balance the proposed new pedestrian infrastructure with the competing demands for bus, cyclists and general traffic as shown in Table 5-1. The proposed new infrastructure will assist to reduce pedestrian crossing distances thus reducing crossing times and improving the overall crossing experience at the junctions for pedestrians.

Table 5-1 Do Minimum and Do Something Cycle Times & Pedestrian Infrastructure

Junction	DM Cycle Time (seconds)	DS Cycle Time (seconds)	Notes
R136 Ballyowen Road / R835 Lucan Road	90	120	Removal of left turn slips, more compact junction with reduced pedestrian crossing distances
N4 (Jct 3) Eastbound Off-Slip / R136 Ballyowen Road	130	120	
N4 (Jct 3) Westbound Off-Slip / R136 Ballyowen Road	130	120	
R136 Ballyowen Road / Hermitage Road Junction	120	120	
N4 Junction 2	60	120	
R148 Palmerstown bypass / Kennelsfort Road	140	120	
R148 Palmerstown bypass / The Oval	115	120	New pedestrian crossings on The Oval and Lucan Road arms
R148 Chapelizod bypass / R148 Con Colbert / R833 Con Colbert Road	110	90	
R148 Con Colbert Road / R839 Memorial Road	100	110	
R148 Con Colbert Road / R111 South Circular Road/ R148 St John’s Road West	100	120	Removal of left turn slips, more compact junction with reduced pedestrian crossing distances.
R148 St Johns Road West / HSQ	90	120	Removal of left turn slip, more compact junction with reduced pedestrian crossing distances.
R148 St Johns Road West / Military Road	115	120	

R148 St Johns Road West / Heuston Station (Steeven's Lane)	120	120	
R148 St John's Road West/ Victoria Quay / Frank Sherwin Bridge	100	120	Removal of left turn slip, more compact junction with reduced pedestrian crossing distance.

5.3.2 Cyclists

The provision for cyclists at junctions is a critical factor in managing conflict and providing safe junctions for all road users. The primary conflict for cyclists is with left turning traffic. Based on international best practice, the preferred layout for signalised junctions is the "Protected Junction", which provides physical kerb build outs to protect cyclists at junctions. The key design features and considerations relating to this junction type are listed below:

- The traffic signal arrangement removes any uncontrolled conflict between pedestrians and cyclists, assigning clear priority to all users at different stages within a traffic cycle;
- Kerbed corner islands should be provided to force turning vehicles into a wide turn and remove the risk of vehicles cutting into the cycle route at the corner, which is a cause of serious accidents at junctions. The raised islands create a protective ring for cyclists navigating the junction, improving safety for right turning cyclists
- Cycle tracks that are protected behind parking or loading bays return to run along the edge of the carriageway approaching the junction. Consideration has been given to remove any parking or loading located immediately at junctions to enhance visibility between motorists and cyclists;
- The cycle track is typically ramped down to carriageway level on approach to the junction and proceeds to a forward stop line. A secondary cycle stop line is also proposed at an advanced location to the vehicular stop line at a number of junctions to cater for right turning cyclists, which also placing the cyclists within viewing of traffic waiting at the junction. Cycle signals will control the movement of cyclists including the second stage movement i.e. right turners; and
- Cyclist and pedestrian crossings have been kept as close as practicable to the mainline desire line. However pedestrian and cyclist crossings are to be separated where feasible, in this instances 2-3m separation should be provided between crossings. This is to ensure motorists infer a clear differentiation between cycle lane crossing through the junction and the pedestrian crossing across the same arm; and
- In some instances, protected junctions have not been incorporated into the design of a signalised junction. In these instances, this has been limited to minor signalised junctions where left turning movements by general traffic is projected to be low and cyclists desire line is projected to be straight through the junction.

5.3.3 Bus Priority

The scheme incorporates different types of bus priority design which have been outlined in the BCPDGB and referred to as Junction Types 1-4. The subsections below provide an overview of each junction type design and the principles for applying this junction type.

5.3.3.1 Junction Type 1

Junction Type 1, as described in Section 7.4.1 of BCPDGB, comprises a dedicated bus lane on both eastbound and westbound direction continues up to the junction stop line. Due to space constraints, general traffic travelling both straight ahead and turning left is restricted to one lane. Junction Type 1 is typically chosen for the following reasons:

- Volume of left turning vehicles greater than 100 PCUs per hour; and
- Urban setting, no space available for dedicated left turning lane / pocket.

In this instance, mainline cyclists proceed with the bus phase. The bus lane gets red, allowing the general traffic lane to proceed. If the volume of turning vehicles is greater than 150 PCUs, then the cyclists should also be held on red. If the volume of left turners is approx. 100 – 150 PCUs, left turners will be controlled by a flashing amber arrow and cyclists should receive an early start.

An example of a Junction Type 1 on the Proposed Scheme is shown in Figure 5-1.

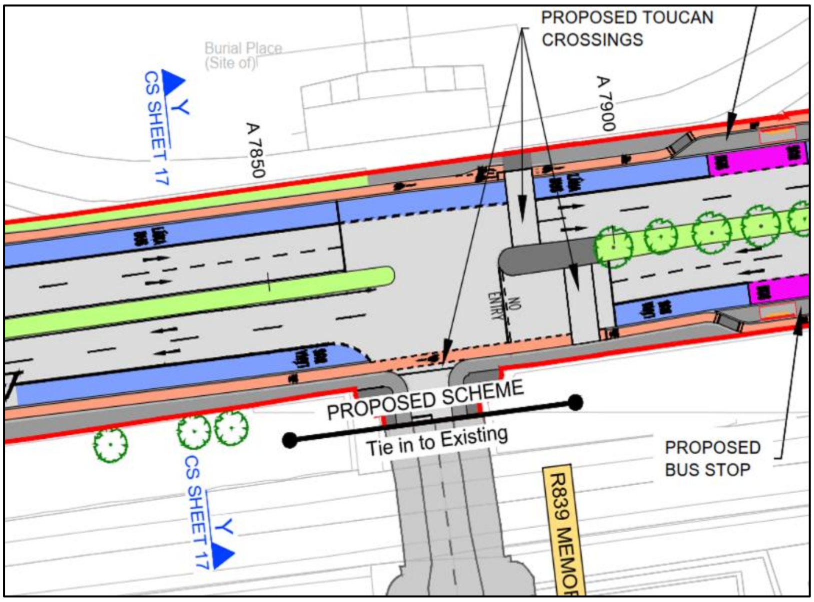

Figure 5-1: Junction Type 1: R148 Con Colbert Road/ R839 Memorial Road

5.3.3.2 Junction Type 2

Junction Type 2, as described in Section 7.4.2 of BCPDGB, comprises a signalised junction in a suburban context where there is room for additional lanes. A dedicated bus lane in both eastbound and westbound directions continue up to the junction stop line. At approximately 30m back from the stop line there is a yellow box to allow left turners to cross the bus lane to enter a dedicated left turn pocket, where space permits. Junction Type 2 has been chosen for the following reasons:

- Suburban setting where space is available for a dedicated left turning lane / pocket, and
- High volume of left turning traffic which can be controlled separately with exiting traffic from side roads.

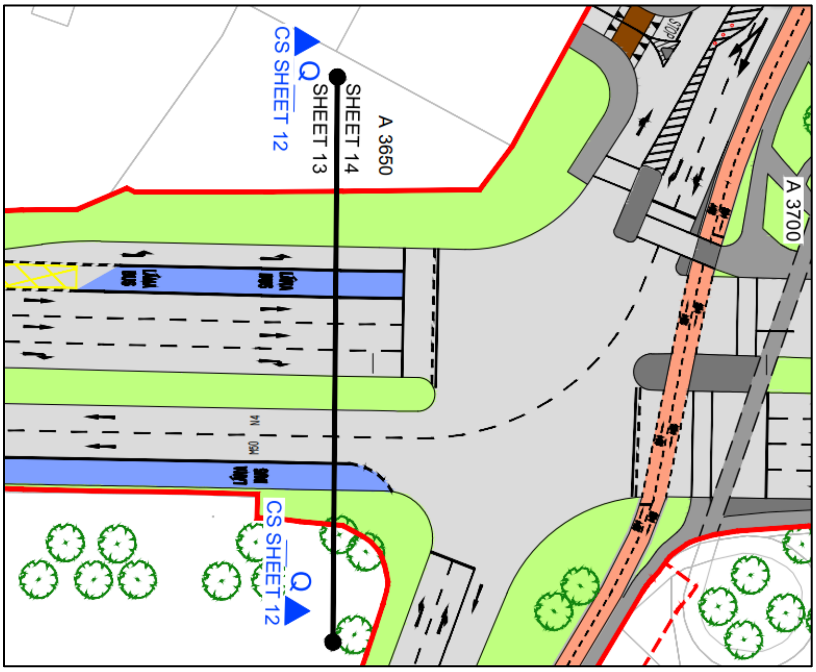

Figure 5-2: Junction Type 2, Proposed R148 Palmerstown bypass (Eastbound) / Kennelsfort Road Junction

5.3.3.3 Junction Type 3

Junction Type 3, as described in Section 7.4.3 of BCPDGB, illustrates a signalised junciton where the eastbound and westbound bus lane terminates just short of the junction to allow left turners to turn left from a short left turn pocket in front of the bus lane. Buses can continue straight ahead from this pocket where a receiving bus lane is proposed. A Junction Type 3 is chosen for the following reasons:

- Volume of left turning vehicles is less than 100 PCUs per hour; and
- Urban setting, no space available for a dedicated left turning lane / pocket.

In this instance, mainline buses and general traffic (including left turners) proceed together, but before they do, mainline cyclists are given an early start of approxiately 5 seconds to assist with cyclist priority and to minimise potential conflicts. When this early start is complete, the mainline cyclists can still proceed, assuming left turning volumes are less than 150 PCUs per hour. Left turning from the left turn pocket are given a flashing amber.

Figure 5-3: Junction Type 3, R148 St John's Road West Westbound / HSQ

5.3.4 Staging and Phasing

The optimum staging for each junction will be determined by the required junction operational parameters and local site conditions. One of the key considerations in the design of signalised junctions is the conflict between left turning traffic and buses, cyclists and pedestrians continuing along the main corridor. The following presents an overview of the design of junction staging a junction specific assessment can be found in the Junction Design Report in Appendix L.

- Cyclists travelling through the junction across the side road will run with straight ahead traffic movements, including buses in a dedicated bus lane;
- A short early start will enable cyclists to advance before general traffic. The amount of green given to cyclists is subject to junction dimensions and signal operation. A 5 second early start has been proposed on the main arms of the majority of junctions, with 3 seconds on side roads;
- Cycle movements crossing a side road can run simultaneously with the bus stage in the same direction, so long as it is not permitted to turn left from the bus lane in this scenario; and
- Cycle movements at junctions are to be controlled by cycle signal aspects where there is an advance stop line ahead of the traffic signals including for hook turns at the far side of the side street crossing. Additional cycle signals have been provided for right turning cyclists.

5.3.5 Junction Design Summary

A detailed junction assessment has been undertaken in line with the principles described previously. The following summary tables, Table 5-2, Table 5-3, Table 5-4 and Table 5-5 provide an overview of the key design principles adopted at each junction location. More detailed information for each junction location can be found in the Junction Design Reports in Appendix L.

Table 5-2 Overview of Major Junctions

No / Type	Junction	Key Design Notes
1 Type 2 Inbound Type 3 outbound	R148 Palmerstown bypass / Kennelsfort Road	Existing 4-arm signalised junction
		Minor geometric changes and removal of southbound left turn
2 Type 2	R148 Con Colbert Road / R111 South Circular Road / R148 St John's Road West	Existing signalised gyratory junction
		Minor geometric changes and introduction of new northbound right turn lane

Table 5-3 Moderate Junctions

No. / Type	Junction	Key Design Notes
1 Type 2	R136 Ballyowen Road / R835 Lucan Road	• Existing 3-arm signalised junction • Minor geometric changes proposed
2 Type 1	N4 (Jct 3) Eastbound Off-Slip / R136 Ballyowen Road	• Existing 3-arm signalised junction • No changes proposed
3 Type 2	N4 (Jct 3) Westbound Off-Slip / R136 Ballyowen Road	• Existing 4-arm signalised junction • Removal of right turn lane
4 Type 1	R148 Palmerstown bypass / The Oval	• Existing 4-arm signalised junction • Minor geometric changes and introduction of new westbound bus-only right turn
5 Type 1	R148 Chapelizod bypass / R148 Con Colbert/ R833 Con Colbert Road	• Existing 3-arm signalised junction • Minor geometric changes
6 Type 1	R148 Con Colbert Road / R839 Memorial Road	• Existing 3-arm signalised junction • Introduction of new eastbound right turn lane
7 Type 3	R148 St John's Road West / Heuston South Quarter Access	• Existing 3-arm signalised junction • Replacement of westbound traffic lane with bus lane
8 Type 3	R148 St John's Road West / Military Road	• Existing 3-arm signalised junction • Minor geometrical changes
9 Type 2	R148 St John's Road West / Victoria Quay / Frank Sherwin Bridge	• Existing 4-arm signalised junction • Minor geometrical changes

Table 5-4 Overview of Minor and Priority Junctions on the Proposed Scheme

No.	Junction	Key Notes
1	N4 Lucan Road / Ballyowen Lane	• Existing priority left in / left out junction • Minor geometrical changes

Table 5-5 Overview of Roundabouts on the Proposed Scheme

No.	Junction	Key Notes
1	R835 Lucan Road / Lucan Retail Park	• Existing 4 arm roundabout • No geometric changes; two-way cycle track added to northwest corner
2	R113 Fonthill Road / N4 Junction 2 eastbound slip roads	• Existing 4 arm roundabout • No geometric changes; two-way cycle track added to northwest corner

5.4 Junction Modelling

5.4.1 Overview

Junction modelling was undertaken to enable understanding of the likely impact of the proposed route design on traffic operation on the surrounding road network. The focus of the assessment was to ensure bus priority was maximised, whilst ensuring the overall movement of people through the junctions was maximised in particular via sustainable modes, i.e. walking and cycling, whilst mitigating any resulting adverse traffic impacts.

The traffic modelling steps can be summarised as follows and are further discussed in the subsequent sections:

- **People Movement Calculator Assessment**: The draft designs were assessed using a high level PMSC to provide a preliminary understanding of the typical green time proportion for each mode and provide an initial input for the Local Area Model (LAM) modelling which was further refined using LinSig and Microsimulation tools.
- **Saturn Modelling - LAM**: The proposed scheme design and traffic signal operation was assessed within the LAM which is a subset model of the NTA's Eastern Regional Model (ERM). The LAM outputs provided projected traffic flows for the DS Operational Year for the peak periods. In addition, traffic dispersion plots were provided, comparing the DS vs the DM to identify where any traffic dispersion is likely to occur off the Proposed Scheme;
- **Design Optimisation:** The proposed junction designs and signal timings were optimised in LinSig, in order to maximise people movement through the corridor and to minimise traffic dispersion off the corridor. Where performance issues such as poor overall capacity, inefficient green time allocation or specific queues were identified, the junction layout was reviewed, and a suitable mitigation or design solution was applied;
- **Iterative process**: The optimised junction designs and signal timings were fed back into the LAM and the above steps were repeated as part of an iterative process until a suitable level of dispersion was achieved;
- **LinSig and Microsimulation**: The optimised LinSig timings were used to inform the microsimulation model developed for the Proposed Scheme. The micro simulation assisted to support the junction designs and traffic control strategies, and provided journey time information. The junction designs and signal timings were further optimised where necessary as a result of the microsimulation modelling; and
- **Final Iterations**: As part of the iterative process the optimised junction designs and signal timings were fed back into the LAM, and the above steps were repeated to inform the final design and signal timings. Final LinSig junction models were undertaken using the final flows and supplemented with projected cycle flows to accommodate a minimum 10% cycle mode share in terms of people movement at each junction.

Figure 5-4 illustrates an overview of the traffic modelling process for the proposed scheme.

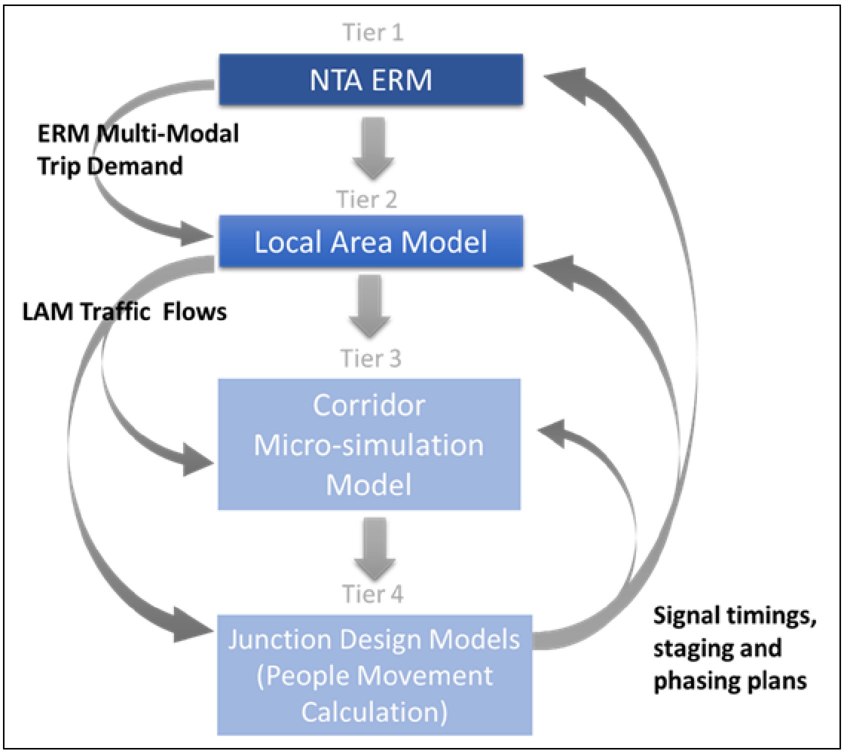

Figure 5-4: Proposed Scheme Traffic Modelling Hierarchy

5.4.2 People Movement

An assessment has been carried out to determine the potential people movement the proposed scheme will generate. This adopts a policy led approach to the design of junctions, which prioritises the people movement and maximisation of sustainable modes, i.e. walking, cycling and bus in advance of the consideration and management of general traffic movements at junctions. The outputs of the calculator provide an estimate of people movement per mode per junction and the respective percentage mode share. Figure 5-5 illustrates the People Movement Formulae.

People Movement Formulae	
Cyclists	$\sum (\frac{Green\ Time}{headway})(\frac{3600}{Cycle\ Time})(\frac{CT\ Width}{1.5})$
Buses	$\sum (No.of\ Buses)(Occupancy)(Direction)$
General Traffic	$\sum LinSig\ PCU\ Capacity\ Outputs$
Pedestrians	$\sum (Green\ Time)(\frac{Walking\ Speed}{Ped.Walking\ Buffer})(\frac{Crossing\ Width}{2})(\frac{3600}{Cycle\ Time})(No.Crossing\ Points)$

Figure 5-5 People Movement Formulae

The emerging proposed designs were inputted to the PMSC tool, which produced initial people movement outputs and indicative green times per mode. The results provided an initial starting point to facilitate a review of the junction designs, where necessary pedestrian, cyclist and bus infrastructure was optimised accordingly to facilitate additional capacity. The revised designs were then added into the LAM to facilitate traffic modelling.

The LAM outputs provided traffic flows for the operational year (2028) and operational year +15 (2043). The traffic flows were fed into the LinSig models to facilitate a detailed analysis of the proposed junction operation. The LinSig and DLAM analysis required multiple traffic modelling iterations to arrive at a balanced solution for prioritising sustainable modes and minimising traffic dispersion. The people movement results were also revaluated during the iteration process, the results were also used to inform the projected number of cyclists in the operational year, as discussed in the following section.

5.4.3 Local Area Model

As noted previously, the Proposed Scheme design and traffic signal operation was assessed within the LAM. The LAM outputs provided projected traffic flows for the DS Operational Year 2028 and Future Year 2043 for the respective AM and PM peak periods. In addition, traffic dispersion plots were produced, comparing the DS vs the DM to identify where any occurred onto the adjoining road network, and where necessary to review and apply traffic management, to retain traffic on the corridor and to minimise dispersion at inappropriate locations.

The results of the LAM were used to inform the proposed junction designs and optimise signal timings, in order to maximise people movement through the corridor and to minimise traffic dispersion off the corridor. Where performance issues such as poor overall capacity, inefficient green time allocation or specific queues were identified, the junction layout was reviewed, and a suitable mitigation or design solution was applied.

To demonstrate the benefits of this iterative process, Figure 5-6 illustrates an initial 2028 AM distribution plot, whilst Figure 5-7 illustrates a final iterated distribution plot. Figure 5-6 illustrates more significant traffic dispersion onto the surrounding road network, whilst the refined Figure 5-7 demonstrates a more optimised Proposed Scheme, where traffic dispersion has been minimised without compromising the sustainable modes.

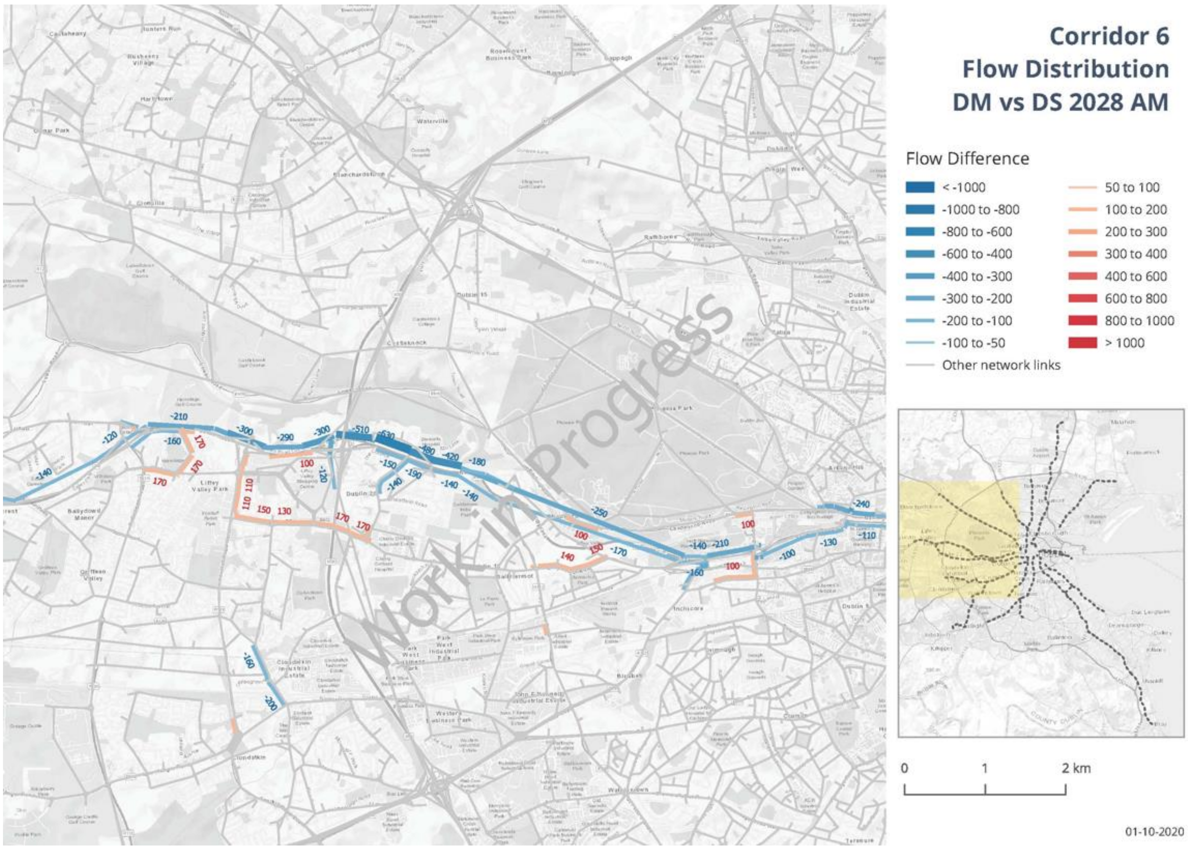

Figure 5-6 An initial 2028 AM Peak DLAM Distribution Plot

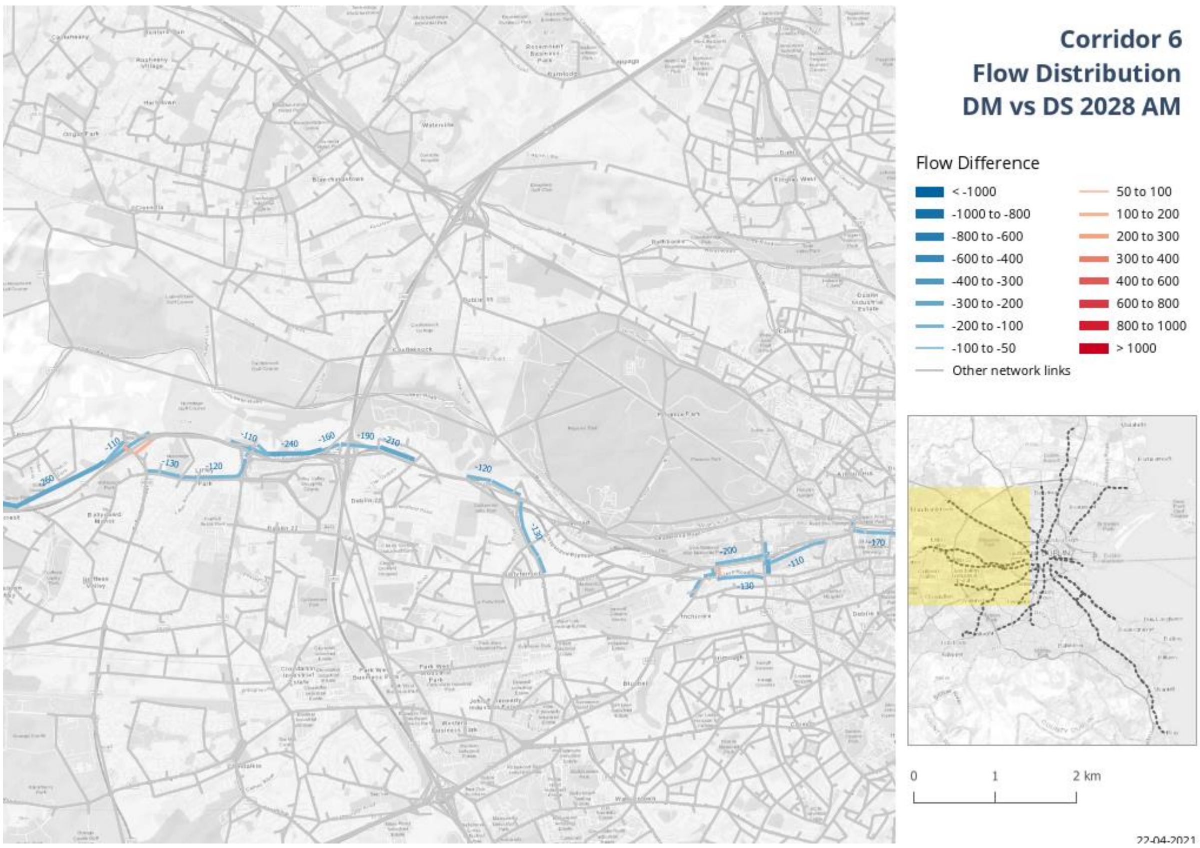

Figure 5-7 Optimised and Iterated 2028 AM Peak DLAM Distribution Plot

5.4.4 LinSig Modelling

Detailed junction modelling analysis using LinSig 3.2.40 was undertaken on the emerging design proposals at each signalised junction until the DLAM model iterations had been concluded and a final preliminary design was achieved. The LinSig modelling adopted the future year traffic flows from the Saturn DLAM model runs for the DS scenario for the Opening Year 2028.

5.4.4.1 LinSig Assumptions

The following LinSig assumptions were applied in the modelling:

Cycle Time

- 120s (max) cycle time permitted.

Pedestrian

- Green Time: 6s minimum green time for pedestrians, and
- Intergreen: based on a walking speed of 1.2m per second plus a 2 second safety buffer using AutoCAD

Cyclist

- Cruise speed: 15km/h or 4.16m per second;
- Cyclist early start: 5s on the majority main CBC arms, with 3s minimum. On the side roads of junctions, 3s cyclist early start; and
- Modelled cyclist flows based on cycle quantification exercise.

5.4.4.2 Cycle Quantification

The vision of the NCPF is that “10% of all trips will be by bike”.

Junctions on the Proposed Scheme have been designed to be consistent with the above objective to accommodate a minimum 10% cycle mode share in terms of people movement at each junction. This will mean that in practice the junctions should be designed to have capacity to provide for at least the existing levels of cycling demand or levels of cycling that provide for a minimum 10% mode share in future years, (whichever is the greater).

A cycle demand quantification assessment was undertaken in order to identify projected cycling demand in the Opening Year (2028) to inform the design of cycle facilities at each junction along the Proposed Scheme in line with the NCPF. The level of cycle demand informs the level of priority and the requirements for geometric design for cyclists. This also has implications for the green time allocation to be provided for cycle movements modelled in LinSig and then in turn in VISSIM.

The cycle demand calculation illustrated in Figure 5-5 is based on the capacity provided rather than being informed by existing or modelled future year cycling numbers. It was noted that using the maximum pedestrian capacity calculation skewed the mode share calculations, therefore the existing pedestrian counts plus an uplift factor of 20% has been applied.

The calculation accounts for the green time provided in a typical signal cycle, the number of cycles within the hour and an assumption on headway between cyclists. The calculation also considers the capacity benefit of wider lane provision, whereby cyclists can overtake each other with greater widths.

Using the cycle quantification and people movement spreadsheet, the following checks were undertaken to ensure cycle demand is catered for at an appropriate level, and that each of the criteria is satisfied:

- A minimum 10% cycle mode share is provided for when summing people movement across all arms (including side roads);
- The calculated cycle capacity (calculated from above) exceeds existing cycling flow; and
- If the calculated mode share of 10% is less than the existing flow. The minimum target is the existing flow plus design buffer level of 20%

To quantify the cycle demand numbers for input into LinSig, the following approach was applied:

- Cycle Design Target demand for the junction calculated based on achieving the above criteria (10% of total people movement at junction or existing plus 20% buffer);
- This Design Target total for whole junction is distributed across turning movements based on existing observed 2019 survey data for cycling;
- A minimum turning demand of 10 cyclists per hour to be allowed for;
- Cycle demand turning flows input to LinSig models with green times and phasing and staging plans adjusted as appropriate; and
- Resulting LinSig models provided for input to VISSIM models which will model the same cycling flows.

Table 5-6 presents a summary of the projected number of cyclists per junction identified as a design target and a total number of cyclists modelled in LinSig per junction.

Table 5-6 Proposed Cyclist Quantification

Junction Name	Cycle Quantification (Number of Cyclists)			
	2028 AM Peak Hour		2028 PM Peak Hour	
	Design Target	Total Modelled	Design Target	Total Modelled
R136 Ballyowen Road / R835 Lucan Road	517	675	420	680
N4 (Jct 3) Eastbound Off-Slip / R136 Ballyowen Road	356	505	349	530
N4 (Jct 3) Westbound Off-Slip / R136 Ballyowen Road	549	620	561	640
R136 Ballyowen Road / Hermitage Road Junction	472	560	484	550
N4 Junction 2	522	585	354	490
R148 Palmerstown bypass / Kennelsfort Road	580	580	390	390
R148 Palmerstown bypass / The Oval	118	118	107	107
R148 Chapelizod bypass / R148 Con Colbert / R833 Con Colbert Road	816	920	754	850
R148 Con Colbert Road / R839 Memorial Road	1,047	1,170	874	980
R148 Con Colbert Road / R111 South Circular Road/ R148 St John's Road West	1,194	1,395	1,066	1,230
R148 St Johns Road West / HSQ	892	995	821	940
R148 St Johns Road West / Military Road	1,035	1,205	946	1,060
R148 St Johns Road West / Heuston Station (Steeven's Lane)	1,266	1,415	1,176	1,310
R148 St John's Road West / Victoria Quay / Frank Sherwin Bridge	1,096	1,350	1,134	1,290

5.4.4.3 LinSig Results

Table 5-7 provides an overview of the junction analysis results.

Table 5-7 Proposed Scheme Signalised Junctions

No	Junction Name	DM Cycle Time (s)	Proposal		Practical Reserve Capacity (%)	
			Cycle Time (s)	Linked Junctions	AM Peak Hour	PM Peak Hour
1	R136 Ballyowen Road / R835 Lucan Road	90	120	1, 2 and 3	-7.7%	8.3%
2	N4 (Jct 3) Eastbound Off-Slip / R136 Ballyowen Road	130	120	1, 2 and 3	3.9%	41%
3	N4 (Jct 3) Westbound Off-Slip / R136 Ballyowen Road	130	120	1, 2 and 3	25.3%	27.8%
4	R136 Ballyowen Road / Hermitage Road Junction	120	120	-	54.3%	30.6%
5	N4 Junction 2	60	75	-	-8.5%	26.9%

6	R148 Palmerstown bypass / Kennelsfort Road	140	120	-	-0.2%	-1.2%
7	R148 Palmerstown bypass / The Oval	115	120	-	7.4%	-35.9%
8	R148 Chapelizod bypass / R148 Con Colbert/ R833 Con Colbert Road	110	90	-	80.3%	43.3%
9	R148 Con Colbert Road / R839 Memorial Road	100	110	-	3.9%	6.4%
10	R148 Con Colbert Road / R111 South Circular Road/ R148 St John’s Road West	100, 85, 110, 100	120	-	-32.8%	-46.7%
11	R148 St Johns Road West / HSQ	90	100	-	61.5%	14.7%
12	R148 St Johns Road West / Military Road	115	100	-	35.6%	13.8%
13	R148 St Johns Road West / Heuston Station (Steeven’s Lane)	90	120	-	25.7%	38.0%
14	R148 St John’s Road West / Victoria Quay / Frank Sherwin Bridge	90	120	-	4.4%	-40.9%

6 Ground Investigation and Ground Condition

6.1 Introduction and Desktop Review

The following sections have been prepared in support of the scheme preparation for the Proposed Scheme. They provide a summary of the desk study and commentary on the findings of ground investigations that have been undertaken for the proposed route. A summary of factual data, which has been gathered for the scheme, is provided with interpretation of design parameters and should be read in accordance with the following documents:

- Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019, which has been located in Appendix E.1.
- Ground Investigation Report (GIR) Lucan to City Centre Proposed Scheme (DRAFT), dated December 2020, which has been located in Appendix E.2.

The above documents were generally prepared in accordance with the procedures set out in TII Managing Geotechnical Risk DN-ERW-03083.

The results of the factual investigation are provided in the following Causeway Geotech Factual Report:

- Report No: 20-0399D Bus Connects Route 6 Lucan to City Centre – Ground Investigation, dated December 2020, prepared by Causeway Geotech Ltd, which has been located in Appendix E.3.

Considering the guidance in IS EN 1997-1, it is considered that Geotechnical Category 2 is currently the most appropriate for the Scheme.

The ground investigation is split into different phases of investigation. The initial phase was concerned with carrying out test holes at key locations to inform design to facilitate the planning phase of the project. It is anticipated that additional ground investigation, locations and spacings generally conforming to guidelines of EC7, will be carried out at later date.

The following sections are a summary of the geotechnical considerations along the proposed route.

6.2 Field Investigation

One project specific ground investigation has been undertaken to date by Causeway Geotech Ltd, conducted between 24th September and 24th October 2020.

In general, the ground investigation utilised the following exploratory techniques:

- Cable percussion (CP) boring sunk using shell and auger techniques. This technique was used to investigate the superficial ground conditions, undertaking in-situ testing and taking undisturbed and disturbed samples for geotechnical / geochemical laboratory testing. Typically, CP boreholes were terminated on encountering refusal on very dense / stiff soils, boulders or weathered bedrock, or at a predefined depth based on the design and construction requirements for the proposed structure / earthwork;
- Rotary drilling both with and without core recovery. Generally, when using rotary drilling within soils standard penetration tests (SPTs) were taken at regular intervals below the depth attained by the CP boring;
- Rotary drilling without core recovery (RO) was typically used to identify rockhead level and extend CP boreholes to rockhead when the CP could not advance due to obstructions (i.e. very dense / stiff soils or boulders);
- Rotary drilling with core recovery (RC) was typically used in soils to extend CP boreholes beyond obstructions (i.e. very dense / stiff soils or boulders), where more soil information was required than would be recovered by RO methods. The use of a geotechnical wireline triple tube core barrel S-size (“Geobor”) allowed recovery of good quality (Class 1) samples, and RC was typically used

in rock to provide information on the rock (i.e. lithology, discontinuities, strength, etc.) and recover core samples suitable for laboratory testing.

- Groundwater monitoring standpipes, installed to identify groundwater levels, provide water samples for geochemical testing and monitor groundwater flow;
- Machine excavated trial pits sunk to identify the near surface ground conditions and, at specific locations, to identify whether there was any archaeological significance. Disturbed samples, and where contamination was suspected, environmental samples were recovered from the trial pits to allow for geotechnical and geochemical testing. In-situ hand vane testing was also carried out in suitable cohesive soils. Dynamic Cone Penetrometers (DCPs) were carried out adjacent to trial pits to provide a profile of penetration with depth and to a derive a CBR value; and
- Window sampling was employed at boreholes locations which were unsuitable to access by means of CP rigs, RC rigs or excavators; the window sampling rig was smaller and easier to mobilise to difficult locations. The window sampler was used to identify superficial ground conditions, taking disturbed samples for geotechnical / geochemical testing and carrying out SPTs. Typically, the window sampling boreholes were terminated on very dense / stiff soils or on possible boulders or bedrock.

The investigation is summarised as follows:

Site operations, which were conducted between 24th September and 24th October 2020, comprised:

- Thirteen boreholes (R6-CP01 to R6-CP11 and R6-WS01 to R6-WS02) were put down in a minimum diameter of 150mm through soils and rock strata to their completion depths by a combination of methods, including light percussion boring using Dando Terrier rigs, light cable percussion boring by Dando 2000 rigs, and rotary drilling (by Hanjin D8 rotary drilling rigs);
- Six boreholes (R6-CP01, R6-CP03 and R6-CP08 to R6-CP11) were put down to completion in minimum 200mm diameter using Dando 2000 light cable percussion boring rigs. All boreholes were terminated on encountering virtual refusal on obstructions;
- One borehole (R6-CP07) was put down by a combination of light percussion boring and rotary follow-on drilling techniques with core recovery in bedrock. Where the light percussion borehole had not been advanced onto bedrock, rotary percussive methods were employed to advance the borehole to completion / bedrock. Symmetrix cased full-hole drilling was used, with SPTs carried out at standard intervals as required;
- Six boreholes (R6-CP02, R6-CP04 – R6-CP06, R6-WS01 and R6-WS02) were put down to completion by light percussion boring techniques using a Dando Terrier dynamic sampling rig. The boreholes were put down initially in 150mm diameter, reducing in diameter with depth as required, down to 50mm by use of the smallest sampler;
- One slit trench (R6-TP01) was excavated by a combination of hand digging and mechanical excavation using a compact 3 tonne tracked excavator fitted with a 600mm wide toothless bucket, to locate and identify buried services at the site. An attempt was also made to investigate foundations of existing bridge abutments at this location; and
- A groundwater monitoring standpipe was installed in R6-CP07.

6.3 Geotechnical Laboratory Testing

A range of geotechnical, geochemical and contamination testing was undertaken on samples of soil, rock, groundwater recovered during the ground investigation.

The Ground Investigation Factual Report provides the laboratory test results / reports and details of the testing methods.

Soils tests, undertaken as part of the ground investigation, include the following:

- Classification tests: moisture content, Atterberg Limits, and particle size distribution by wet sieving and sedimentation;
- Compaction related tests: Moisture Condition Value (MCV); and

- Shear strength (total stress): unconsolidated undrained, single stage triaxial tests on nominal 100mm diameter specimens prepared from U100 and Geobor core samples.

Rock tests, undertaken as part of the ground investigations, are detailed below:

- Point load strength tests, and
- Uniaxial compressive strength (UCS) tests.

The following chemical tests were undertaken:

- pH;
- Water soluble sulfate content;
- Acid soluble sulfate content; and
- Total sulphur content.

A suite of contamination testing was scheduled on selected soil and water samples recovered at various locations along the proposed scheme. The full lists of tests and the test results are included in the Ground Investigation Factual Report.

6.4 Soils and Geology

6.4.1 Quaternary Sediments

Refer to Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019.

6.4.2 Bedrock

Refer to Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019.

6.5 Ground Summary and Material Properties

6.5.1 Overview

The following lithologies have been assigned to the ground types encountered in the ground investigations:

- Topsoil;
- Made Ground / Highway Fill;
- Glacial Till deposits – subdivided into brown Dublin Boulder Clay, and black Dublin Boulder Clay;
- Sand and Gravel deposits;
- Glacial Till deposits – subdivided into brown Dublin Boulder Clay, and black Dublin Boulder clay; and
- Bedrock (ROCK) – subdivided into Limestone.

Table 6-1 summarises the ground conditions encountered in Route 06 in approximate lithological order.

Table 6-1 Proposed Scheme Summary of Soil Units Encountered

Stratum	Depth to Top of Stratum (m bgl)	Level at Top of Stratum (m AOD)	Thickness (m)
Topsoil	0	64.42 to 45.94	0.10 to 0.4
Made Ground	0 to 0.3	60.62 to 19.45	0.5 to 4.3*
Glacial Till	0.7 to 3**	59.62 to 22.13**	0.5 to 4.3*

Sands and Gravels	0.3 to 5.2	64.12 to 49.87	0.2 to 1*
Possible Rock	3.7 to 4.8	55.92 to 41.14	Not Cored
Limestone	7.6	48.45	3.1***

**not proven in all testholes*
***Glacial Till described as Possible Made Ground*
**** not proven*

The strata of each exploratory hole shown on the geotechnical long sections have been assigned to one of the above lithologies by considering:

- strata descriptions and laboratory test results;
- published geology and interpreted geomorphology; and
- topography in the area.

The following sections of the report describe the general nature of the identified lithologies and the primary locations where they have been identified in the ground investigations.

6.5.2 Made Ground

Made Ground is present in various areas along the length of the route corridor. Highway Fill is associated with existing roads or areas of hard standing; it typically comprises general fill of reworked clay / silt / sands and selected fills formed by silty sandy gravels.

Paved surface: boreholes R6-CP10 and R6-CP11 encountered 0.3 m of macadam surfacing with approximately 1.0m of aggregate fill beneath the paved surfaces. In addition, R6-TP01 penetrated concrete down to 100mm. Concrete was also encountered at 4.0mbgl in borehole R6-CP10.

Made Ground (fill) comprising of reworked sandy gravelly clay fill occasionally with fragments of concrete extending to a maximum depth of 4.0 m in R6-CP10. The main occurrences encountered in exploratory holes along the route, with approximate chainage are summarised in the following Table 6-2.

Table 6-2 Proposed Scheme Occurrences of Made Ground

Approximate Chainage	Test hole	Depth range (m bgl)	Thickness (m)	Description
A 1288	R6-CP01	0.1 - 1	0.9 m	MADE GROUND: Soft brown sandy gravelly CLAY.
A 1522	R6-CP02	0.2 – 0.7	0.5 m	MADE GROUND: Grey angular to subangular fine to coarse GRAVEL of mixed lithologies
A 2199	R6-CP03	0.1 – 1	0.9 m	0.1 – 0.4 m bgl :MADE GROUND: Soft brown sandy gravelly CLAY. 0.4 -0.6 m bgl :MADE GROUND: Grey sandy subrounded GRAVEL of mixed lithologies 0.6 – 1 m bgl: MADE GROUND: Soft brown sandy gravelly CLAY.
A 2237	R6-CP04	0.10 – 1.7	1.6 m	MADE GROUND: Stiff brown sandy gravelly CLAY with high cobble content and concrete fragments.
A 2252	R6-CP05	0.1 – 1.9	1.8	MADE GROUND: Firm becoming stiff brown sandy gravelly CLAY with high cobble content.
A 2235	R6-CP06	0.1 – 1.8	1.7	0.1 – 0.6 m bgl : MADE GROUND: Grey sandy angular to subangular fine to coarse GRAVEL of mixed lithologies. 0.6 – 1.2 m bgl : MADE GROUND: Light grey angular to subangular fine to coarse GRAVEL of mixed lithologies. 1.2 – 1.80 m bgl : MADE GROUND: Loose light grey angular to subangular fine to coarse GRAVEL of mixed lithologies.

Approximate Chainage	Test hole	Depth range (m bgl)	Thickness (m)	Description
A 2242	R6-CP07	0.2 – 1	0.8	MADE GROUND: Firm brown sandy gravelly CLAY.
A 2150	R6-CP08	0 – 0.4	0.4	MADE GROUND: Soft brown sandy gravelly CLAY
A 3675	R6-CP09	0.3 – 3	2.7	0.3 – 1.2 m bgl : MADE GROUND: Soft to firm brown sandy gravelly CLAY 1.2 – 3 m bgl : MADE GROUND: Very soft brownish grey sandy gravelly CLAY
A 5596	R6-CP10	0 – 4	4	0 - 0.3 m bgl : BITMAC 0.3 – 1 m bgl : MADE GROUND: Black slightly sandy angular fine to coarse GRAVEL of limestone. 1 – 3 m bgl : MADE GROUND: Firm becoming stiff brown slightly sandy slightly gravelly CLAY. 3 – 4 m bgl : MADE GROUND: Very stiff brown sandy gravelly CLAY.
A 5622	R6-CP11	0 – 4.2	4.2	0 - 0.3 m bgl : BITMAC 0.3 – 1.1 m bgl : MADE GROUND: Black sandy angular fine to coarse GRAVEL of limestone. 1 – 3 m bgl : MADE GROUND: Firm becoming stiff brown slightly sandy slightly gravelly CLAY. 3 – 4 m bgl : MADE GROUND: Very stiff brown sandy gravelly CLAY.
A 5636	R6-TP01	0 -1.10	1.10	0 – 0.18 m bgl: MADE GROUND: Grey slightly sandy angular fine to coarse GRAVEL of limestone. 0 – 0.48 m bgl : MADE GROUND: Dark grey slightly sandy angular fine to coarse GRAVEL of limestone 0.48 – 1.10 m bgl: MADE GROUND: Brown slightly sandy clayey angular fine to coarse GRAVEL of limestone

Table 6-3 summarises the geotechnical laboratory and in-situ testing carried out within the deposit.

Table 6-3 Summary of Geotechnical Laboratory and In-situ Results on Made Ground

Geotechnical Property	Unit	No. Tests	Min Value	Mean Value	Max Value
Particle Size Distribution					
Clay	%	2	10	14.5	19
Silt			27	27.5	28
Sand			28	30.5	33
Gravel			25	27.5	30
Cobbles			0	0	0
Atterberg Limits					
Moisture Content		10	10	17.5	26
Liquid Limit (LL)	%	5	28	32.4	41
Plastic Limit (PL)		5	15	17.6	23
Plasticity Index (PI)		5	11	14.8	18
In-situ testing					

Geotechnical Property	Unit	No. Tests	Min Value	Mean Value	Max Value
Standard Penetration Test		12	2	21.25	50
Soil Chemistry					
pH		8	8.2	8.6	9.4
Water Soluble Sulfate	g/l	7	<0.010*	NA	1.2

** two samples less than limit of detection*

6.5.3 Sands and Gravels

Underlying the topsoil, sands and gravels were encountered in R6-WS01 and R6-WS02. These testholes effectively refused at 1.4 and 0.87 m bgl, respectively. Published geological mapping indicate the superficial deposits are in an area of gravels derived from limestone.

A 0.9 m thick loose brown gravelly silty fine to coarse sand was encountered at 0.4 m bgl in R6-CP08.

Thin granular deposits were also encountered in R6-CP03 and R6-CP07.

Table 6-4 summarises the geotechnical laboratory and in-situ testing carried out within the deposit.

Table 6-4 Summary of Geotechnical Laboratory and In-situ Results on Sands and Gravels

Geotechnical Property	Unit	No. Tests	Min Value	Mean Value	Max Value
Particle Size Distribution					
Clay	%	2	4	5	6
Silt			12	21	30
Fines		4	11	18.75	34
Sand			10	38	77
Gravel			12	36.75	52
Cobbles			0	6.5	26
In-situ testing					
Standard Penetration Test	Blows per 300 mm	2	50	50	50
Soil Chemistry					
pH		3	8.7	8.76	8.8
Water soluble sulfate	g/l	3	<0.010*	NA	0.024

**two samples less than limits of detection*

6.5.4 Glacial Till

The Glacial Till is typical of the drift cover in much of the Dublin area, comprising boulder clay, a lodgement till deposited during the last ice age, about 10,000 years ago. Farrell et al. (1995) made the distinction between the 'brown Boulder Clay' and the 'black Boulder Clay', stating that the brown Boulder Clay was a weathering product of the black Boulder Clay, and is broadly similar to it in terms of particle size distribution.

The brown Dublin Boulder Clay generally consists of sandy gravelly silt / clay with low to medium cobble content; occasionally soft to firm to 0.5 m; typically, firm / firm to stiff to maximum of about 3 m.

The black Dublin Boulder Clay is found underlying the brown Dublin Boulder Clay and consists of generally stiff / very stiff / sandy gravelly silt/clay with high cobble content and occasional boulders, and are typically below 2.0m bgl.

For the purposes of interpretation where a very stiff brown slightly sandy slightly gravelly CLAY was encountered underlying the very stiff black Dublin Boulder Clay, it was still classified as the black Dublin Boulder Clay for interpretation and presentation purposes.

Glacial Till was encountered in the majority of testholes and was generally described as sandy gravelly clay, typically firm or stiff in upper horizons, becoming very stiff with increasing depth.

Soft deposits of Glacial Till were encountered as follows:

- In R6-CP03, from 1.2 to 3.7 m bgl described as soft becoming firm brown slightly gravelly sandy silty CLAY;
- In R6-CP04, from 3 to 3.6 m bgl described as soft brown sandy gravelly SILT with low cobble content; and
- In R6-CP07, from 1 to 2.5 m bgl described as soft brown slightly sandy slightly gravelly CLAY

It's possible that water strikes due to shallow bedrock may have contributed to the softening at the above locations.

A very soft brown sandy gravelly CLAY was encountered in R6-CP09 with an undrained shear strength of 15 kPa from 3 to 4 m bgl, although the geological mapping indicates this is in an area of glacial till, it's possible this was a pocket of alluvium from an old river tributary / stream.

Table 6-5 summarises the geotechnical laboratory and in-situ testing carried out within the deposit.

Table 6-5 Summary of Geotechnical Laboratory and In-situ Results on Glacial Till on Proposed Scheme

Geotechnical Property	Unit	No. Tests	Min Value	Mean Value	Max Value
Particle Size Distribution					
Clay	%	7	2	4	9
Silt			13	27.5	45
Sand			20	32	55
Gravel			3	36.5	65
Cobbles			0	0	0
Atterberg Limits					
Moisture Content	%	22	9.6	16.9	33
Liquid Limit (LL)		7	28	31.4	40
Plastic Limit (PL)		7	13	19.2	25
Plasticity Index (PI)		7	9	12.1	16
In-situ testing					
Standard Penetration Test blows per 300 mm		16	4	22.6	50

Geotechnical Property	Unit	No. Tests	Min Value	Mean Value	Max Value
MCV		1	9.3		
Shear strength (total stress)					
UU Triaxial test, cu	kPa	1	15		
SPT, cu	kPa	16	24	136	300
Soil Chemistry					
pH		8	8.2	8.65	8.9
Water soluble sulfate	g/l	8	<0.010*		0.069

**seven samples less than limits of detection*

6.5.5 Bedrock

In R6-CP07 from 6.85 to 7.10 m bgl, a possible shelf of Limestone bedrock was encountered. This was underlain by a 0.5 m thick layer of brown silty gravelly fine to coarse Sand. A medium strong thinly bedded dark grey Limestone was encountered at 7.6 m bgl extending to the borehole completion depth of 10.7 m bgl.

Although not proven, possible bedrock was noted in the borehole logs at depths ranging from 3.7 to 4.8 m bgl to in R6-CP01, R6-CP03, RP-CP08, and R6-CP09 with descriptions generally comprising of grey sandy angular coarse GRAVEL of limestone.

Full descriptions are available in the borehole logs.

Table 6-6 summarises the geotechnical laboratory and in-situ testing carried out within the deposit.

Table 6-6 Summary of Geotechnical Laboratory and In-situ Results on Bedrock in Proposed Scheme

Geotechnical Property	Unit	No. Tests	Min Value	Mean Value	Max Value
Rock Strength					
Uniaxial Compressive Strength	MPa	1	35.6		
Point Load Index	MPa	6	0.9	2.22	4.10
Discontinuities					
Fracture Index	Nr/m	2	5	7.5	10
Chemistry					
pH		1	8.6		
Water soluble sulfate	%	1	0.09		

6.6 Groundwater

6.6.1 Groundwater Monitoring

A standpipe was installed in R6-CP07. The results of ground water monitoring are as follows in Table 6-7:

Table 6-7 Groundwater Monitoring

Testhole	Standpipe Depth	Slotted Screen Range (m bgl)	Response Zone	Water Level 19-11-2020
R6-CP07	6.38	1- 6.38	Typically, fine grained Glacial till deposits. Granular deposits from 5.2 to 5.50 m and 6.2 to 6.38 m bgl	6.3

6.6.2 Groundwater Strikes

Groundwater strikes were as follows in Table 6-8:

Table 6-8 Groundwater Strikes

Testhole	Water struck at (m)	Casing to (m)	Time (min)	Rose to (m)	Drilling Remarks
R6-CP03	3	3			Water strike at 3.00m
R6-CP04	3	3	20	2.7	Water strike at 3.00m
R6-CP05	3.10	3.10	20	2.9	Water strike at 3.10m
R6-CP07	2.5	2.5			Seepage at 2.5 m
R6-TP01	0.65				Slow seepage at 0.65 m

6.6.3 Contaminated Land

6.6.3.1 Contamination Testing

Both former and present industrial land use may have resulted in the presence, along the proposed route corridor, of potentially toxic or other hazardous material, which may pose a threat to human health, controlled waters or other sensitive receptors.

The PSSR collected information on potentially contaminative land use within the route corridor.

Instances of Made Ground are recorded in section 6.5.2.

Contamination testing was undertaken on Made Ground encountered during the 2020 investigation and consisted of the following:

- Rialta Suite, and
- Suite E soil samples.

6.6.3.2 Summary from PSSR

The presence of Made Ground along the route means the possibility of contamination cannot be discounted. Samples for contamination testing shall be taken as part of the intrusive ground investigation.

EPA mapping indicates the following along the route:

- IPPC Facility: Diageo Ireland, St James Gate.

The Geohive map viewer indicates the following:

- Historical gravel pits to the north and south of the N4, and
- Historical power station north of the N4 near Hermitage Golf Course.

There is the possibility for contamination associated with the railway yard at Heuston Station and petrol stations along the route.

- A historical report, GSI reference 1091, related to a site investigation in Longmeadows Ballyfermot (sewer replacement) where the new sewer crosses the proposed Chapelizod bypass, close to First Avenue and Liffey Street South. The site was in the old city dump: compact domestic waste was encountered from 4.6 to 11 m bgl; overlying Glacial Till; overlying boulders / rock at 18 m.

The site sloped from high ground down to the banks of the River Liffey at the time of the investigation in 1989, when earthworks, associated with the Chapelizod bypass, were underway. The site appears be a present-day pitch and putt course.

6.6.3.3 2020 Geo-environmental Testing Summary

Samples for geo-environmental testing were taken from Made Ground along the proposed route.

A list of the main Made Ground deposits encountered during the ground investigations is provided in Section 6.5.2.

The samples tested are listed below in Table 6-9.

Table 6-9 Summary of Samples Tested

Testhole	Depth
R6-CP09	1
R6-CP07	0.5
R6-CP10	1

Table 6-10 below summarises the soil laboratory test results. Full details are available in Report No: 20-0399D BusConnects Route 6 Lucan to City Centre, dated December 2020, located in Appendix E.3.

Table 6-10 Summary of Soil Geo-environmental Test Results

Determinant	Unit	No. of samples	Minimum Concentration	Maximum Concentration
		No.	Min	Max
Organics				
Total Organic Carbon		1	1.40	1.40
Organic Matter	%	2	1.90	2.20
Mineral Oil and TPH				
Mineral Oil	mg/kg	1	<10	<10
Total Petroleum Hydrocarbons (by IR)	mg/kg	2	230.00	230.00
Aliphatic TPH >C5-C6	mg/kg	1	< 1.0	< 1.0
Aliphatic TPH >C6-C8	mg/kg	1	< 1.0	< 1.0
Aliphatic TPH >C8-C10	mg/kg	1	< 1.0	< 1.0
Aliphatic TPH >C10-C12	mg/kg	1	< 1.0	< 1.0
Aliphatic TPH >C12-C16	mg/kg	1	< 1.0	< 1.0
Aliphatic TPH >C16-C21	mg/kg	1	< 1.0	< 1.0
Aliphatic TPH >C21-C35	mg/kg	1	< 1.0	< 1.0
Aliphatic TPH >C35-C44	mg/kg	1	< 1.0	< 1.0
Total Aliphatic Hydrocarbons	mg/kg	1	< 5.0	< 5.0
Aromatic TPH >C5-C7	mg/kg	1	< 1.0	< 1.0
Aromatic TPH >C7-C8	mg/kg	1	< 1.0	< 1.0
Aromatic TPH >C8-C10	mg/kg	1	< 1.0	< 1.0
Aromatic TPH >C10-C12	mg/kg	1	< 1.0	< 1.0

Determinant	Unit	No. of samples	Minimum Concentration	Maximum Concentration
		No.	Min	Max
Aromatic TPH >C12-C16	mg/kg	1	< 1.0	< 1.0
Aromatic TPH >C16-C21	mg/kg	1	< 1.0	< 1.0
Aromatic TPH >C21-C35	mg/kg	1	< 1.0	< 1.0
Aromatic TPH >C35-C44	mg/kg	1	< 1.0	< 1.0
Total Aromatic Hydrocarbons	mg/kg	1	< 5.0	< 5.0
Total Petroleum Hydrocarbons	mg/kg	1	< 10	< 10
BTEX and MTBE				
Benzene	µg/kg	1	< 1.0	< 1.0
Toluene	µg/kg	1	< 1.0	< 1.0
Ethylbenzene	µg/kg	1	< 1.0	< 1.0
m and p-Xylene	µg/kg	1	< 1.0	< 1.0
o-Xylene	µg/kg	1	< 1.0	< 1.0
Methyl Tert-Butyl Ether	µg/kg	1	< 1.0	< 1.0
PAH				
Naphthalene	mg/kg	3	< 0.10	9.20
Acenaphthylene	mg/kg	3	< 0.10	0.57
Acenaphthene	mg/kg	3	< 0.10	5.70
Fluorene	mg/kg	3	< 0.10	4.80
Phenanthrene	mg/kg	3	< 0.10	18.00
Anthracene	mg/kg	3	< 0.10	3.10
Fluoranthene	mg/kg	3	< 0.10	11.00
Pyrene	mg/kg	3	< 0.10	10.00
Benz(a)anthracene	mg/kg	3	< 0.10	4.50
Chrysene	mg/kg	3	< 0.10	4.70
Benzo(a) pyrene	mg/kg	3	< 0.10	4.00
Indeno(1,2,3-c,d)pyrene	mg/kg	3	< 0.10	2.10
Dibenz(a,h)anthracene	mg/kg	3	< 0.10	0.98
Benzo(g,h,i)perylene	mg/kg	3	< 0.10	2.20
Benzo(b)fluoranthene	mg/kg	2	<0.1	4.80
Benzo(k)fluoranthene	mg/kg	2	<0.1	2.00
PAHs (Sum of total)	mg/kg	3	<2	88.00
SVOC				
Coronene	mg/kg	3	<0.1	<0.1
PCB				
PCB 28	mg/kg	1	< 0.010	< 0.010
PCB 52	mg/kg	1	< 0.010	< 0.010

Determinant	Unit	No. of samples	Minimum Concentration	Maximum Concentration
		No.	Min	Max
PCB 90+101	mg/kg	1	< 0.010	< 0.010
PCB 118	mg/kg	1	< 0.010	< 0.010
PCB 153	mg/kg	1	< 0.010	< 0.010
PCB 138	mg/kg	1	< 0.010	< 0.010
PCB 180	mg/kg	1	< 0.010	< 0.010
Total PCBs (7 Congeners)	mg/kg	1	< 0.10	< 0.10
Phenolics				
nonchlorinated phenols	mg/kg	3	<0.3	<0.3
Metals				
Arsenic	mg/kg	3	4.80	20.00
Antimony	mg/kg	1	<2	<2
Barium	mg/kg	1	42.00	42.00
Boron	mg/kg	3	<0.4	0.56
Cadmium	mg/kg	3	<0.1	1.60
Chromium (III+VI)	mg/kg	3	13.00	29.00
Chromium (Trivalent)	mg/kg	1	29.00	29.00
Chromium (Hexavalent)	mg/kg	1	<0.5	<0.5
Copper	mg/kg	3	15.00	24.00
Lead	mg/kg	3	14.00	27.00
Mercury	mg/kg	3	<0.1	<0.1
Molybdenum	mg/kg	1	<0.2	<0.2
Nickel	mg/kg	3	25.00	41.00
Selenium	mg/kg	1	<0.2	<0.2
Zinc	mg/kg	3	50.00	79.00
Inorganic				
Cyanide Total	mg/kg	2	<0.5	<0.5
Moisture	%	3	9.60	14.00
Sulfate (soluble)	g/L	3	<0.01	0.50
pH (Lab)	pH_Units	3	8.30	8.70
Asbestos				
Asbestos		3	NAD	NAD

6.7 Overview of Soil Classification

6.7.1 Fill Materials

6.7.1.1 General

Engineering Fill will be required on this project for the construction of embankments and backfill to retaining structures.

The primary types of fill materials (classified in accordance with Table 6/1and Table 6/2 of TII Specification for Roadworks (CC-SPW-00600 series) that will be required include the following:

- General granular fill (Class 1);
- General cohesive fill (Class 2) – consisting of fine–grained Glacial Till of adequate remoulded undrained shear strength;
- Selected uniformly graded granular material (Class 6C) - for use as a starter layer if required;
- Selected granular fill (Class 6F1/6F2/6F3): capping;

6.7.1.2 Selected Granular Fill (Class 6N1) – For Use as a Fill to Structures;

- Selected granular fill (Class 6N2) – for use as a fill below structures; and
- Selected granular fill (Class 6I/J) – for use as a fill to reinforced earth and anchored earth.

6.7.2 Re-use of Excavated Material

6.7.2.1 General

Reuse of topsoil and excavated material within the Proposed Scheme is proposed, where practicable.

6.7.2.2 Topsoil

Topsoil stripped as part of earthworks will classify as Class 5A material.

6.7.2.3 Glacial Till

Glacial Till with a minimum remoulded shear strength of 50 kPa will generally be acceptable as Class 2 general fill.

Laboratory CBR testing of silty boulder clay soils can often provide unexpectedly low results, often attributed to dilatancy, migration of water from granular lenses, or excess pore water pressures within the remoulded specimen following its preparation. MCV test data at the site investigation stage can also frequently underestimate the acceptability of Class 2 materials.

In-situ CBR results obtained from DCP testing in trial pits and measured SPT from the boreholes available in the Ground Investigation Factual Reports may provide more realistic predictions of the in-situ soil stiffness.

For SPT values in Glacial Till, a multiplier has been applied on SPT values to convert to an appropriate cu value as follows:

Cu = f1 x N60.

Guidance on the value of f1 is provided by Stroud and Butler (1975) who related the parameter to the soil plasticity index. A value of 5.5 - 6 could be used for f1 which is consistent with the typical plasticity indices of the Glacial Till encountered across the site. This would indicate, allowing for some reduction of strength on remoulding, that an SPT blow count in excess of about 10 blows per 300 mm would provide an acceptable remoulded shear strength of 50 kPa.

Glacial Till with a remoulded shear strength of less than 50 kPa may be suitable as Class 4 landscaping fill if sufficient stiffness to allow placement and light compaction.

Unacceptable Class U1 cohesive glacial till can also be treated with lime modification to improve to Class 2 general fill.

6.7.2.4 Sands and Gravels

Sands and Gravels on the route are typically associated with Hermitage golf course.

The material will generally classify as Class 1 granular fill; however, there may be some instances when the fines are in excess of the 15% limit.

6.8 Hydrogeology, as applicable

6.8.1 Aquifer Classification

According to the GSI Groundwater Resources (Aquifer) map, the Lucan Formation which predominantly underlies the site, is classified as a Locally Important Aquifer (LI). These formations are moderately productive only in local zones.

Most of the subsoil permeability across the route and surrounding area is classified as low. Exceptions are as follows:

- N4 and M50 junction: this has not been classified, and
- Irish War Memorial Gardens near Con Colbert Road: This is classified as high.

The route does not lie within a Group Scheme or Public Supply Source Protection Area.

6.8.2 Groundwater Vulnerability

The GSI National Groundwater Vulnerability map indicates that the groundwater vulnerability is variable. The route is generally “Low” to “High” with “Extreme” pockets also encountered.

6.8.3 Karst Landforms

According to the GSI Groundwater Karst Data map there are no karst features recorded within 1 km of the route.

6.9 Preliminary Engineering Assessment

6.9.1 Embankments

Refer to Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019, included in Appendix E.1.

6.9.2 Cuttings

Refer to Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019.

6.9.3 Pavement Design

Refer to Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019.

6.10 Geotechnical Inputs to Structures

6.10.1 Foundations

Refer to Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019.

6.10.2 Retaining Structures

Refer to Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019.

6.10.3 Soil Chemistry

Refer to Preliminary Sources Study Report (PSSR): Bus Connects Corridor Route 06: Lucan to City Centre, dated December 2019.

7 Pavement, Kerbs, Footways and Paved Areas

7.1 Pavement

7.1.1 Introduction

This section identifies the proposed pavement strategy, setting out the design development considerations for the pavement works in current and future design stages. It also outlines the key elements for consideration for future testing requirements, and considerations for the use of recycled aggregates in the detailed design stage.

7.1.2 Overview of Pavement

The road pavement design for the Proposed Scheme considers rehabilitation of the existing road pavement and new road pavement construction resulting from road widening or changes in geometry along the scheme extents. The details of the preliminary pavement design can be found on the PAV_PV Pavement Treatment Plans and GEO_CS Typical Cross Section drawing series in Appendix B. It should be noted that the pavement boxing shown on the typical cross section series has been shown indicatively only for the purposes of demonstrating areas of full depth reconstruction.

The nature of the works associated with the Proposed Scheme is to generally widen the existing carriageway or reallocate existing road space to facilitate new bus and cycle infrastructure. Existing footways and existing traffic lanes will also be impacted by the works. In general, all existing footways will be required to be removed and reinstated resulting from the realignment / widening works. Similarly, existing traffic lanes may be required to undergo pavement rehabilitation due to existing defects or pavement reconstruction works due to road realignment works or a pavement inlay / overlay treatment due to lane marking reallocation.

For the purposes of the pavement assessment the future bus flows and base 2019 traffic flows have been adopted as a reasonable worst-case scenario to inform the new pavement loading criteria for a 40-year design life.

Existing pavement asset testing information provided by the Road Management Office (RMO) has been assessed to provide an understanding of the existing pavement performance and quality. This data has been reviewed against high quality aerial photography, Google Street View imagery (2019), and site imagery to correlate the data against visual defects.

The preliminary design of pavement assets is based on the following standards:

- DN-PAV-03021 (Dec. 2010) – Pavement and Foundation Design;
- DN-PAV-03023 (Jun. 2020) – Surfacing Materials for New and Maintenance Construction for use in Ireland;
- AM-PAV-06050 (Mar. 2020) – Pavement Assessment, Repair and Renewal Principles;
- PE-SMG-02002 (Dec. 2010) – Traffic Assessment;
- CC-SPW-00600 (Mar. 2013) – Specification for Road Works Series 600 – Earthworks;
- CC-SPW-00700 (Jan. 2016) – Specification for Road Works Series 700 – Road Pavements – General;
- CC-SPW-00800 (Mar. 2013) – Specification for Road Works Series 800 – Road Pavements – Unbound and Cement Bound Mixtures; and
- CC-SPW-00900 (Sep. 2017) – Specification for Road Works Series 900 – Road Pavements – Bituminous Materials.

The different pavement assets are designed taking consideration of:

- Traffic loads;
- Changes in road geometry;

- Existing pavement construction build-up;
- Existing pavement condition;
- Landscape Architect's requirements; and
- The impact of other assets such as drainage, utilities, and structures.

7.1.3 Design Constraints

7.1.3.1 Traffic Loading Considerations

The requirements for the design life of the pavement works are set out in PE-SMG-02002 and DN-PAV-03021 for new pavement construction and AM-PAV-06050 for pavement strengthening measures. The design life for different pavement scenarios are shown below in Table 7-1.

Table 7-1 Pavement Design Criteria

Pavement Type	Design criteria
New build, widening, full reconstruction	• 40 year 'long life' pavement to max 80msa
Structural strengthening of the existing pavement	• 20-year design life

Current traffic count data (Traffic Count Data 2019-2020) has been used to understand the current traffic loads that are currently operational on the road network. A representation of surveyed traffic counts along the proposed scheme is displayed on Figure 7-1 below.

Figure 7-1 2019-2020 AADF – Proposed Scheme

Based on surveyed flows Table 7-2 below gives the estimated design msa for 20-year (rehabilitation) and 40-year (widening / new construction) design periods for the Proposed Scheme. Based on the Bus Network redesign, the forecast bus frequency of 60 busses per hour equates to 40 msa for a 40-year design life in accordance with the relevant design standard as shown below in Table 7-3.

Table 7-2 Estimated Design Traffic Ranges for Proposed Scheme

Design Life	
20 Years	40 Years
2 to >80 msa	4 to >80 msa
Note: "msa" stands for million standard axles.	

Table 7-3 Bus Frequencies and Associated msa for 40 Year Design Life

Bus Frequency / hour	Proposed Scheme	Traffic Loading Million standard axles (msa)
15		10
30		20
45	45	30
60	60	40

Locations of new highway pavement are predominantly anticipated to be at areas of widening for bus lane pavement. The standard DCC flexible pavement design specification for Bus Corridors is detailed in the Construction Standards for Roads and Street Works in Dublin City Council (CSRSW) and is presented below in Figure 7-2. The design allows for HRA or SMA surface course but specifies 40/60 pen Asphalt Concrete binder and base materials providing structural capacity to support 80msa traffic load. Whilst this detail is noted to cater above the future anticipated traffic loading in some areas, adopting this detail will provide a more robust pavement solution which could result in lower potential for maintenance / rehabilitation and thus reducing the future potential for delays to the bus services along the Proposed Scheme.

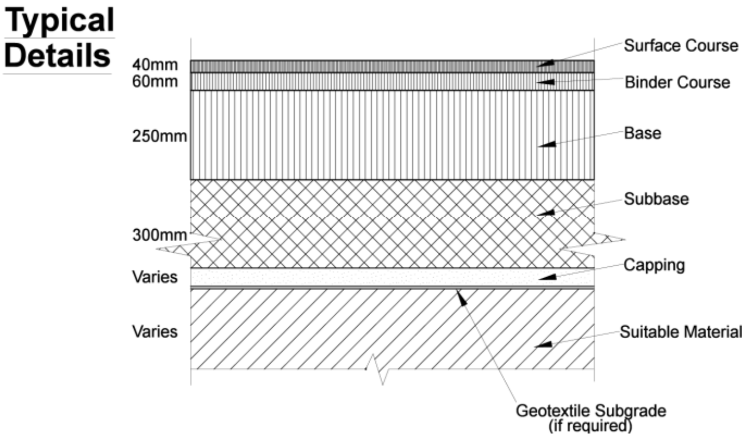

Figure 7-2 DCC Construction Standards for Roads and Street Works – Bus Corridor – Asphalt Road (indicative 80msa design)

Where it is considered uneconomical to provide a standard design for particular low traffic scenarios, like non bus routes / Quiet Streets, alternate design thickness, based upon different base material and design traffic, should be designed in accordance with DN-PAV-03021 (as per CSRSW requirements for design in accordance with the NRA Design Manual for Roads and Bridges).

Other specific areas for consideration along the Proposed Scheme are noted below:

- Bus stops (on- and off-line);
- N4 Junction 3 westbound off-ramp – possible requirements for concrete back-slab to support retaining wall;
- Loading / unloading areas for delivery vehicles;
- Off-line parking areas;
- Driveways; and
- Traffic calming features.

7.1.3.2 Geometry Considerations

7.1.3.2.1 Road Geometry Changes Overview

The proposed scheme is running on existing pavement assets, within constrained urbanised environments. It is therefore essential for the preliminary pavement design to consider the current road geometry and how it is proposed to be amended for the purpose of the proposed scheme.

The following road geometry changes expected to have an impact on the preliminary pavement design are:

- Pavement widening;
- Pavement narrowing;
- Horizontal realignment leading to relocation of pavement longitudinal joints (in relation to location of wheel tracks);
- Increase in vertical alignment;
- Decrease in vertical alignment;
- Impact on utilities and services trenches;
- Relocation of traffic islands; and
- Any combination of the above.

7.1.3.2.2 Pavement Widening

Widening is about extending transversely a rehabilitated existing pavement ensuring that the pavement structure shall be consistent from kerb to kerb and drainage paths are being maintained. It is therefore essential to understand what the existing pavement construction and condition is, as well as how it will be rehabilitated, before finalising the design of any widening.

It is proposed that any widening will be the full width of any proposed new lane, be it a cycle lane, a bus lane, or a general traffic lane. The widened lane shall be tied to the existing pavement as per transverse and longitudinal joint details CC-SCD-00704 – Pavement – Longitudinal Joint Between New Construction and Existing Road (Dec. 2010) and CC-SCD-00703 – Pavement – Transverse Joint Between New Construction and Existing Road (Sep. 2010).

7.1.3.2.3 Pavement Narrowing

Narrowing the pavement is the least disturbing geometrical change. Attention should however be given to the location of longitudinal joints in the existing pavement if the alignment of the traffic lanes is being shifted one way or the other. No longitudinal joint should be located in the wheel tracks.

It is proposed for any narrowing to be limited, in terms of excavation, to the area between the existing and the proposed kerb lines.

7.1.3.2.4 Horizontal Realignment

Usually combined with a widening or a narrowing, a change in lanes alignment will result in the relocation of wheel tracks on the transverse profile of the pavement. If it leads to the relocation of the wheel tracks above an existing pavement joint, pavement works are required to prevent accelerated deterioration. Those pavement works could consist of the relocation of longitudinal joints in the binder and surface courses, by renewal of both layers. A geotextile would also be installed on top of the longitudinal joint in the base course to delay reflective cracking.

7.1.3.2.5 Increase in Vertical Alignment

Where the vertical alignment is proposed to be increased, the do-minimum treatment would be removal of the existing surface course before overlaying to the new finish level. In some instances, poor condition of the underlying layers may lead to deeper rehabilitation works. The use of regulating layers and materials is likely to be required.

7.1.3.2.6 Decrease in Vertical Alignment

Where the vertical alignment is proposed to be decreased, the do-minimum treatment would require the pavement to be cold milled down to the proposed finished level of the binder course, as a minimum. If the bond between the layer being cold milled into and the underlying layer is weak, (i.e. the planer removed the material down to the interface at some locations), cold milling should be extended to this interface. In some instances, poor condition of the underlying layers may lead to deeper rehabilitation works. The use of regulating layers and materials is likely to be required.

7.1.3.2.7 Pavement Works over existing Utilities

Where the proposed works require new or modified utilities and drainage infrastructure, their depth or cover will require consideration with the proposed pavement profile. Typically new utilities are installed below the structural pavement layers to facilitate an even load distribution onto the assets however in many cases the depth of existing services will not be sufficiently deep enough to fall beneath the structural pavement layers and may require protection, diversion or a modified pavement design.

7.1.3.2.8 Relocation of Traffic Islands

Existing traffic islands to be relocated or removed should be fully excavated and may require a full depth pavement construction in trafficked areas, while proposed traffic islands may use the existing pavement as foundation where appropriate.

7.1.3.3 Existing Pavement Considerations

7.1.3.3.1 Construction

As the Proposed Scheme is running on existing pavement assets, it is essential to gather intelligence on those existing assets in terms of construction build-up and condition.

No as-built data was available to confirm existing pavement construction for the Proposed Scheme; however, for non-national routes the RMO pavement asset database generally includes details of more recent rehabilitation and resurfacing works [data as of 2019] including the following:

- “Surface Inventory Material Type”: this provides information on which type of surface material or treatment is present;
- “Completed Pavement Interventions”: this provides the location of where the carriageway has been resealed, surface restored, structurally overlaid, fully reconstructed or if a different treatment has been applied as Table 7-4 below [data as of 2019]; and
- “Planned Pavement Interventions”: this provides the location of where the carriageway is planned to undergo routine maintenance, surface restoration or full depth reconstruction as per Table 7-4 below [data as of 2019].

Table 7-4 Lengths of Completed and Planned Interventions on Local Authorities' Networks

Pavement Interventions (in linear metres)	
Completed	**Planned**
Surface restoration: 1760m in 2015, and 2200m in 2017.	Surface restoration: 1400m for 2020, and 1080m for 2021.

The surface materials and treatments recorded on the Proposed Scheme are a mix of Hot Rolled Asphalt (HRA) and Stone Mastic Asphalt (SMA)with some localised Surface Dressing (SD).

Local Pavement Asset Managers have also been contacted to establish if tar contaminated materials have been encountered on previous projects in the area. No known issues were identified; notwithstanding future testing will need to be undertaken to confirm the presence of tar contaminated materials.

7.1.3.3.2 Condition

As noted above, data from the RMO has been retrieved to assess the existing pavement condition. The data provided comprises limited network level survey data of non-national routes, including road surface measurements and limited visual condition surveys. This surface characteristics and visual condition data has been reviewed to give an indicative assessment of the pavement structural condition and to inform estimated high-level treatments.

For the sections of the Proposed Scheme running on the network of non-national routes, access to the RMO data sets was granted and DCC provided their Road Condition Index data. The following datasets were made available in early 2020:

- **Sideway-Force Coefficient Routine Investigation Machine (SCRIM)** data: Characteristic Skid Coefficient (CSC);
- **Pavement Surface Condition Index (PSCI)**: PSCI giving an idea of general pavement condition from the analysis of surface observed defects;

- **Road Surface Profiler (RSP)** data: International Roughness Index, Mean Profile Depth, and Rutting Depth and Longitudinal Profile Variance; and
- **Road Condition Index (RCI) Scanner** (DCC only): RCI giving an indication of general pavement condition from the analysis of surface observed defects.

The pavement surface condition is directly assessed while the pavement structural condition is indirectly estimated. The structural condition of the pavement can only be reported on and assessed from indirect condition indicators taken from the surface of the pavement: rut depth, International Roughness Index (IRI) and Longitudinal Profile Variance (LPV). This initial assessment of these indicators of the pavement structural condition has been used to inform estimated high-level treatments at this preliminary design stage. At detailed design stage with additional pavement condition information available from further testing, assessment of pavement structural capacity can be accurately estimated, and residual life determined for existing and rehabilitated pavements along the proposed scheme.

The following are the key findings of the initial pavement quality assessment and proposed treatment interventions for this preliminary design stage.

SCRIM data: Characteristic Skid Coefficient (CSC)

Where SCRIM data is available and processed to provide a Characteristic SCRIM Coefficient (CSC), preliminary strengthening designs have considered the following treatments, as a minimum, based upon measured SCRIM values categories:

- "GREEN" – (Very Good and Good) Good Condition (CSC >0.5) – Do nothing
- "LIGHT GREEN" – Good Condition (CSC 0.45 - 0.5) – Do nothing
- "YELLOW" – (Fair) Some deterioration (CSC 0.4 – 0.45) – Retexturing treatment – Shot-blasting
- "AMBER" – (Poor) Some deterioration (CSC 0.35 – 0.4) – Retexturing treatment – Shot-blasting
- "RED" – (Very Poor) Poor condition (CSC <0.35) – 40mm Asphalt Surface Course

The extents of the proposed treatment interventions are illustrated on PAV_PV drawing series in Appendix B.

Figure 7-3 Corrected SCRIM Conditions for Proposed Scheme (N4 Jct.3 to M50 Jct.7) Source: ArcGIS RMO MapRoad (2019 DCC Pavement Surveys) - Esri UK, Esri, HERE, Garmin, METI/NASA, USGS mapping

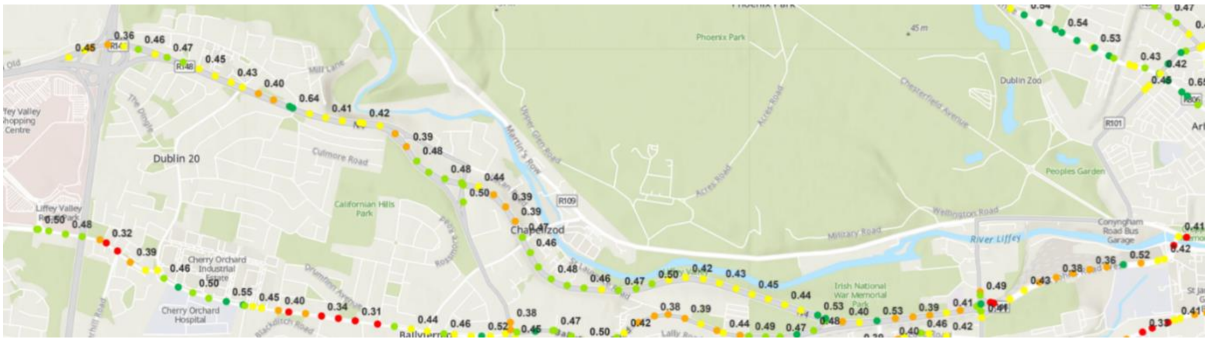

Figure 7-4 Corrected SCRIM Conditions for Proposed Scheme (from M50 Jct. 7 to Heuston Station). Source: ArcGIS RMO MapRoad (2019 DCC Pavement Surveys) - Esri UK, Esri, HERE, Garmin, METI/NASA, USGS mapping

The SCRIM assessment (Figure 7-3 and Figure 7-4) for the Proposed Scheme indicates that retexturing treatment or replacement of the surface course (40mm asphalt) may be required along intermittent sections of the route, as they have been categorised as 'Amber' or 'Red', notably Con Colbert Road and St John's Road West. Generally, the remainder of the route requires no intervention and has been categorised as 'Green'. This data will be reviewed during the detailed site investigation stage to determine if the apparently low CSC values result from a loss of texture or material.

Pavement Surface Condition Index (PSCI)

Where PSCI data is available, preliminary strengthening designs have been proposed for lengths of the existing carriageway pavements based upon the PSCI condition category. Preliminary strengthening designs based upon the PSCI categories are as follows:

- PSCI 9-10 – Routine Maintenance – Do nothing
- PSCI 7-8 – Resealing and Restoration of Skid Resistance – Shot-blasting
- PSCI 5-6 – Surface Restoration – 40mm Asphalt Surface Course plane and replace
- PSCI 3-4 – Structural Overlay / Inlay – 150mm Asphalt Inlay
- PSCI 1-2 – Road Reconstruction – 250-350mm Asphalt Inlay

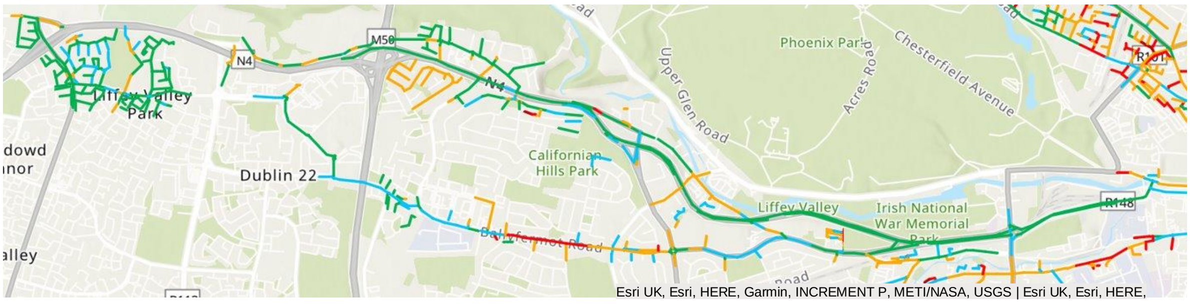

Figure 7-5 PSCI Survey for the Proposed Scheme

The PSCI survey (Figure 7-5) for the route of the Proposed Scheme shows the majority of the route is in generally good condition falling between the 'Overall PSCI Rating' of 7-10. However, the PSCI data indicates that there are some localised areas with moderate defects located along Chapelizod Hill Road, Old Lucan Road, Kennelsfort Road Lower and Lucan Road (at Jct. 3 of N4). There is also an area of the route in poor / distressed condition located on the R112 Old Lucan Road at the limit of the scheme.

The PSCI data was cross checked at problem areas with high quality aerial photography and Google Street View imagery (2019), and site imagery to further investigate the received data. See examples below (Figure 7-6 and Figure 7-7) showing defects which corroborate with the PSCI data received.

Figure 7-6 Poor Road Pavement Condition on Chapelizod Hill Road ©2020 Google Maps

Figure 7-7 Good Road Pavement Condition on Chapelizod bypass, Palmerstown – (but with some damage around utility chamber covers) ©2020 Google Maps

Road Condition Index (RCI) Scanner

Where SCANNER RCI is available, preliminary strengthening designs have been proposed for lengths of the existing carriageway pavements based upon the RCI condition category. Preliminary strengthening designs based upon the RCI categories are as follows:

- "GREEN" Generally good condition (<40) – Do nothing

- “Yellow” Some deterioration is apparent (Fair), (≥40 and <80) - Plan investigation soon
- "AMBER" – Some deterioration is apparent (Poor), (≥80 and <100) - Pavement Strengthening, 150mm Asphalt Inlay
- "RED" – Poor overall condition (≥100) - Full Reconstruction, 250-350mm Asphalt Inlay

The SCANNER survey (Figure 7-8) for the route of the Proposed Scheme indicates that the pavement is generally classified as good along the route. Very few areas along the route appear to be in poor condition with these generally limited to localised areas of poor condition identified along St John’s Road near Heuston Station and Chapelizod Hill Road.

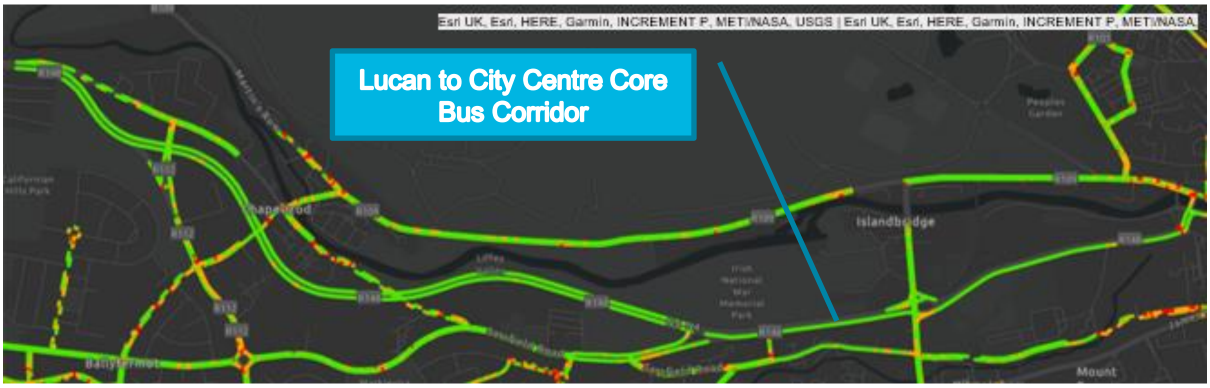

Figure 7-8 Road Condition Index for the Proposed Scheme

Summary of Assessment

The RCI and PSCI values have been combined in ArcGIS and analysed in Microsoft Access to establish the most onerous rating and avoid double counting of areas requiring intervention. From this assessment (Table 7-5) the overall pavement quality for the length of the route was established. Along sections of the route where there are multiple lanes, the poorest graded lane was used in the assessment.

The assessment describes the pavement condition being in one of four categories: red (poor), amber (moderate / poor), yellow (moderate / good) and green (good), which will determine the proposed treatment intervention.

Table 7-5 Preliminary Overall Pavement Quality Assessment of Pavement Works for Proposed Scheme (Both Directions)

Section	Length (both sides)	Pavement Quality								N/A
		Red		Amber		Yellow		Green		(No Data)
	(m)	Length (m)	%	Length (m)	%	Length (m)	%	Length	%	
Lucan Road	1702	20	1	80	4	704	41	794	46	104
Ballyowen Road	538	0	0	0	0	0	0	538	100	538
Jct.3 to Jct.2 N4	6326	0	0	0	0	0	0	0	0	6326
Hermitage Road	1506	0	0	0	0	38	3	1468	97	0
Old Lucan Road (east of M50)	2314	0	0	0	0	650	28	1664	72	0
Jct.2 to Jct.1 N4	6668	0	0	0	0	0	0	1630	24	5038
Old Lucan Road (west of M50)	2578	0	0	0	0	186	7	2392	93	0
Kennelsfort Road (lower and upper)	314	0	0	0	0	238	76	76	24	0
M50 to Kennelsfort Road	1642	0	0	0	0	0	0	834	51	808
Kennelsfort Road to R112 (Lucan Road)	3222	0	0	0	0	0	0	1802	56	1420
R112 (Lucan Road) to Con Colbert Road	12504	80	1	276	2	790	6	11358	91	0
Con Colbert Road	1948	0	0	20	1	80	4	1848	95	0
South Circular Road / Junction	430	0	0	0	0	112	26	318	74	0
St John’s Road West	2280	40	2	26	1	100	4	2114	93	0

A summary of the overall assessment in Figure 7-9 indicates just 1.5% of the pavement on the route needs further intervention than resurfacing [noting appreciable lengths with no data].

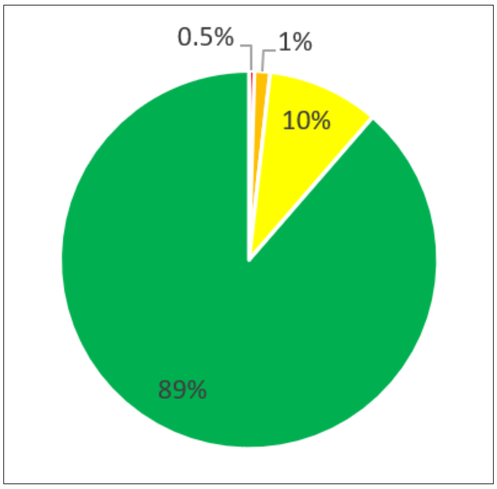

Figure 7-9 Summary of Overall Preliminary Pavement Quality Assessment – Key: Red (Poor), Amber (Moderate / Poor), Yellow (Moderate / Good) and Green (Good)

7.1.3.4 Required Complementary Surveys

Whilst the information provided by the RMO has been useful for the purposes of providing an indication of the existing pavement condition there are other elements that would need to be confirmed with more detailed testing such as the pavement structural condition and subgrade condition. The additional condition data requirements, including surveys, will be required for future design stages to develop and implement pavement rehabilitation strategies. Those requirements shall be in line with AM-PAV-06050 (Mar. 2020).

As part of the future testing regime a Ground Penetration Radar (GPR) survey is to be procured. Cores will be taken at regular intervals to allow for the calibration of the GPR against the extracted pavement layers. Such survey would generate the following datasets essential for the pavement design:

- Depth of unbound granular materials;
- Depth of rigid materials (concrete);
- Depth of bituminous materials;
- Detailed pavement build-up (number of layers and their associated thicknesses – bound materials only);
- Condition of the bound materials;
- Condition of the interlayer bonds;
- Condition of the foundation layer(s) through the use of DCP testing; and
- Likely presence of tar contaminated materials.

To greater understand the pavement structural condition and more accurately determine strengthening requirements in terms of extents and depth, additional surveys will be required for the detailed pavement design. These should include both non-intrusive and intrusive testing in addition to those proposed to inform pavement construction. The pavement surveys which are recommended to be undertaken to inform the existing pavement structural condition are as follows:

- Falling Weight Deflectometer including back-analysis and residual life calculations, and
- Laboratory materials testing.

7.1.4 Pavement Design

7.1.4.1 Pavement Materials and Design Considerations

During future design stages, the selection of appropriate pavement materials should be made with the following considerations:

- Pavement structure most appropriate and compatible with existing pavement; (i.e. fully flexible vs. flexible composite vs. rigid pavement);

- Materials most appropriate for noise, permeability, colour, texture, etc; and
- Materials lifecycle which provide the best value in terms of environmental impact, durability, maintainability, repairability, recyclability, cost.

Specific materials should be selected for specific loading areas.

The ambition in terms of pavement materials is to reuse or recycle all the excavated materials. The specification of materials and processes with a reduced environmental impact should be prioritised.

The choice of surfacing materials has been discussed with the Landscape Architect, in particular in potential development opportunity areas.

If it is considered uneconomical to provide a standard subbase thickness for all pavement locations (i.e. due to variable subgrade strength) alternate design thickness can be designed in accordance with TII Publication DN-PAV-03021 "*Pavement and Foundation Design*" December 2010. DN-PAV-03021 should be consulted with regards to allowable subbase materials in case of use of high stiffness asphalt base, where bound support layer is best practice to support the additional compactive effort required to lay the 'stiff' asphalt and to help ensure required material performance.

Table 7-6 Foundation Designs – Fully Flexible Pavement with EME2 Base (Foundation Class 3)

Subgrade Long Term Design CBR (%)	Single Foundation Layer (DN-PAV-03021 Fig. 5.1)
2.5	340mm CBGM C8/10
3	320mm CBGM C8/10
4	290mm CBGM C8/10
5	280mm CBGM C8/10
8	230mm CBGM C8/10
10	210mm CBGM C8/10
15	200mm CBGM C8/10

Table 7-6 Notes:

Subbase to be Cement Bound Granular Mixture (CBGM) to Clause 821 or 822 of the NRA Specification for Road Works (MCDRW1) achieving at least the strength class C8/10 when tested in accordance with Clause 825 of MCDRW1

EME2 denotes Enrobe à Module Elevé asphalt

CBR denotes California Bearing Ratio

Design should consider drainage continuity with adjacent pavement. However, this information is not currently available generally and so this should be reviewed at detailed design stage once localised pavement construction build-up is confirmed.

Longitudinal tie-in details for the widening designs should be undertaken in accordance with the appropriate NRA Standard Construction Details (ref. CC-SCD-00704 December 2010) as shown in Figure 7-10. This shows the requirements for longitudinal offsetting of the joints at each individual layer.

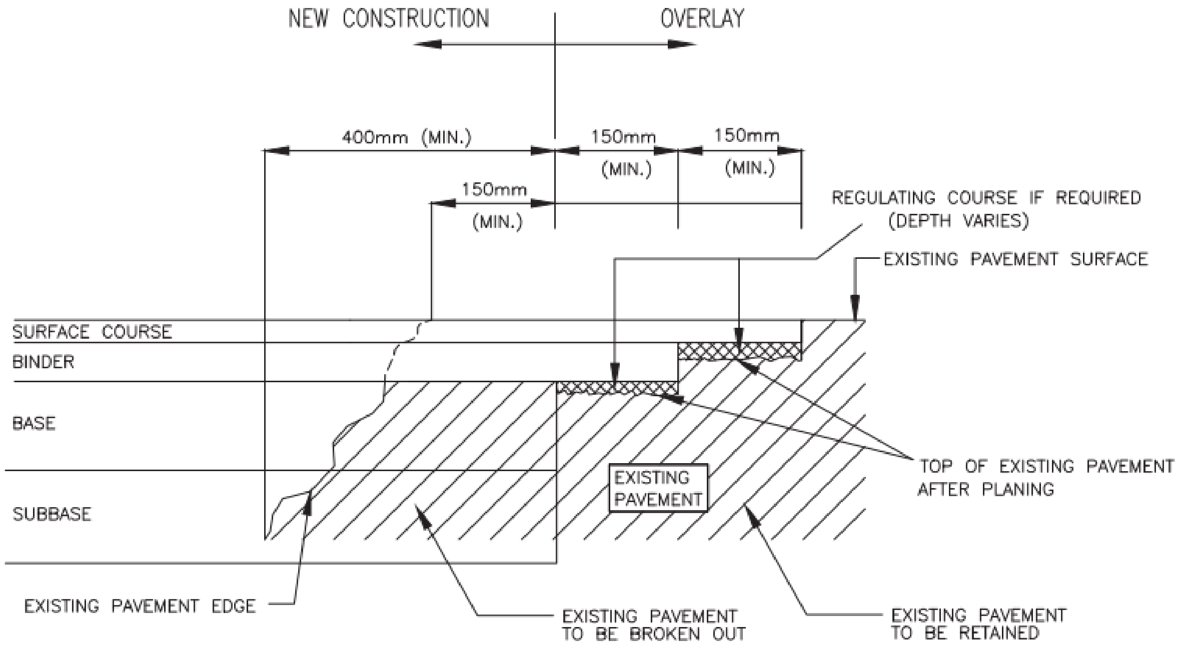

Figure 7-10 TII - Typical Road Section Longitudinal Tie-in with Existing Road

In addition to the requirements of the example standard detail, care should be taken to avoid locating surface joints within wheel track zones to help minimise damage and required maintenance.

Where greater traffic volumes are expected and where it is considered uneconomical to provide a standard design for particular low traffic scenarios, alternate design thickness, based upon different base material and design traffic should be designed in accordance with DN-PAV-03021 (as per CSRSW requirements for design in accordance with the NRA Design Manual for Roads and Bridges).

Design thickness for the pavement options and materials provided in DN-PAV-03021 are presented below in Table 7-7 for a range of design traffic which will cover the variable traffic volumes along the bus lanes.

Table 7-7 Pavement Design Thickness for New Construction – Design Thickness for Planning Application Highlighted

Design Traffic (msa)	Fully Flexible Design Min. Asphalt Thickness (mm)[5]			Flexible Composite Design Min. Asphalt / CGBM Thickness (mm)[5]	Rigid Design min. Concrete (mm)	
	AC 40/60	AC 70/100	EME2[1]	AC 40/60 + C12/15[2]	URC[3]	CRCP[4] with 30mm As Surface
1	200	200	200	100 + 150	150	230
2	200	210	200	100 + 150	150	230
3	210	230	200	100 + 150	150	230
4	220	240	200	110 + 150	160	230
5	230	250	200	120 + 150	165	230
10	250	280	200	140 + 150	190	230
20	280	320	220	150 + 150	215	230
30	300	340	240	160 + 170	235	230
40	310	350	240	170 + 170	250	230
50	320	370	250	180 + 180	260	230

60	340	370	260	180 + 180	270	230
70	340	380	260	180 + 180	275	230
80	350	390	270	180 + 190	285	230

Table 7-7 Notes:

1 EME2 asphalt pavement requires a Class 3 Foundation performance

2 CBGM comprises CBGM 1 grading envelope Category G2 (strength class C12/15 with Crushed Aggregate (crushed gravel not permitted). Flexible composite design assumes Foundation Class 2.

3 URC comprise strength class C32/40 with design based upon assumption of mean 28-day compressive cube strength of 50 N/mm2 as per requirements of TRL Report RR87 (1987), with Class 3 foundation performance. Design assumes untied shoulder to concrete.

4 CRCP comprise strength class C32/40 with 5.0MPa design concrete flexural strength and crushed rock aggregate, with Class 2 foundation performance. Design thickness is increased by 30mm to account likely lack of 1m edge strip or tied shoulder in urban environment.

5 Total thicknesses of asphalt shown include the thickness of the surface course. Binder and base asphalt materials to be design or performance mixtures.

msa denotes Million Standard Axles
AC 40/60 denotes Asphalt Concrete with 40/60 Pen Bitumen
AC 70/100 denotes Asphalt Concrete with 70/100 Pen Bitumen
EME2 denotes Enrobe à Module Elevé asphalt
CBGM denotes Cement Bound Granular Mixture
C8/10 denotes Concrete Class C8/10
URC denotes Unreinforced (Jointed) Concrete
CRCP denoted Continuously Reinforced Concrete Pavement
design thicknesses are rounded to the nearest 10mm as per requirements of DN-PAV-03021

7.1.4.2 Pavement Strategy

7.1.4.2.1 New Pavement and Bus Interchange Strategy

No new sections of carriageway alignment or bus interchanges are proposed on the Proposed Scheme.

7.1.4.2.2 Pavement Rehabilitation Strategy

At specimen design stage, the pavement strategy will be revisited to develop options for:

- Areas to be widened or fully reconstructed; and
- Areas to be rehabilitated (do minimum, intermediary strategies, fully reconstruct).

As noted in 7.1.3.4 an appropriate testing regime will be undertaken at specimen design stage. The successful contractor will undertake further testing as deemed required by the findings of the testing regime, and to satisfy any specific requirements for their design.

In order to estimate the waste quantities and the carbon emissions from the Proposed Scheme pavement works, the following assumptions were made:

- Where full depth reconstruction is anticipated (e.g. widening, traffic island relocation…), a conservative fully flexible pavement design is assumed: 350mm of bituminous mixtures on top of 150mm of subbase material and 400mm of capping material; and
- Where the existing pavement is anticipated to only require rehabilitation, are informed by the most onerous of the PSCI or RCI:
  - Fully flexible carriageway
    - Green and Yellow condition: No action (but may need to be reprofiled / resurfaced for proposed works);
    - Amber condition: Pavement Strengthening – 150mm asphalt Inlay required; and
    - Red condition: Full pavement reconstruction – 250-350mm asphalt Inlay (+ 150mm subbase + 400mm capping as required).
  - Rigid carriageway
    - PSCI ≥ 5: no works, and
    - PSCI ≤ 4: 200mm Concrete Inlay.

Preliminary pavement drawings detailing the extents of the proposed treatment interventions are illustrated on PAV_PV drawing series in Appendix B. Detailed general arrangement cross section drawings have also been prepared; however, these show a simplified pavement arrangement. The reader should refer to typical TII standard pavement edge and tie-in details like Figure 7-10 above, and the BusConnects Design Guide for more detailed insight to the proposed tie-in and edge of pavement proposals.

The above pavement strengthening proposals are based upon provision of a new surface and binder course layer to help remove any surface defects and provide some additional strengthening to the pavement. The 150mm inlay can typically be installed in one night shift, with lengths of treatment limited by the time available. The full reconstruction treatment assumes the expected fully flexible pavement thickness range (accounting for expected variation in design traffic and existing construction thickness) which would be required to remove all failed bound pavement materials which can no longer provide sufficient structural capacity to the vehicular trafficking. As noted above, the preliminary design full reconstruction thicknesses is based upon the DCC Bus Route specification (for new construction).

It should be noted that there is risk of underestimating strengthening requirements in the absence of additional testing. Additional testing may identify extents of 'Green' condition pavement that may be fatigued and require strengthening to meet future trafficking. Additionally, the later any future strengthening works are undertaken the greater the risk that these earlier assumptions underestimate the pavement fatigue and damage at time of the works.

All proposed treatments will be subject to confirmation and refinement by ground investigation and additional pavement survey works during future detailed design, where defect causation, pavement construction and thickness, structural capacity and foundation performance are confirmed. This is essential if a specific design life is to be provided for the pavement.

The risk of tar contaminated material presence in the existing pavement is expected to be mitigated with the delivery of the GPR survey through the testing of the calibrating cores for tar. Ideally, where any tar bound materials are located at depth in the pavement, the design should consider the potential to leave them in situ. In the absence of core logging and testing for presence of Polyaromatic Hydrocarbons (PAH), pavement rehabilitation cannot consider reducing inlay depths to prevent tar bound layer excavation. As such, there is a risk that tar bound materials may be identified later and excavated, requiring material classification (as inert or hazardous), and potential costly disposal as hazardous waste.

7.1.4.3 Opportunities for Innovation

Innovative materials and processes delivering enhanced environmental, social and financial benefits are being promoted in the ongoing pavement design process.

7.1.4.4 Reuse and Recycling Considerations

Opportunities for reuse and recycling of secondary materials have and should also continue to be identified and quantified throughout the Specimen Design process.

Current opportunities include but are not limited to:

- Where practicable incorporation of minimum 20% of reclaimed asphalt into new base and binder layers of the pavement;
- Excavated capping layer material to be reused as new capping material if compliant with current standards; and
- Excavated subbase layer material to be reused as new subbase material if compliant with current standards.

Developments in standards and design codes, the capacity of the Irish market to deliver, and the programming of the individual schemes and collective programming schedule, are key elements that will inform the final reuse and recycling proposals to be adopted in the development of the tender design strategy.

To generate likely waste volumes for the planning application a waste calculator has been developed for the Proposed Scheme and is detailed in Section 11. It quantifies and classifies the likely material types in accordance with TII GE-ENV-01101 and the European Waste Catalogue waste codes, and where possible breaks down into the likely TII material specification to establish an understanding of the volume of materials that could potentially be reused / recycled.

7.2 Kerbs, Footways and Paved Areas

7.2.1 Overview of Kerbs, Footways and Paved Areas

This section covers the preliminary design for the kerbs, footways, and paved areas (KFPA) assets:

- Kerbs;
- Footways (concrete, bituminous and paved); and
- Cycle tracks.

For the proposed scheme, two pavement networks are being considered, the primary and the secondary networks. The primary network refers to the bus corridor under consideration while the secondary network refers to the roads impacted by the re-routing of existing traffic from the proposed scheme to the nearby road network.

The preliminary design of KFPA assets is based on the following standards:

- DN-PAV-03021 (Dec. 2010) – Pavement and Foundation Design;
- DN-PAV-03026 (Jan. 2005) – Footway Design;
- Construction Standards for Road and Street Works in Dublin City Council (May 2016) – Revision 1;
- PE-SMG-02002 (Dec. 2010) – Traffic Assessment;
- CC-SPW-00600 (Mar. 2013) – Specification for Road Works Series 600 – Earthworks;
- CC-SPW-00700 (Jan. 2016) – Specification for Road Works Series 700 – Road Pavements – General;
- CC-SPW-00800 (Mar. 2013) – Specification for Road Works Series 800 – Road Pavements – Unbound and Cement Bound Mixtures;
- CC-SPW-00900 (Sep. 2017) – Specification for Road Works Series 900 – Road Pavements – Bituminous Materials;
- CC-SPW-01000 (Mar. 2013) – Specification for Road Works Series 1000 – Road Pavements – Concrete Materials;
- CC-SPW-01100 (Feb. 2012) – Specification for Road Works Series 1100 – Kerbs, Footways and Paved Areas; and
- BS 7533 series of standards (1999 – 2021) – Pavement Constructed with Clay, Concrete or Natural Stone paving Units.

The different KFPA assets are designed taking consideration of:

- Traffic loads;
- Changes in road geometry;
- Existing KFPA construction build-up;
- Existing KFPA condition;
- Landscape Architect's requirements; and
- The impact of other assets such as drainage, utilities, and structures.

New cycleway and cycle track pavements should be designed considering the requirements of the BCPDGB. This booklet notes that reference should be made to the guidance provided in the National Cycle Manual (NCM) with regards to cycle track design and materials selection. This is in line with DCC CSRSW requirements.

7.2.2 Design Constraints for Kerbs, Footways and Paved Areas

7.2.2.1 Traffic Loading Considerations

Depending on the expected traffic characteristics (volumes, pedestrian versus vehicular) and the proposed surface material, the Design Traffic may be categorised slightly differently as illustrated on Figure 7-11.

For bituminous footways and cycle tracks, the Design Traffic will be calculated in accordance with PE-SMG-02002 (Dec. 2010) and categorised as per DN-PAV-03026 (Jan. 2005), if the Design Traffic is below 50,000 standard axles over their lifetime (40 years).

For concrete footways, the Design Traffic will be calculated in accordance with PE-SMG-02002 (Dec. 2010) for a 40-year design life.

For paved footways, the Design Traffic will be calculated in accordance with PE-SMG-02002 (Dec. 2010) and categorised as per BS 7533 series.

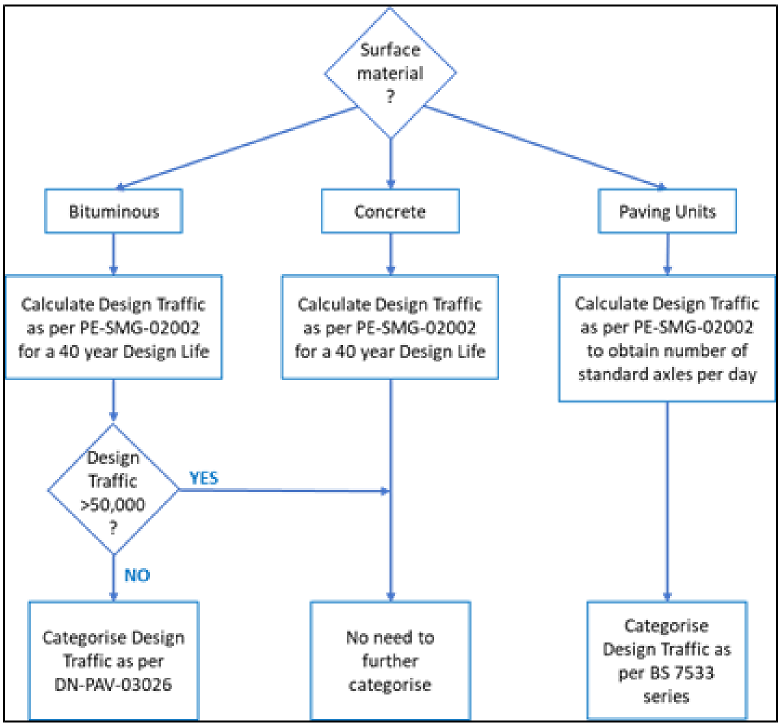

Figure 7-11 Traffic Design and Categorisation for KFPA

7.2.2.2 Geometry Considerations

For the planning application the preliminary design has estimated where the full depth footway or cycle track reconstruction is required. It has assumed full depth carriageway construction at cycle lanes.

7.2.2.3 Existing Pavement Condition Considerations

For the footways and cycle tracks that will be fully reconstructed, the design of the foundation will be based on an assumed Design CBR of 2.5%, the minimum permitted value as per Clause 3.23 of DN-PAV-03021 (Dec. 2010).

If some existing footways and cycle tracks are proposed to be maintained (no impact from utilities etc), their condition will be assessed visually before proposing any potential rehabilitation works.

7.2.3 Pavement Design for Kerbs, Footways and Paved Areas

7.2.3.1 Pavement Materials

The selection of appropriate pavement materials should be undertaken with the following considerations:

- Pavement structure most appropriate and compatible with existing pavement; (i.e. fully flexible vs. flexible composite vs. rigid pavement);
- Materials most appropriate for noise, permeability, colour, texture, etc; and
- Materials lifecycle which provide the best value in terms of environmental impact, durability, maintainability, repairability, recyclability, cost.

Specific materials should be selected for specific loading areas.

The ambition in terms of pavement materials is to reuse or recycle all the excavated materials where practicable. The specification of materials and processes with a reduced environmental impact should be prioritised.

At preliminary design stage the choice of surfacing materials has been discussed with the Landscape Architect, in particular in Potential Development Opportunity (PDO) areas.

For bituminous footways and cycle tracks, the bituminous layer(s) should make use of as much recycled material as practicable. Low Energy Bound Mixtures (LEBM) should be considered as an alternative to the conventional Asphalt Concrete (AC), Hot Rolled Asphalt (HRA) and Stone Mastic Asphalt (SMA) mixtures.

7.2.3.2 Pavement Structures

Selection of pavement and foundation construction types for footways and cycle tracks will be influenced by existing adjacent pavement construction, existing utilities, drainage continuity and ease of pavement tie-in, and will be reviewed at pre-tender design stage when more information would be expected to be available with additional survey work undertaken.

Where subgrade conditions are identified as being poor, based upon geotechnical investigation, consideration should be given to provision of geogrids to stiffen the foundation and to aid transition between pavements at widening.

7.2.3.3 Opportunities for Innovation

Innovative materials and processes delivering enhanced environmental, social and financial benefits are being promoted in the ongoing pavement design process.

7.2.3.4 Reuse and Recycling Considerations

Opportunities for reuse and recycling of secondary materials have and should continue to be identified and quantified throughout the Specimen Design process.

Current opportunities include but are not limited to:

- Excavated capping layer material to be reused as new capping material if compliant with current standards;
- Excavated subbase layer material to be reused as new subbase material if compliant with current standards;
- Up to 50% of capping and subbase materials can be substituted with reclaimed asphalt;
- Concrete base to paved areas to make use of Recycled Aggregate, Recycled Concrete Aggregate, and more sustainable hydraulic binders (e.g. CEM III/A);
- Concrete footways to also make use of more sustainable hydraulic binders;
- Jointing and bedding mortars used in the construction of paved areas may contain recycled materials; and
- Aggregate for base / binder layer for cycle tracks could be 100% reclaimed asphalt (Low Energy Bound Material – LEBM).

As noted in Section 7.1.4.4, a waste calculator has been developed for the Proposed Scheme and is detailed in Section 11.

8 Structures

8.1 Overview of Structures Strategy

There are several existing and proposed structures along the Proposed Scheme. The structures vary in form and complexity and are detailed below.

Where the scheme interfaces with an existing bridge structure a visual inspection has been carried out to identify the current condition and any repair / maintenance works required. In some cases, a visual inspection was not possible to due access issues, i.e. M50 bridges. Where alterations to the existing carriageway lines, kerbs lines and verge widths are proposed, a Stage 1 Structural Assessment has been carried out to ensure the structural capacity can withstand the revised arrangement.

Where new structures are proposed the preliminary design has been prepared in accordance with the requirements TII DN-STR-03001, Technical Acceptance of Structures on Motorways and Other National Roads. This includes Structures File Notes, Outline Structures Reports, Structures Options Reports and Preliminary Design Reports.

8.2 Summary of Existing Structures

The Proposed Scheme interfaces twenty existing bridge structures from its starting point in Lucan to its terminus in the city centre at the Frank Sherwin Bridge. A full list of structures including coordinates, Local Authority, and proposed works are listed below in Table 8-1. Further information on each structure can be found within the Structures File Note prepared for the Proposed Scheme included within Appendix P.

Table 8-1 Summary of Existing Bridge Structures along the Proposed Scheme

Structure Name	Co-ordinates	Local Authority	Comment
Ballyowen Road Bridge	704,861.066, 735,315.957	SDCC	Carriageway rearrangement proposed
Ballydowd Pedestrian Bridge	704,873.521, 735,324.544	SDCC	Existing bridge to be demolished and replaced
St Lomans Pedestrian Bridge	705,710.811, 735,464.595	SDCC	Structure not impacted
R133 Underbridge	706,374.228, 735,244.196	SDCC	Structure not impacted
Liffey Valley Pedestrian and Cycle Bridge	707,162.687, 735,199.886	SDCC	Access step to existing bridge to be removed
R148 Eastbound M50 Diverge Underbridge	707,392.740, 735,217.968	SDCC	Structure not impacted
R148 Eastbound M50 Overbridge	707,565.805, 735,336.178	SDCC	Structure not impacted
N4 Eastbound M50 Merge Overbridge	707,551.890, 735,200.660	SDCC	Structure not impacted
N4 Westbound M50 Overbridge	707,548.680, 735,181.412	SDCC	Structure not impacted
N4 Westbound M50 Diverge Underbridge	707,661.576, 735,330.604	SDCC	Structure not impacted
M50 Footbridge	707,586.322, 735,444.894	SDCC	Structure not impacted
Kennelsfort Rd / R143 Pedestrian Bridge	708,372.983, 735,097.869	SDCC	Structure not impacted
R112 Kylemore Road Underbridge	709,648.993, 734,582.788	DCC	Structure not impacted
Chapelizod Hill Road Underbridge	710,010.120, 734,249.929	DCC	Existing bridge to be widened
St Laurence's Road Underbridge	710,576.692, 733,983.141	DCC	Structure not impacted

Structure Name	Co-ordinates	Local Authority	Comment
Pedestrian Bridge over R148	711,465.823, 733,935.558	DCC	Structure not impacted
OBC3 Memorial Road Rail Bridge	712,083.256, 733,817.027	DCC	Structure not impacted
OBC1 South Circular Road (Con Colbert road) Westbound Rail Bridge	712,675.273, 733,918.044	DCC	Structure not impacted
OBC0A South Circular Road (St John's Road West) Eastbound Rail Bridge	712,743.056, 733,965.423	DCC	Structure not impacted
Frank Sherwin Bridge	713,797.218, 734,361.344	DCC	Structure not impacted

8.3 Summary of Principal Structures

There are three proposed principal structures on the Proposed Scheme, summarised in the Table 8-2 below.

Table 8-2 List of Principal Structures

Structure Name	Co-ordinates	Local Authority	Comment
ST01 Liffey Valley Pedestrian Bridge	706930.894, 735123.223	SDCC	Single span fully through warren truss
ST02 Chapelizod Hill Road Underbridge Widening	710,010.120, 734,249.929	DCC	Precast portal frame
ST03 Ballydowd Pedestrian and Cycle Bridge	704,873.521, 735,324.544	SDCC	Arched truss

The PDR prepared in accordance with Phase 4 of DN-STR-03001 for each principal structure has been included in Appendix J.1 (ST01), Appendix J.2 (ST02), and Appendix J.3 (ST03).

PDR prepared for retaining walls are included in Appendix J.4 (Hermitage Golf Club Retaining Walls), Appendix J.5 (TII Retaining Walls), Appendix J.6 (Non TII Retaining Walls), and retaining walls are discussed in section 8.5

PDR prepared for gantries in included in Appendix J.7 (Gantries) and gantries are discussed in section 8.6.

A short summary of each structure has been provided below for reference and the location is shown in Figure 8.1.

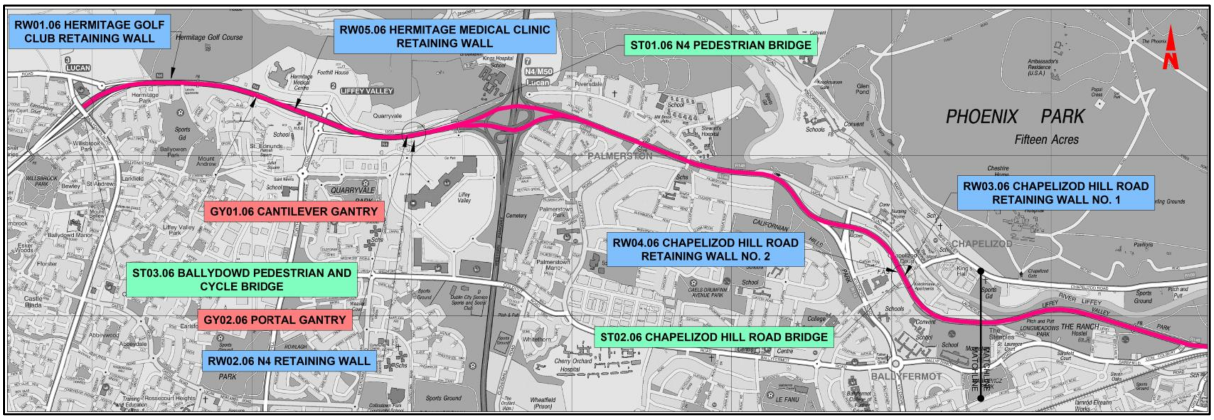

Figure 8-1 Location of Proposed Structures

8.3.1 ST01 Liffey Valley Pedestrian Bridge

Liffey Valley Pedestrian Bridge will be a single span fully through warren truss structure. The structure will be painted structural steel, supported on braced steel supports to the north and south of the N4 with a span length of approximately 42.8m. The structure will span the N4 with no skew and have a constant longitudinal gradient of 1-in-73 falling from the southern to the northern support. The warren truss will be designed with a full through construction where the structure is built up around the deck. This is a light and economical form of construction and works well with longer spans. The warren truss also reduces the structural depth of the bridge, allowing the 5.7m clearance envelope to the carriageway to be achieved. The vertical bracing of the truss will be located above the deck level with the addition of horizontal top chord bracing adding to the lateral stability of the structure. A mesh will then be applied around the horizontal and vertical structures to create a safe enclosed structure. The truss will be prefabricated and assembled off site in two separate units that will then be erected and lifted on site. A further painted steel, simply supported, 9.115m ladder beam structure shall span over the bridge approach ramps connecting the pedestrian bridge to the Fonthill Road tie-in point. The approach ramps servicing the eastbound bus stop shall be formed of a combination of ladder beam structures and retained earthworks. The westbound bus stop approach ramp will be formed of a combination of ladder beam structure and graded earthworks embankment on approach to Fonthill Road. The eastbound ramp will have a total length of 134.1m. The westbound ramp will have a total length of 207.7m, composed of a 57.0m steel ramp structure and 150.7m of a graded earthworks solution. The ramps will be designed with a 1-in-20 gradient from the proposed bridge deck level to the bus stop levels. All ramp and stair details will be designed in accordance to DN-STR-03005.

The bridge will be designed with steel structural hollow sections as its main top and bottom chords and as the secondary members. The top chord acts in compression and the bottom chord is in tension under downward loading, and the two chords are braced by the diagonal members. The diagonal members create a series of triangles which are inherently rigid shapes thus reducing the sag that occurs in comparison to a simply supported beam. In theory a truss design uses pinned joints between members to eliminate any restraint to free rotation and thus preventing the creation of any internal bending moments. Resulting in the components of the truss only imparted with axial forces, compression and tension. In axial loading the force is carried equally by each part of the member, enabling the designer to maximise the efficiency of the truss members and create a lightweight structure. This is a category 2 structure in accordance with DN-STR-03001. This structure will be fully integral and will not require bearings or expansion joints. The parapets will be detailed to a height of 1.25m along the length of the truss.

Refer to the Preliminary Design Report – ST01 Liffey Valley Pedestrian Bridge in Appendix J.1 for further information.

8.3.2 ST02 Chapelizod Hill Road Bridge Widening

The Chapelizod Hill Road Bridge will require widening to facilitate the provision of a new bus stop along the eastbound carriageways of the R148 Chapelizod bypass. The existing bridge is a insitu box structure with an internal span of 9.75m. The vertical clearance of the structure is limited to 5.2m on its southern side. The existing bridge will be widened by 5.975m by the provision of a new portal frame accommodating the new 3.3m bus stop and 2m wide footway. As part of the construction the existing wingwall and associated foundations will be removed to allow construction of the new portal frame. The superstructure portal frame will be supported on an insitu concrete pilecap substructure founded on bored concrete piled foundations rock socketed to the bedrock substrate. The earth fill to the rear of the structure will be retained by the combined resistance of the superstructure, substructure and foundations. Fill to the sides of the side of the structure will be retained by the proposed RW03 Chapelizod Hill Road Widening Retaining Wall No.1 which will be a piled retaining structure. The portal frame will be made of reinforced concrete and will be precast off site and transported to site via the motorway network and then lifted into place. A concrete parapet will also be provided to prevent falls from height, the solid concrete parapet has been chosen to limit the environmental effects of glare from vehicles on the Chapelizod bypass on the surrounding residential area. An additional 0.55m high steel fence with mesh infill will be provided to the top of the concrete parapet to minimise antisocial behaviour and people sitting on the parapet while waiting for an oncoming bus.

Refer to the Preliminary Design Report – ST02 Chapelizod Hill Road Bridge Widening in Appendix J.2 for further information.

8.3.3 ST03 Ballydowd Pedestrian and Cycle Bridge

The existing Ballydowd Footbridge is located parallel to the Ballyowen Road Bridge and provides a route over the N4 at Junction 3 for pedestrians travelling north / south along the R136 Ballyowen Road. The bridge links residential neighbourhoods on the south side of the N4 with Lucan Retail Park, the R835 Lucan Road and residential areas to the north. During the development of the Proposed Scheme requirements for additional capacity for pedestrians and cyclists was identified along the route. Numerous options to provide increased capacity at the crossing were considered. However, the structural form with a half through truss made widening unfeasible, and the narrow cross-sectional width of the bridge was deemed unsuitable to be redefined for both pedestrian and cyclist usage

It is proposed to remove the existing footbridge and replace with a new wider structure providing sufficient capacity for both pedestrians and cyclists. The bridge superstructure will be approximately 5.9m (internal) wide with a span of approximately 50m formed of a three-dimensional arched truss bridge with a 0° skew over the N4. The superstructure will be supported on cast-in-place reinforced concrete abutments with spread foundations. This bridge accommodates the new two-way cycle track along the eastern side of R136 Ballyowen Road.

The bridge will be designed to match the existing footbridge being replaced where practicable. The arched truss will be formed in painted structural steel hollow sections. These sections will be used for the main arched top, bottom and middle chords, and for all secondary members. The top chord acts in compression and the bottom chord acts in tension under downward loading and the two chords are braced by the diagonal members. The diagonal members create a series of triangles which are inherently rigid shapes thus reducing the sag that occurs in comparison to a simply supported beam. In theory a truss design uses pinned joints between members to eliminate any restraint to free rotation and thus preventing the creation of any internal bending moments. As a result the components of the truss are only imparted with axial forces in compression and tension. In axial loading the force is carried equally by each part of the member, enabling the designer to maximise the efficiency of the truss members and create a lightweight structure. The bridge deck will be formed of a structural steel plate welded to the truss members. The plate will be surfaced with a combined waterproofing and surfacing material providing appropriate slip resistance. The sub structure will be formed of in situ reinforced concrete abutment located within the existing N4 embankments. The abutments will be designed and detailed to match the geometry of the existing abutments to be removed.

The bridge will be a Category 2 structure in accordance with DN-STR-03001 and will be fully integral with the concrete substructure avoiding the need for any bearings or expansion joints. As the bridge will be defined for cyclist usage, the parapets will be detailed to a height of 1.45m along the length of the truss in accordance with DN-STR-03011.

Refer to the Preliminary Design Report – ST03 Ballydowd Pedestrian and Cycle Bridge in Appendix J.3 for further information.

8.4 Summary of Minor Structures

No minor structures are proposed on the Proposed Scheme.

8.5 Summary of Retaining Structures

The following table summarises the retaining walls located on the Proposed Scheme. Further information in the form of a PDR prepared in accordance with Phase 4 of DN-STR-03001 for each retaining structure have been included in the following appendices: Appendix J.4 (Hermitage Golf Club Retaining Wall), Appendix J.5 (TII Retaining Walls) and Appendix J.6 (non TII Retaining Walls).

Table 8-3 Summary of Retaining Structures

Structure Name	Co-ordinates	Local Authority	Comment
RW01 Hermitage Golf Club Retaining Wall	705501.442, 735501.246	SDCC	Located on the eastbound verge of the N4 road, the Hermitage Golf Club Retaining Wall will be approximately 306.4m in length with a maximum retained height of 3.5m. The wall is required to facilitate the provision of continuous 2-way cycle track and footway along the N4. A piled retaining structure has been progressed to minimise the removal of mature trees along the N4 carriageways. The piling will be installed from a temporary piling platform extending in to the existing footway and bus lane on the N4, which will require closure during the works. The retaining wall will be clad to match the masonry cladding of the existing retaining wall. The existing retaining

Structure Name	Co-ordinates	Local Authority	Comment
			wall is to be demolished and replaced to facilitate the required widening.
RW02 N4 Retaining Wall	706930.894, 735123.223	SDCC	Located on the westbound verge of the N4 beside Abbott Pharmaceuticals, the N4 Retaining Wall will be approximately 135.0m in length with a maximum retained height of 2.6m. The wall is required to facilitate carriageway widening and the creation of a new bus stop and associated infrastructure along the N4. A gravity retaining wall structural form has been progressed for this wall. The existing boundary wall on site is to be demolished and replaced. A new boundary wall will be provided to the top of the retaining wall with a minimum height of 1.8m and patterned profile finish.
RW03 Chapelizod Hill Road Retaining Wall No.1	710039.237, 734239.358	DCC	Located on the eastbound verge of the Chapelizod bypass this retaining wall will be approximately 38m in length with a maximum retained height of 4.5m and formed of by a piled retaining structure. The structure is required to retain the earthwork embankment of a widened R148 Chapelizod bypass to facilitate a new bus stop at Chapelizod Hill Road Bridge. The wall will also retain fill from proposed access steps and ramps between the R148 Chapelizod bypass and Chapelizod Hill Road. The wall will be finished in precast concrete fascia panels with a pattern profile finish.
RW04 Chapelizod Hill Road Retaining Wall No.2	709973.622, 734282.386	DCC	Located on the westbound verge of the Chapelizod bypass this retaining wall will be required to facilitate R148 Chapelizod bypass carriageway widening to form a new bus stop at Chapelizod Hill Road Bridge. The wall will be 68m long with a maximum retained height of 1.95m. The wall will be formed of soil nails with a shotcrete facing. A supplementary insitu reinforced concrete facing with a pattern profile finish shall be provided to the front of this shotcrete.
RW05 Hermitage Medical Centre Retaining Wall	706013.874, 735412.926	SDCC	Located on the eastbound verge of the N4 and Junction 2 off-slip beside Hermitage Medical Centre, this wall will be approximately 83m in length with a maximum retained height of 1.5m. The wall is required to facilitate carriageway widening of the slip road. It will be formed by a gravity retaining structure with a combined boundary wall. The boundary wall will have a minimum height of 2.0m and finished with a masonry stone cladding to match the masonry cladding of the existing boundary wall.

8.6 Summary of Miscellaneous Structures

The following table summarises the miscellaneous structures located on the Proposed Scheme. Further information in the form of a PDR prepared in accordance with Phase 4 of DN-STR-03001 for the proposed gantry structures have been included in Appendix J.7.

Table 8-4 Summary of Miscellaneous Structures

Structure Name	Co-ordinates	Local Authority	Comment
GY01 Cantilever Gantry	705856.828, 735456.499	SDCC	Existing cantilever gantry to N4 Junction 2 Eastbound Diverge to be relocated 5.4m to the north to facilitate carriageway widening.
GY02 Portal Gantry	706952.764, 735165.711	SDCC	Supplementary portal gantry to provide advance direction signage to the N4 eastbound carriageways on approach to M50 Junction 7. The gantry is required due to the ST01 N4 Pedestrian Bridge creating a visibility constraint to existing gantry signage.

L01 High Mast Lighting Colum	705046.075, 735412.471	SDCC	Relocated High Mast Lighting Column
L02 High Mast Lighting Colum	712649.582, 733932.888	DCC	Relocated High Mast Lighting Column

9 Drainage, Hydrology and Flood Risk

9.1 Overview of Drainage Strategy

The drainage preliminary design was developed following consultation with the relevant Local Authority and Irish Water where applicable. The strategy and design parameters to be adopted throughout BusConnects is summarised in the Drainage Design Basis included in Appendix K.

The design basis statement was developed whilst taking the Greater Dublin Regional Code of Practice (GDRCoP), Greater Dublin Strategic Drainage Study (GDSDS), Planning requirements of Local Authorities within the Dublin region, TII requirements and international best practices such as CIRIA The SuDS Manual (C753). The principal objectives of drainage design are as follows:

- To drain surface water from existing and proposed pavement areas throughout the BusConnects Development and maintain the existing standard of service;
- To maintain existing runoff rates from existing and newly paved surfaces using SuDS;
- To minimise the impact of the runoff from the roadways on the surrounding environment using SuDS and / or silt traps; and
- No drainage features like gullies or manholes are to be located at, or any ponding will be allowed to occur at, pedestrian cross-walk locations or at bus-stop locations. Where any such drainage features currently exist at such locations they will be relocated.

Drainage of newly paved areas will include SuDS measures to treat and attenuate any additional runoff. These measures will ensure that there is:

- No increase in existing runoff rates from newly paved areas, and
- Appropriate treatment to ensure runoff quality.

A hierarchical approach to the selection of SuDS measures has been adopted with ‘Source’ type measures e.g. tree pits implemented in preference to catchment type measures e.g. attenuation tanks. Further details of the SuDS hierarchy are provided in the Drainage Design Basis.

9.2 Existing Watercourses and Culverts

The location of existing watercourses and culverts has been identified using OS Mapping (www.osi.ie). All watercourses are culverted beneath the existing highway. A Stage 1 Flood Risk Assessment has been completed on the preliminary design and is summarised in Section 9.7. The Proposed Scheme crosses the following watercourses:

Table 9-1 Existing Watercourses and Culverts

Watercourse	Chainage	Crossing Detail
River Camac	A9520	Culvert

9.3 Existing Drainage Description

The Proposed Scheme extends from the N4 Junction 3 to Heuston Station. Based on the information received from Irish Water the existing highway along the Proposed Scheme is served by both surface water and combined drainage networks. The surface water drainage system is managed by the local authority, whilst combined sewers system is managed by Irish Water. Flows are typically collected in standard gully grates, or via near surface collection systems such as slot drains and combined kerb and drainage units along the N4 and routed via a gravity network to outfall points. There are no SuDS / attenuation measures on the existing drainage networks to treat or attenuate runoff from the existing highway.

The existing drainage network along the scheme can be split into eleven catchment areas based on topography and the existing pipe network supplied by Irish Water. The approximate catchment areas, existing sewer networks, outfalls and watercourses are shown on the existing catchment drawings, refer to drawings BCIDA-ACM-DNG_RD-0006_XX_00-DR-CD-1001 to BCIDA-ACM-DNG_RD-0006_XX_00-DR-CD-1003 in Appendix B. The catchments are summarised in Table 9-2 below.

Table 9-2 Summary of Existing Catchments

Existing Catchment Reference	Chainage	Approx. Drainage Catchment Area (km^2)	Existing Network Type	Existing Outfalls
6.1	A0 – A970	1.05	Surface Water (Storm)	Network outfalls to the Griffeen River in Griffeen Valley Park (discharges to River Liffey)
6.2	A970 – A2840	3.86	Surface Water (Storm)	Network outfalls to the River Liffey
6.3	A2840 – A4300	0.88	Surface Water (Storm)	Network outfalls to the River Liffey
6.4	A4300 – A5400	1.27	Surface Water (Storm)	Network outfalls to the River Liffey
6.5	A5400 – A5670	0.13	Surface Water (Storm)	Network outfalls to the River Liffey
6.6	A5670 – A5950	0.09	Surface Water (Storm)	Network outfalls to the River Liffey
6.7	A5950 – A6350	0.34	Surface Water (Storm)	Network outfalls to the River Liffey
6.8	A6350 – A7790	0.85	Surface Water (Storm)	Network outfalls to the River Liffey
6.9	A7790 – A8450	0.37	Surface Water (Storm)	Network outfalls to the River Liffey
6.10	A8450 – A9600	1.21	Surface Water (Storm) and Combined	Network outfalls to the River Liffey
6.11	A9600 – End	0.01	Surface Water (Storm) and Combined	Network outfalls to the River Liffey

9.4 Overview of Impacts of Proposed Works on Drainage / Runoff

Whilst in some areas the proposed development increases the impermeable areas, additional permeable areas are also provided by the softening of public realm along the routes. The drainage design aims to sustain flow levels within the existing pipe network after a rainfall event by controlling discharge rates within each catchment. Flows will be controlled by the implementation of SuDS techniques. One of the principal objectives of the road drainage system is to minimise the impact of the runoff from the roadways on the surrounding environment via the position of: filter drains, swales, bio retention areas, tree pits, silt traps and attenuation features if necessary. The welfare of pedestrians and cyclists is a high priority in the consideration of the drainage system design.

For details of surface water drainage proposals, refer to drainage drawings BCIDA-ACM-DNG_RD-0006_00-DR-CD-0001 to 0031 for the Proposed Scheme in Appendix B.

Table 9-3 provides information of the proposed additional catchments (new paved areas) against the proposed permeable areas (current paved areas to become grassed).

Each catchment area has been broken down into sub-catchments in order to define the change in impermeable surface area as a result of the proposed scheme. Where there is a net increase in impermeable surface area, a form of attenuation will be required prior to discharge. Where there is no net change or net decrease, then no form of attenuation will be required prior to discharge. A summary list of the sub-catchments, the associated chainage, and impermeable surface area differential is given below. Note, permeability factors have been applied to the impermeable and permeable areas. These factors are described in the Design Basis Statement and are required due to the difference in the calculated runoff rate from an impermeable surface, such as a road, when compared with a permeable surface, such as a verge. The following tables contain a column entitled “Net change” which take account of the applicable permeability factors and the change of use from impermeable to permeable areas and vice versa.

Table 9-3 Summary of Increased Permeable and Impermeable Areas

Existing Catchment Reference	Chainage	Road Corridor Area (m^2)	Change of use to Impermeable Areas (m^2)	Change of use to Permeable Areas (m^2)	Net Change (m^2)	Percentage Change (%)
6.1	A0 – A970	56047	3792	36	2629	4.7
6.2	A970 – A2840	112576	7091	3703	2372	2.1
6.3	A2840 – A4300	77684	2365	570	1257	1.6
6.4	A4300 – A5400	25635	124	0	87	0.3
6.5	A5400 – A5670	10840	1411	0	988	9.1
6.6	A5670 – A5950	6427	0	0	0	0
6.7	A5950 – A6350	10189	0	0	0	0
6.8	A6350 – A7790	32172	131	68	44	0.1
6.9	A7790 – A8450	22916	477	846	-258	-1.1
6.10	A8450 – A9600	35232	849	1737	-622	-1.8
6.11	A9600 – End	3172	229	15	150	4.7

9.5 Preliminary Drainage Design

Where no new paved areas are proposed, the existing drainage network should be utilised:

- **Existing Drainage** The existing drainage network will be maintained and used as the main discharge point for the new drainage system. Existing drainage gullies located in the bus lane or cycle track should be removed when necessary and reused where practicable. Side-entry kerb drainage / side-entry gullies should be considered for all new kerblines that must accommodate rainwater run-off. Existing gully connections will be used where practicable

The following drainage systems were considered for the Proposed Scheme where new paved areas are proposed and were incorporated where deemed appropriate:

- **Sealed Drainage (SD)** comprises narrow profile gullies and sealed pipes. They will collect, convey, and discharge runoff. The narrow profile gullies will be located within the kerb line mostly between the cycle track and bus lane and / or the footway and the cycle track depending on the carriageway profile, but with the location of the bicycle and / or bus wheel-track in mind for cycling safety and ride-quality purposes.
- **Grass Surface Water Channels, Swales, and Bio Retention Areas/ Rain Gardens (SW/RG)** are provided as road edge / footway edge drainage collection systems. They will provide treatment and can provide attenuation if required. A filter drain can be laid below the swales to keep the swale dry during low return period rainfall events.
- **Filter Drains (FD)** are provided as road edge channels. These comprise a perforated pipe with granular surround and are designed to convey, attenuate, and treat runoff prior to discharge.
- **Soakaways and Infiltration Trenches (SO/IT)** are provided for small catchments where ground conditions permit and are designed to discharge into the adjacent ground.
- **Tree Pits (TP)** are provided in close proximity to the road, where practicable. These receive flows from the sealed pipe network and are designed to convey, attenuate, and treat runoff prior to discharge.
- **Attenuation Tanks/Oversized Pipes/Ponds (AT/OSP)** – Where there is insufficient attenuation volume provided by the proposed SuDS drainage measures, hard attenuation measures such as concrete tanks and or oversize pipes can be provided to meet the required attenuation volume.

9.5.1 Summary of Surface Water Drainage

The proposed drainage types for the Proposed Scheme are listed in Table 9-4.

Table 9-4 Summary of Proposed Surface Water Infrastructure

Existing Catchment Reference	Chainage	Drainage Type
Asset Owner/Location: Irish Water/South Dublin City Council		
6.1	A0 – A970	Existing drainage, sealed drainage, oversized pipes
6.2	A970 – A2840	Existing drainage, sealed drainage, bioretention area, filter drains, oversized pipes
6.3	A2840 – A4300	Existing drainage, sealed drainage, bioretention area, filter drains, oversized pipes
6.4	A4300 – A4550	Existing drainage, sealed drainage
Asset Owner/Location: Irish Water/Dublin City Council		
6.4 (continued)	A4550 – A5400	Existing drainage, sealed drainage
6.5	A5400 – A5670	Existing drainage, sealed drainage, bioretention area, filter drains oversized pipes
6.6	A5670 – A5950	Existing drainage
6.7	A5950 – A6350	Existing drainage
6.8	A6350 – A7790	Existing drainage, sealed drainage, oversized pipes
6.9	A7790 – A8450	Existing drainage, sealed drainage, oversized pipes
6.10	A8450 – A9600	Existing drainage, sealed drainage, oversized pipes
6.11	A9600 – End	Existing drainage, sealed drainage, oversized pipes

9.5.2 Summary of Attenuation Features, SuDS and Outfalls

Where practicable, and in new areas of public realm gained as part of the design, sustainable drainage systems is considered in the form of rain gardens, bioretention areas, filter drains, swales, tree pits, permeable paving, etc. SuDS is considered in existing areas where required and practicable.

The attenuation measures for the Proposed Scheme are summarised for each catchment within Table 9-5 below. Attenuation Volumes have been estimated using MicroDrainage software and are based on factored impermeable areas and the Permitted Discharge for a 1 in 30-year return period plus 20% climate change.

Table 9-5 Summary of Proposed Attenuation Features, SuDS and Outfalls

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area		Permitted Discharge (l/s)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
		Existing (m^2)	Change (m^2)			
Asset Owner / Location: Irish Water / South Dublin City Council						
C0 – C270	6.1.1	2486	733	10	Oversized pipes, attenuated volume 12-26m^3	Discharge to existing surface water network DN375. Catchment ultimately outfalls to Griffeen River in Griffeen Valley Park (River Liffey).
N0 - N368	6.1.2	4230	320	75	Additional pipe / upsize of existing pipework with flow controls parallel to kerb drain, Attenuated Volume 16-74m^3	New combined kerb and drainage units with parallel carrier drain to attenuate flow from additional impermeable area. Discharge to existing surface water network DN600. Catchment ultimately outfalls to Griffeen River in Griffeen Valley Park (River Liffey).
B0 - B254 and C0 - C250 West-bound	6.1.3	7415	118	5.5	Oversized pipes, attenuated volume 1.3-5m^3	Discharge to existing surface water network DN225. Catchment ultimately outfalls to Griffeen River in Griffeen Valley Park (River Liffey).
A170 - A460	6.1.4	5636	425	12	Oversized pipes, attenuated volume 5-15m^3	Discharge to existing surface water network DN300. Catchment ultimately outfalls to Griffeen River in Griffeen Valley Park (River Liffey).

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area		Permitted Discharge (l/s)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
		Existing (m^2)	Change (m^2)			
A0 - A500 Mainline and A500 - A970 West-bound	6.1.5	27675	74	2	Sealed drainage	Discharge to existing surface water network DN375. Catchment ultimately outfalls to Griffeen River in Griffeen Valley Park (River Liffey). Over the edge drainage proposed within Hermitage Park for additional impermeable area.
A500 - A970 East-bound	6.1.6	8605	959	15.9	Oversized pipes, attenuated volume 18-40m^3	Discharge to existing surface water network DN375. Catchment ultimately outfalls to Griffeen River in Griffeen Valley Park (River Liffey).
A970 - A1350 East-bound and E0 - E305	6.2.1	12428	1773	22.6	Oversized pipes, attenuated volume 29-63m^3	Discharge to existing surface water network DN375 / DN TBC. Catchment ultimately outfalls to River Liffey.
A970 - A1590 West-bound	6.2.2	12054	-56	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A1350 - A1590 East-bound	6.2.3	4104	-477	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A1590 - A2215 East-bound	6.2.4	10811	416	12.8	Oversized pipes, attenuated volume 11-26m^3	Discharge to existing surface water network DN1200. Catchment ultimately outfalls to River Liffey
A2215 - A2580 East-bound	6.2.5	6800	352	2.0	Oversized pipes, attenuated volume 6-11m^3	Discharge to existing surface water network DN225 / DN1200. Catchment ultimately outfalls to River Liffey
A1590 - A1770 West-bound	6.2.6	3433	-253	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A1770 - A2215 West-bound	6.2.7	9005	608	11.2	Oversized pipes, attenuated volume 19-39m^3	Discharge to existing surface water network DN1200. Catchment ultimately outfalls to River Liffey
A2215 - A2520 West-bound	6.2.8	9612	-110	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A1630 - A1770 East-bound on-slip	6.2.9	2160	-171	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A1600 East-bound round-about	6.2.10	3307	279	2.0	Oversized pipes, attenuated volume 1.3-3m^3	Discharge to existing surface water network DN TBC. Existing stormwater network needs to be confirmed on site.
G0 - G270	6.2.11	6804	353	28.3	Oversized pipes, bioretention area, attenuated volume 13-40m^3	Discharge to existing surface water network DN TBC. Existing stormwater network needs to be confirmed on site.

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area		Permitted Discharge (l/s)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
		Existing (m^2)	Change (m^2)			
G270 - H295	6.2.12	9490	-342	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A2520 - A2800 West-bound	6.2.13	10604	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A2580 - A2840 East-bound	6.2.14	11964	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A2840 - A3200 East-bound	6.3.1	4358	356	39.4	Oversized pipes, attenuated volume 11-43m^3	New combined and kerb drainage units or slot drains with parallel carrier drain to be designed to accommodate and attenuate flow from additional impermeable area. Discharge to existing surface water network DN375. Catchment ultimately outfalls to River Liffey
A2800 East-bound On-slip to M50	6.3.2	3048	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A2800-A2970 M50 Off-slip West-bound	6.3.3	1482	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A2800-A3100 West-bound	6.3.4	5614	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A2890-A3200 M50 Off-slip East-bound	6.3.5	4281	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A3100 - A3680 – West-bound	6.3.6	7335	-42	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A3200 - A3680 – East-bound	6.3.7	6881	405	9.9	Additional pipe with flow control parallel to kerb / slot drain. Attenuated volume 5-13m^3	New combined and kerb drainage units or slot drains with parallel carrier drain to be designed to accommodate and attenuate flow from additional impermeable area. Discharge to existing surface water network DN450. Catchment ultimately outfalls to River Liffey.
A3680 - A4085 East-bound	6.3.8	6363	174	31.6	Oversized pipes, bioretention area, attenuated volume 9-34m^3	Discharge to existing surface water network DN750. Catchment ultimately outfalls to River Liffey

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area		Permitted Discharge (l/s)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
		Existing (m^2)	Change (m^2)			
A3680 - A4000 – West-bound	6.3.9	6107	92	31.7	Oversized Pipes, Filter Drains, Attenuated Volume 7-33m^3	Discharge to existing surface water network DN300/DN450. Catchment ultimately outfalls to River Liffey
A4010 - A4085 West-bound	6.3.10	1532	52	6.2	Oversized pipes, attenuated volume 2.7-8.5m^3	Discharge to existing surface water network DN225. Catchment ultimately outfalls to River Liffey
A4085 - A4300 East-bound	6.3.11	2258	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A4085 - A4300 West-bound	6.3.12	2848	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
J0 - J430	6.3.13	7451	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
J430 - L70	6.3.14	15151	93	2	Oversized pipes, attenuated volume 0-0.9m^3	Discharge to existing surface water network DN900. Catchment ultimately outfalls to River Liffey
K0	6.3.15	1771	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
L70 - L210	6.3.16	672	76	9.2	Oversized pipes, attenuated volume 4-12m^3	Discharge to existing surface water network DN300. Catchment ultimately outfalls to River Liffey
L210 - L310	6.3.17	532	50	9.1	Oversized pipes, attenuated volume 3-10m^3	Discharge to existing surface water network DN225. Catchment ultimately outfalls to River Liffey
A4300 - A4830 East-bound +A4300 - A4400 West-bound	6.4.1	6938	87	4	Oversized pipes, attenuated volume 0.3-2m^3	Discharge to existing surface water network DN225. Existing storm network to remain and take existing road area where feasible. Catchment ultimately outfalls to River Liffey
A4400 - A4830 West-bound	6.4.2	5254	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
Asset Owner/Location: Irish Water/ Dublin City Council						
A4830 - A5110 East-bound	6.4.3	3019	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A4830 - A5110	6.4.4	4281	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network.

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area		Permitted Discharge (l/s)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
		Existing (m^2)	Change (m^2)			
West-bound						Catchment ultimately outfalls to River Liffey.
A5110 - A5400 East-bound	6.4.5	3217	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A5110 - A5400 West-bound	6.4.6	2926	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A5400 - A5670	6.5.1	10840	988	15 Westbound	Oversized pipes, attenuated volume 8-23m^3	Discharge to existing surface water network DN300. Catchment ultimately outfalls to River Liffey
				6 Eastbound	Oversized Pipes, Bioretention Areas, Attenuated Volume 14-27m^3	
A5670 - A5950	6.6.1	6427	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A5950 - A6350	6.7.1	10189	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A6350 - A7500	6.8.1	23290	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A7500 - A7790 East-bound	6.8.2	3347	88	31.6	Oversized pipes, attenuated volume 7.5-32m^3	Discharge to existing surface water network DN225. Catchment ultimately outfalls to River Liffey
A7500 - A7790 West-bound	6.8.3	2660	-32	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A7500 - A7790 West-bound off-slip	6.8.4	2875	-12	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A7790 - A8380 East-bound	6.9.1	8279	5	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area		Permitted Discharge (l/s)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
		Existing (m^2)	Change (m^2)			
A8380 - A8450 East-bound	6.9.2	1749	-268	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A8500 Junction	6.9.3	2796	16	N/A	N/A	Discharge to existing surface water network DN225. Existing stormwater network utilised where practicable. Catchment ultimately outfalls to River Liffey.
A7790 - A7830 Westbound (N)	6.9.4	261	0	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A7790 - A8450 West-bound	6.9.5	9831	-11	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A8500 - A9600 East-bound	6.10.1	17767	-387	N/A	N/A	Discharge to existing surface water network DN225. Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A8500 - A9530 – West-bound	6.10.2	15641	-533	N/A	N/A	Existing gullies to be replaced with narrow profile gullies, relocated to new kerbline, and connected to existing surface water network. Catchment ultimately outfalls to River Liffey.
A9530 - A9600 West-bound	6.10.3	1823	299	4.9	Oversized pipes, attenuated volume 7.5-16m^3	Discharge to existing surface water network DN225/DN375 Catchment ultimately outfalls to River Liffey
A9600 - End	6.11.1	3172	150	9.8	Oversized pipes, attenuated volume 4-12m^3	Discharge to existing surface water network DN300. Catchment ultimately outfalls to River Liffey

9.6 Drainage at New Bridge Structures

The Proposed Scheme includes for the replacement of the existing pedestrian footbridge at the R136 Ballyowen Road. Linear gullies will collect drainage at both ends of the bridge structure. It is not practicable or feasible to provide SuDS features to attenuate additional areas. The Proposed Scheme is also inclusive of new strategic bus stops on the N4, adjacent to Liffey Valley Shopping Centre, which includes a new overbridge. The walkway access structures are located on a steep slope up to Fonthill Road and down to Old Lucan Road. It is therefore not practicable or feasible to provide SuDS features to attenuate for these additional impermeable areas. Linear gullies and drains are expected to provide conveyance to a new oversized pipe network located at the bus stop.

9.7 Flood Risk

9.7.1 Flood Risk Overview

Flood risk assessment (FRA) has been prepared as part of the planning application for the Proposed Scheme.

The Stage 1 FRA is a high-level study of the scheme to identify flood risks to the Proposed Scheme and any potential flooding issues arising due to the project. The FRA will inform the planning process and identify whether a further Stage 2 FRA is required.

The FRA includes the following:

- Confirmation of the sources of flooding which may affect the site;
- A qualitative assessment of the risk of flooding to the site and to adjacent sites as a result of construction of the proposed development;
- Review of the availability and adequacy of existing information;
- Identification of possible measures which could mitigate the flood risk to acceptable levels; and
- Areas for further investigation (Stage 2 FRA) if required.

Refer to Appendix N for Site Specific Flood Risk Assessment Lucan to City Centre.

9.7.2 Flood Risk Assessment

This site-specific flood risk assessment for the Proposed Scheme has been undertaken in accordance with the requirements of “The Planning System and Flood Risk Management Guidelines for Planning Authorities”.

No past flood events have been identified along or near the Proposed Scheme.

The eastern (city centre) end of the Proposed Scheme runs adjacent to the coastal boundaries of the River Liffey (which is tidally influenced). As per the Dublin City Development Plan 2016-2022 Strategic Flood Risk Assessment Vol 7, an area of the Proposed Scheme is located within Flood Zone B.

The risk of pluvial flooding along most of the proposed route is considered to be high. However, along the R148 at Con Colbert Road there is a significant risk of pluvial flooding.

The above risks exist in the current scenario and will be reduced as a result of the Proposed Scheme, as where new surface water sewers are being proposed along the development, these networks shall be designed to provide attenuation for return period of up to 30 years where practicable. This would be an improvement on the existing historical drainage network infrastructure and will reduce the overall risk of pluvial flooding. New drainage infrastructure will be provided including SuDS such as rain gardens, swales, and tree pits where practicable. These SuDS features will provide source control measures and reduce the risk of pluvial flooding.

The groundwater vulnerability varies along the proposed development route. As most of the proposed development is on existing roads with no known flooding specifically from groundwater, it is expected that this risk will not increase as a result of the Proposed Scheme. To accurately assess the site-specific risk of groundwater flooding, a pre-construction geotechnical site investigation will be carried out as part of the final design in order to confirm groundwater conditions along the Proposed Scheme.

With the exception of the areas outlined above, the rest of the route does not fall within any flood extents, and therefore categorised as a Vulnerability Class Flood Zone C development.

Finally, the Proposed Scheme is categorised by the Guidelines as a ‘highly vulnerable development’ and is required to pass the justification test if any part of the development is located within Flood Zone A or Flood Zone B. The Plan Making Justification Test and Development Management Justification have been assessed and passed in Chapter 5 of the Site-Specific Flood Risk Assessment Lucan to City Centre (refer to Appendix N), and further investigation of the flood risk in the form of a Stage 2 FRA is not required.

10 Services and Utilities

10.1 Overview of Utilities Strategy and Survey

Utility records from all providers were sought at an early stage of the scheme design. These records combined with topographic survey records, GPR survey, walk over inspections and desktop analysis of the proposed scheme identified areas of risk to existing assets. Where risk was initially identified to high value assets, such as high voltage ESB cables, high pressure gas mains and trunk water mains, a review was undertaken to ascertain if the risk could be mitigated by amending the highways design whilst still meeting the objectives of the scheme. Some areas of conflict were designed out at this stage; however, some remained and had to be accommodated within the overall scheme design.

10.1.1 Record Information

Available utility records were submitted by service providers and reviewed along the Proposed Scheme. These records have assisted with informing the scheme design. Utility records were received from the following service providers:

- Irish Water;
- Gas Networks Ireland (GNI);
- Electricity Supply Board (ESB);
- Eir;
- Virgin Media;
- BT;
- Vodafone;
- Enet;
- SDCC; and
- DCC.

10.1.2 Phase 1 Utility Survey

A targeted utility survey to PAS 128A, including GPR, was commissioned by the NTA to investigate areas where there is risk identified to existing high value assets such as high voltage ESB cables, high pressure gas mains and trunk water mains due to the proposed carriageway alignment. Some areas where there is a high concentration of utility diversions proposed were also surveyed to ensure that adequate spacing is available for relocation of assets. The results of the utility survey have been reviewed to confirm the adequacy of design provisions made with respect to diversion proposals. Additionally, a more extensive utility survey will be completed to inform the detailed design phase of the Proposed Scheme.

10.1.3 Consultation with Utility Service Providers

Consultation with all relevant utility service providers was undertaken to evaluate the impact of the Proposed Scheme on existing utilities.

Based on records and topographical survey that was available, utility diversions and areas where protection measures might be required were identified. These potential impacts were documented on a set of consultation drawings and a technical note was prepared for each utility company.

Consultation meetings were held with ESB, GNI, Irish Water and Eir. The Proposed Scheme proposals were also outlined to them and scenarios where utility infrastructure might be impacted by the Proposed Scheme were discussed.

10.2 Overview of Service Diversions

The construction of the Proposed Scheme will result in conflicts with several existing utility assets. These conflicts have been identified, and preliminary consultation has been undertaken with the relevant service providers so that the conflict can be resolved by relocating or diverting the services where necessary and protecting in-situ where appropriate.

The principal statutory and other service providers affected are:

- ESB;
- Irish Water (water and public sewer);
- GNI; and
- Telecommunication Services – Eir, Virgin Media, eNet and BT.

In addition to the above, it will be necessary to relocate and upgrade some of the existing public lighting and traffic signalling network and equipment along the extents of the Proposed Scheme.

The services conflicts and the associated diversions will need to be considered in the design and construction of the Proposed Scheme. The design considerations have been taken into account as much as practicable at this stage, but it is likely that design modifications will be required at detailed design stage when further site investigations have taken place.

During construction, it will be necessary to maintain supply to certain services. This will require the retention and protection of existing utility supplies until such time as permanent diversions can be commissioned, or alternatively the construction of temporary diversions to facilitate completion of the works including the permanent diversion of services. The sequence of works must also take into account the need to liaise with service providers and, subject to their availability to carry out diversions, staging of the works may be necessary.

The service diversions required for this development are discussed in the following paragraphs. The locations of all known services from records provided from the service providers are shown on Combined Utility Drawings in Appendix B. Table 10-1 provides a summary of the service data received to date.

Table 10-1 Service Data Received Summary

Service Type	Data Available	Comments	Date Received
High Pressure (HP) Gas	Yes	No network present for sheets 1-4 and 6-31 TBC by utility provider.	15/10/2019
Medium Pressure (MP) Gas	Partial	No data available for sheets 6-14 and 16-29.	15/10/2019
Low Pressure (LP) Gas	Partial	No data available for sheets 1, 4-9, 18, 23 and 25.	15/10/2019
Telco Duct	Partial	No data available for sheets 1-25 and 29.	15/10/2019
Foul Sewer (FS)	Yes	No network present for sheets 5, 25, 28 and 29 TBC by utility provider.	15/10/2019, 26/03/2020
HV Electricity	Partial	No data available for sheets 1-7 and 13-25.	15/10/2019
MV Electricity	Yes	No network present for sheets 3, 4, 7, 16, 23, and 25 TBC by utility provider.	15/10/2019
LV Electricity	Yes	No network present for sheets 18, 23, 25 and 29 TBC by utility provider.	15/10/2019
IW Water Network (WN)	Yes	No network present for sheets 9, 18, 23, 25 and 29 TBC by utility provider.	15/10/2019, 26/03/2020
IW Abandoned Lines	Yes	No network present for sheets 1 and 3-30 TBC by utility provider.	15/10/2019, 26/03/2020
Eir	Partial	No data available for sheets 23 and 25.	20/03/2020

10.3 Summary of Recommended Diversions

10.3.1 Gas Networks Ireland

No impacts to high pressure gas mains have been identified. No impacts to medium pressure gas mains have been identified. There are two potential locations where GNI low pressure gas mains require diversions. Table 10-2 below outlines potential diversions of GNI services, and these are illustrated on drawing series BCIDC-ACM-UTL-UG-0006_XX_00-DR-CU-9001 in Appendix B.

Table 10-2 GNI Asset Diversions / Protection

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R06-LP-G14-N	GNI	A 3730 - A 3750	LP Underground	Localised diversion c. 15m of LP gas main in the verge/ footway of the R148 Palmerstown bypass south of footbridge at the intersection with Kennelsfort Road.
R06-LP-G15-N	GNI	A 3940 – A 3970	LP Underground	Localised diversion c. 35m of LP gas main in the verge/ footway of the R148 Palmerstown bypass west of where road merges with the Old Lucan Road.

10.3.2 ESB

One high voltage underground cable, six sections of medium voltage cables, and six sections of low voltage cables (under and overground) potentially require diversions along the length of the route. Table 10-3 below outlines potential diversions of ESB services, and these are illustrated on drawing series BCIDC-ACM-UTL-UE-0006_XX_00-DR-CU-9001 in Appendix B.

Table 10-3 ESB Asset Diversions

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R06-ESB1	ESB	A 340	Existing ESB Chambers and Mini Pillars	Relocation of 2 no. ESB chambers and mini pillars in the verge / footway of the N4 National Road adjacent to Hermitage Gardens.
R06-UG-LV-E2-G	ESB	A 340 - A 370	LV Underground	Localised diversion c. 26m of LV cables in the verge / footway of the N4 National Road adjacent to Hermitage Gardens.
R06-OH-LV-E4-I	ESB	A 950 - A 1030	LV Overhead	Localised relocation of c. 90m of LV overhead lines in the verge / footway of the N4 National Road east of existing pedestrian footbridge leading to Mount Andrew Court.
R06-ESB2	ESB	A 3030	Existing ESB Chamber	Localised relocation c. 3m of ESB chamber in the verge/ footway of the R148 Palmerstown bypass immediately east of N4 / M50 Interchange.
R06-UG-LV-E12-N	ESB	J 420	LV Underground	Localised diversion c. 4m of LV cables and chambers in the verge / footway of the Old Lucan Road at Riverside Drive Junction.
R06-UG-MV-E12-A	ESB	A 3240 - A 3520	MV Underground	Diversion c. 285m of MV cables in the verge / footway of the R148 Palmerstown bypass commencing at N4/ M50 Interchange continuing to the N4 Car Sales Dealership.
R06-UG-MV-E20-A	ESB	A 5560 - 5620	MV Underground	Localised diversion c. 65m of MV cables in the verge / footway of the R148 Chapelizod bypass at proposed ramp / steps structure providing access to bus stop from Chapelizod Hill Road.
R06-UG-MV-E28-A	ESB	A 8460	MV Underground	Localised diversion c. 80m of MV cables crossing R148 Con Colbert Road at intersection with R111 South Circular Road.
R06-UG-MV-E28-B	ESB	A 8460	MV Underground	Localised diversion c. 55m of MV cables crossing R148 Con Colbert Road at intersection with R111 South Circular Road.
R06-UG-LV-E28-J	ESB	A 8460	LV Underground	Localised diversion c. 55m of LV cables crossing Con Colbert Road at intersection with R111 South Circular Road.
R06-UG-MV-E31-D	ESB	A 9520 - A 9580	MV Underground	Localised diversion c. 80m of MV cables in the verge / footway of R148 St John's Road West across from Heuston Station.
R06-UG-LV-E31-AB	ESB	A 9520 - A 9580	LV Underground	Localised diversion c. 80m of LV cables in the verge / footway of R148 St John's Road West across from Heuston Station.

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R06-UG-HV-E31-G	ESB	A 9640 - A 9665	HV Underground	Localised diversion c. 40m of HV cables in the verge / footway of R148 St John's Road West across from Heuston Station.

10.3.3 Irish Water

There are five sections of water mains along the route where conflicts occur, and potential diversions are identified. Table 10-4 below outlines potential diversions of Irish Water watermain services, and these are illustrated on drawing series BCIDC-ACM-UTL-UW-0006_XX_00-DR-CU-9001 in Appendix B.

Table 10-4 Irish Water Watermain Asset Diversions

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R06-W1-E	IW	C 10 - C 60	200mm PVC-A	Localised diversion c. 55m ductile iron of DN 200mm PVC-A watermain in verge / footway of Lucan Road at R136 Ballyowen Road junction.
R06-W7-H	IW	G 280 - G 400	152.4mm Cast Iron	Localised diversion c. 125m ductile iron of DN 152.4mm CI watermain in verge / footway of the Old Lucan Road at proposed pedestrian overbridge to Liffey Valley Shopping Centre.
R06-W8-A	IW	H 80	100mm PVC	Localised diversion c. 20m ductile iron of DN 100mm PVC watermain in verge / footway of the Old Lucan Road across from The Deadman's Inn.
R06-W28-E-1	IW	A 8470	228.6mm Cast Iron	Localised diversion c. 14m ductile iron of DN 228.6mm CI watermain in verge / footway of South Circular Road where road is being widened at intersection with Con Colbert Road and St John's Road West.
R06-W31-H	IW	A 9520 - A 9590	152.4mm Cast Iron	Localised diversion c. 80m ductile iron of DN 152.4mm CI watermain in verge / footway of St John's Road West across from Heuston Station.

There are four sections of wastewater sewers along the route where conflicts occur, and diversions are required. Table 10-5 below outlines potential diversions of Irish Water wastewater sewers, and these are illustrated on drawing series BCIDC-ACM-UTL-UD-0006_XX_00-DR-CU-9001 in Appendix B.

Table 10-5 Irish Water Foul Sewer Asset Diversions/ Protections

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R06-S8-I	IW – Foul Sewer	A 2210 - A 2270	450mm Foul Sewer	Localised diversion c. 65m of DN 450mm foul sewer network in north verge / footway of the N4 National Road at proposed pedestrian overbridge to Liffey Valley Shopping Centre.
R06-S8-I-BB	IW – Foul Sewer	A 2180 - A 2220	450mm Foul Sewer	Localised diversion c. 38m of DN 450mm foul sewer network in south verge / footway of the N4 National Road at proposed pedestrian overbridge to Liffey Valley Shopping Centre.
R06-S8-I-A	IW – Foul Sewer	A 2180 - A 2220	450mm Foul Sewer	Localised diversion c. 46m of DN 4 50mm foul sewer network in south verge / footway of the N4 National Road at proposed pedestrian overbridge to Liffey Valley Shopping Centre.
R06-S20-C	IW – Foul Sewer	A 5640 - A 5670	300mm Foul Sewer	Localised diversion c. 130m of DN 300mm foul sewer network in verge / footway of Chapelizod Hill Road at proposed ramp / steps structure providing access to proposed bus stops from Chapelizod Hill Road.

10.3.4 Telecommunications

There are sixteen locations along the route where conflicts with telecommunications infrastructure occur, and diversions are required. Table 10-6 below outlines potential diversions of telecommunications infrastructure, and these are illustrated on drawing series BCIDC-ACM-UTL-UL-0006_XX_00-DR-CU-9001 in Appendix B.

Table 10-6 Telecommunications Asset Diversions / Protections

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R06-ER2-O-1	Eir	C 50 - C 80	Eir Ducting	Combined diversion c. 50m of 10 no. 100mm ducts (1 bank of 6 no. ducts, 1 bank of 4 no. ducts) including chamber relocations in the island at the junction between R835 Lucan Road and R136 Ballyowen Road.
R06-VM2-J	Virgin Media	N0 – N 140	Virgin Media Ducting	Localised diversion c. 135m of ducts including chamber relocations in the verge / footway of the N4 National Road along Hermitage Gardens and adjacent car park.
R06-ER2-O	Eir	N 40 - N 90	Eir Ducting	Localised diversion c. 50m of 6 no. 100mm ducts including chamber relocations in the verge / footway of the N4 National Road along car park adjacent to Hermitage Gardens.
R06-ER2-O	Eir	N 40	Eir Ducting	Localised diversion c. 10m of ducts including chamber relocations in the verge / footway of the N4 National Road along car park adjacent to Hermitage Gardens.
R06-ER2-S	Eir	D 170 - D 280	Eir Ducting	Localised diversion c. 110m of ducts including chamber relocations in the verge / footway of the N4 National Road along across from service station.
R06-ER8-V	Eir	G 490 - H 30	Eir Ducting	Localised diversion c. 60m of 4 no. 100mm ducts including chamber relocations in verge / footway of the Old Lucan Road at proposed pedestrian overbridge to Liffey Valley Shopping Centre.
R06-VM8-T	Virgin Media	G 490 - H 30	Virgin Media Ducting	Localised diversion c. 65m of ducts including chamber relocations in verge / footway of the Old Lucan Road at proposed pedestrian overbridge to Liffey Valley Shopping Centre.
R06-ER8-U	Eir	A 2200 - A 2270	Eir Ducting	Localised diversion c. 65m of 4 no. 100mm ducts including chamber relocations in verge/ footway of the N4 National Road at proposed pedestrian overbridge to Liffey Valley Shopping Centre.
R06-ER12-AA	Eir	J 50 – J 480	Eir Ducting	Diversion c. 440m of ducts including chamber relocations in verge/ footway of the Old Lucan Road east of the M50 motorway.
R06-VM12-V	Virgin Media	A 3280 - A 3300	Virgin Media Ducting	Localised diversion c. 15m of ducts including chamber relocations where the R148 Palmerstown bypass is being widened after the M50 off-ramp merge with the R148 Palmerstown bypass.
R06-ER12-Y	Eir	A 3210 – A 3400	Eir Ducting	Diversion c. 205m of ducts including chamber relocations R148 Palmerstown bypass is being widened after where the M50 off ramp merges with the Chapelizod bypass.
R06-ER14-AT	Eir	A 3720 - A 3750	Eir Ducting	Localised diversion c. 35m of 5 no. 100mm ducts including chamber relocations in verge / footway of the R148 Palmerstown bypass at new bus stop lay-by south of pedestrian overbridge at the intersection with Kennelsfort Road.
R06-ER15-AI	Eir	A 3930 - A 3980	Eir Ducting	Localised diversion c. 60m of 6 no. 100mm ducts including chamber relocations in verge / footway of the R148 Palmerstown bypass at new bus stop lay-by west of The Oval junction.
R06-VM31-AJ	Virgin Media	A 9450 - A 9590	Virgin Media Ducting	Localised diversion c. 135m of ducts including chamber relocations in island of St John's Road West outside Heuston Station.
R06-ER31-AS	Eir	A 9520 - A 9580	Eir Ducting	Localised diversion c. 60m of 16 no. 100mm ducts including chamber relocations in verge / footway of St John's Road West across from Heuston Station.
R06-ER31-SS	Eir	A 9560 - A 9880	Eir Ducting	Localised diversion c. 40m of ducts including chamber relocations in verge / footway of St John's Road West outside the main entrance to Heuston Station.

11 Waste Quantities

11.1 Overview of Waste

The majority of the waste arisings from the works are likely to accumulate from excavation related activities resulting from road widening and drainage / utility works in addition to proposed public domain street works. A waste calculator was developed for the Proposed Scheme to quantify and classify the likely material types in accordance with TII GE-ENV-01101 and the European Waste Catalogue waste codes. The waste quantities associated with soil and stones (waste code 17 06 02) were further broken down into the likely TII material specification to establish an understanding of the volume of materials that could potentially be reused / recycled. In developing the waste estimate quantities a number of assumptions were required to undertake the assessment which have been outlined in Section 11.2.

Due to the nature of the works in an urban environment there are limited opportunities to provide a cut/ fill balance of materials that could be more readily accommodated on a greenfield project where earthworks embankments / bunds are more common. Material from the existing pavement layers could be sent to a suitable recovery facility for recycling and reuse as recycled aggregate material in the industry. The existing made ground material will need to be tested for quality and contamination and could potentially be sent to a suitable soil recovery facility also for reuse as general fill or general landscape fill material in the industry under the provisions of Article 28. Similarly alternative sites could be identified under the provisions of Article 27 for material re-use during future design stages. No such suitable sites have been identified for the Proposed Scheme during the preliminary design phase.

Future design stages will undertake additional site investigations to inform the detailed pavement design and associated excavation quantity assessment. Various mitigations could be considered during the design and construction works to offset the net volume of material that will be sent off site to a soil recovery facility including stockpiling of existing subbase, capping layer and topsoil material on site for direct reuse in the proposed works (subject to quality testing, construction sequencing and material availability versus demand given the intermittent nature of the streetworks). Similarly, there are potentially other opportunities within the proposed pavement design / construction to further offset the net volume of natural aggregate material requirements through consideration for the use of recycled aggregates and reclaimed asphalt material. Suitable recycled aggregates and appropriate site won material could be implemented in the proposed road base / binder layers, subbase layers under footway / cycle tracks, and capping layer material within the road pavement. Adopting these mitigations in the proposed designs may have significant benefits in offsetting the overall quantity of natural aggregate materials requirements and could potentially realise up to a significant volume of recycled/reused aggregates to improve the overall sustainability of the Proposed Scheme.

Waste arisings from street furniture, trees and materials from within the public domain (17 01 02 Bricks, 17 04 07 Mixed metals, 17 02 03 Plastic, 17 02 01 wood, 17 02 02 Glass) are also likely to result from the nature of the works. These materials will need to be segregated by waste classification on site and sent to a suitable recovery facility for recycling. The principles of prevention and minimisation will be further considered in detailed design / construction stages through value engineering, substitution or reuse of materials, and effective methods or control systems (e.g. just in time deliveries / effective spoil management) so that waste production is minimised.

11.2 Waste Calculation Assumptions

The following tables provide an overview of the various material weights that have been applied in consideration of the overall materials waste estimate quantities for the Proposed Scheme.

Table 11-1 Street Furniture Unit Weights

Item	Material	Assumed Nominal Weight	Notes
Timber arising from trees	Timber/ Wood	150 kg per tree	Average value per tree across the length of the Proposed Scheme.
Vegetation (e.g. hedges, shrubs, leaves and branches)	Organic	N/A	Organic material from hedges, shrubs, leaves and branches have not been quantified.
Walls	Masonry/ Bricks	1.5m height 0.3m width	Nominal assumed dimensions for purposes of assessment
Gates	Metal	100 kg/unit	Nominal assumed average weight per gate over scheme
Metal railings	Metal	15 kg/m	Nominal assumed average weight per railing over the length of the Proposed Scheme.
Fencing	Metal	40 kg/m	Nominal assumed average weight per railing over the length of the Proposed Scheme.
Traffic signals	Metal	68 kg/ 4m pole 15kg per traffic signal head Assumed two heads per pole	Source: Siemens Helios General Handbook Issue 18. Nominal assumed average scenario per signal over the length of the Proposed Scheme.
	Plastic	9 kg	
Traffic signs	Metal	20kg/ 3m pole 0.75 m sign height 0.01 m pole thickness	Nominal assumed average scenario per traffic sign over the length of the Proposed Scheme.
Lighting poles	Metal	100 kg per 8m pole	Nominal assumed average scenario over the length of the Proposed Scheme.
ESB/EIR poles	Timber/wood	250 kg per 9m pole	Nominal assumed average scenario over the length of the Proposed Scheme.
Bus stops	Plastic	365 kg per bus stop	JCDecaux and NTA (2017) Reliance Bus Shelter information
	Metal	2400 kg per bus stop	JCDecaux and NTA (2017) Reliance Bus Shelter information
	Glass	54 kg per bus stop	JCDecaux and NTA (2017) Reliance Bus Shelter information
Litter bins	Metal	60 kg per bin	Omos specification. Nominal assumed average scenario over the length of the Proposed Scheme.
Safety barrier	Metal	20 kg/m	Nominal assumed average scenario over the length of the Proposed Scheme.
Cabinets	Metal	85 kg	ESB (2008). National Code of Practice for Customer Interface 4th Edition. Available online: https://www.esbnetworks.ie/docs/default-source/publications/national-code-of-practice.pdf (Accessed on 6 May 2021)
Benches	Metal	32kg	Lost Art (2016). Benches: Product information operation and maintenance instructions. Available online: https://www.lostart.co.uk/pdf/lost-art-limited-product-information.pdf (Accessed on 6 May 2021)
	Wood	8kg	
Cameras	Metal	35 kg	2b Security Systems (2021) PTZ-7000 Long range IP PTZ camera. Available online: https://www.2bsecurity.com/product/long-range-ptz-camera/ (Accessed on 6 May 2021)

Item	Material	Assumed Nominal Weight	Notes
Overhead gantry (steel)	Metal	7000 in per m^3	TII (nb). CC- SCD- 01804-02. Available online:https://www.tiipublications.ie/library/CC-SCD-01804-02.pdf (Accessed on 6 May 2021) TII (nb). CC- SCD- 0180-02. Available online:https://www.tiipublications.ie/library/CC-SCD-01805-02.pdf (Accessed on 6 May 2021)
Cast iron bollard	Metal	50 kg	Furnitubes (2013) Cast Iron Bollards: Product Brochure. Available online: https://www.furnitubes.com/uploads/assets/brochures-2013/furnitubes-e-008-01-13-cast-iron-bollard-brochure.pdf (Accessed on 6 May 2021)
Non assigned bollard	Metal	40kg	Furnitubes (2013) Cast Iron Bollards: Product Brochure. Available online: https://www.furnitubes.com/uploads/assets/brochures-2013/furnitubes-e-008-01-13-cast-iron-bollard-brochure.pdf (Accessed on 6 May 2021)
Stainless steel bollard	Metal	30kg	Furnitubes (2013) Cast Iron Bollards: Product Brochure. Available online: https://www.furnitubes.com/uploads/assets/brochures-2013/furnitubes-e-008-01-13-cast-iron-bollard-brochure.pdf (Accessed on 6 May 2021)
Vehicle restraint bollard	Metal	130 kg	Furnitubes (2013) Cast Iron Bollards: Product Brochure. Available online: https://www.furnitubes.com/uploads/assets/brochures-2013/furnitubes-e-008-01-13-cast-iron-bollard-brochure.pdf (Accessed on 6 May 2021)
Bike railings/ handrails	Metal	16 kg	Dublin City Council (2016) Construction Standards for Road and Street Works in Dublin City Council
Gully grates	Metal	40 kg	Pam Saint-Gobain (2016). Ductile Iron Access Covers and Gratings: Product selection and specification guide. Available online: https://www.saint-gobain-pam.co.uk/sites/pamline_uk/files/access_covers_and_gratings_product_guide_0.pdf (Accessed on 6 May 2021) Greater Dublin Region (2012) Greater Dublin Regional Code of Practice for Drainage works. Available online: (https://www.sdcc.ie/en/download-it/guidelines/greater-dublin-regional-code-of-practice-for-drainage.pdf (Accessed on 6 May 2021)
Chamber covers and frame	Metal	0.112 tonnes	Pam Saint-Gobain (2016). Ductile Iron Access Covers and Gratings: Product selection and specification guide. Available online: https://www.saint-gobain-pam.co.uk/sites/pamline_uk/files/access_covers_and_gratings_product_guide_0.pdf (Accessed on 6 May 2021) Greater Dublin Region (2012) Greater Dublin Regional Code of Practice for Drainage works. Available online: (https://www.sdcc.ie/en/download-it/guidelines/greater-dublin-regional-code-of-practice-for-drainage.pdf (Accessed on 6 May 2021)

Item	Material	Assumed Nominal Weight	Notes
Manholes	Metal	0.04 tonnes	Pam Saint-Gobain (2016). Ductile Iron Access Covers and Gratings: Product selection and specification guide. Available online: https://www.saint-gobain-pam.co.uk/sites/pamline_uk/files/access_covers_and_gratings_product_guide_0.pdf (Accessed on 6 May 2021) Greater Dublin Region (2012) Greater Dublin Regional Code of Practice for Drainage works. Available online: https://www.sdcc.ie/en/download-it/guidelines/greater-dublin-regional-code-of-practice-for-drainage.pdf (Accessed on 6 May 2021)

Table 11-2 In-situ Pavement and Earthworks Densities

Material	Densities (tonnes/m^3)	Notes
Soil	2.2	Professional judgement (Dublin boulder clay), laboratory testing - Nominal assumed average scenario over scheme length
Bitumen containing material	2.4	Professional judgement (Engineering Designers) - Nominal assumed average scenario over scheme length
Concrete	2.4	Professional experience and (Bath Inventory - Version 2.0 (2011)) - Nominal assumed average scenario over scheme length
Granite	2.7	https://pubs.usgs.gov/of/1983/0808/report.pdf - Nominal assumed average scenario over scheme length
Paving stones (assumed concrete or natural stone)	2.4	Professional judgement (Engineering Designers) Nominal assumed average scenario over scheme length
Granular material	1.6	Nominal assumed average scenario over scheme length

Table 11-3 Utilities Material Excavation Assumptions

Asset type	Assumed nominal average trench width (m)	Assumed material spec. (TII)	Assumed nominal average trench depth under pavement layer (m)	Notes
Drainage pipe bedding excavation assessment (assumed at 1.2m cover i.e. obvert at 0.35m under capping layer of road)	0.9	Class 2/4/U1 cohesive subgrade material	1.25	Irish Water (2020) Water Infrastructure Standard Details: Connections and Developer Services. Available online: https://www.water.ie/connections/Water-Standard-Details.pdf (Accessed on 6 May 2021)
Foul sewer pipe bedding excavation assessment (assumed at 1.2m cover, i.e. obvert at 0.35m under capping layer of road)	0.9	Class 2/4/U1 cohesive subgrade material	1.25	Irish Water (2020) Water Infrastructure Standard Details: Connections and Developer Services. Available online: https://www.water.ie/connections/Water-Standard-Details.pdf (Accessed on 6 May 2021)
Potable water pipe bedding excavation assessment (assumed at 1.2m cover i.e. obvert at 0.35m under capping layer of road)	0.9	Class 2/4/U1 cohesive subgrade material	1.25	Irish Water (2020) Water Infrastructure Standard Details: Connections and Developer Services. Available online: https://www.water.ie/connections/Water-Standard-Details.pdf (Accessed on 6 May 2021)

Asset type	Assumed nominal average trench width (m)	Assumed material spec. (TII)	Assumed nominal average trench depth under pavement layer (m)	Notes
Road pavement excavation (extra over in addition to road widening allowances e.g. transverse trenching)	0.9	Bitumen (surface+binder and base)	0.35	Irish Water (2020) Water Infrastructure Standard Details: Connections and Developer Services. Available online: https://www.water.ie/connections/Water-Standard-Details.pdf (Accessed on 6 May 2021)
		Class 1/2 granular subbase material	0.3	Irish Water (2020) Water Infrastructure Standard Details: Connections and Developer Services. Available online: https://www.water.ie/connections/Water-Standard-Details.pdf (Accessed on 6 May 2021)
		Class 6 granular capping material	0.2	Irish Water (2020) Water Infrastructure Standard Details: Connections and Developer Services. Available online: https://www.water.ie/connections/Water-Standard-Details.pdf (Accessed on 6 May 2021)
Electric/ power bedding excavation assessment (assumed at 0.75m cover under footway i.e. obvert at 0.55m under subbase layer of footway/ cycle track)	0.05	Class 2/4/U1 cohesive subgrade material	0.925	ESB (2008) Standard Specification for ESB MV/LV Network Duction (Minimum Standards). Available online: https://www.esbnetworks.ie/docs/default-source/publications/summary-of-standard-specification-for-esb-networks-mvlv-ducting.pdf?sfvrsn=f34b33f0_4 (Accessed on 6 May 2021)
Comms bedding excavation assessment (assumed at 0.75m cover under footway i.e. obvert at 0.55m subbase layer of footway)	0.5	Class 2/4/U1 cohesive subgrade material	0.925	ESB (2008) Standard Specification for ESB MV/LV Network Duction (Minimum Standards). Available online: https://www.esbnetworks.ie/docs/default-source/publications/summary-of-standard-specification-for-esb-networks-mvlv-ducting.pdf?sfvrsn=f34b33f0_4 (Accessed on 6 May 2021)
Street lighting/comms/traffic excavation assessment (assumed at 0.6m cover under footway i.e. obvert at 0.4m subbase layer of footway)	0.5	Class 2/4/U1 cohesive subgrade material	0.56	South Dublin County Council (2016) Public Lighting Specification. Available online: https://www.sdcc.ie/en/services/transport/public-lighting/sdcc-public-lighting-specification.pdf (Accessed on 6 May 2021)
Gas excavation assessment (assumed at 0.6m cover i.e. obvert at 0.4m under subbase layer of footway)	0.45	Class 2/4/U1 Cohesive subgrade material	0.7	Gas Network Ireland (2018) Guidelines for Designers and Builders- Industrial and Commercial (Non-domestic) Sites. Available online: https://www.gasnetworks.ie/Guidelines-for-Designers-and-Builders-Industrial-and-Commercial-Sites.pdf (Accessed 6 May 2021)

Table 11-4 Footway and Road Widening Excavation Assumptions

Layer	Assumed Layer thickness (m)	Assumed material spec. (TII)
Footway surface treatment due to all works (remove and replace)	0.1	Concrete
Full Depth construction (FDC) new pavement depth	0.85	As per DCC standard bus corridor detail with 200mm capping assumed.
Footway sub-layer excavation due to FDC widening (material under footway)	0.1	Granular material- Class 1/2 granular subbase material
	0.75	Soil and stones- Class 2/4/U1 cohesive subgrade material
Verge and sub-layer excavation due to FDC widening (material under verge)	0.3	Soil and stones- Class 5 topsoil material
	0.55	Soil and stones- Class 4/U1 cohesive subgrade material
Verge and sub-layer excavation due to footway widening (material under verge)	0.3	Soil and stones- Class 5 topsoil material
	0	Soil and stones- Class 4/U1 cohesive subgrade material
Road surface treatment due to road markings and utilities trench reinstatement (mill and re-sheet)	0.05	Bitumen containing material - bitumen (surface)
Road sub-layer excavation due to FDC (material under road)	0.3	Bitumen containing material - bitumen (binder and base)
	0.3	Class 1/2 granular subbase material
	0.2	Granular material - Class 6 granular capping material
	0	Soil and stones- Class 2/4/U1 cohesive subgrade material

11.3 Waste Estimate Summary

The majority of the waste arisings from the works are likely to accumulate from excavation related activities resulting from road widening and drainage/utility works in addition to proposed public domain street works.

It is estimated that an order of magnitude of 89,000 tonnes of pavement and made ground material (17 01 01 Concrete / 17 06 02 non-hazardous bituminous mixture / 17 05 04 - Soil and stones (non-contaminated)) will be excavated as part of the works, refer to Table 11-5. Due to the nature of the works in an urban environment there are limited opportunities to provide a cut / fill balance of materials that could be more readily accommodated on a greenfield project where earthworks embankments / bunds are more common. Material from the existing pavement layers could be sent to a suitable recovery facility for recycling and reuse as recycled aggregate material in the industry as further described below. The existing made ground material will need to be tested for quality and contamination and could potentially to be sent to a suitable soil recovery facility also for reuse as general fill or general landscape fill material in the industry under the provisions of Article 28. There are no known Article 27 sites available at the time of planning for the site however this could also be considered for reuse of material arisings from the project at a later date.

Potentially up to 100% of concrete and asphalt material could be sent to a suitable aggregate recovery facility for recycling. Under TII specification crushed concrete material could be used in selected granular fill material under Series 600 for Earthworks (6A,6B,6C,6F, 6G,6H,6I, 6M, 6N) or as Type A Clause 803 unbound subbase material under Series 800 for Road Pavements. Similarly TII specification allows for use of recycled bituminous plannings to be used in capping material and 803 sub-base material type A (for use under bituminous footway) in addition to LEBM pavements for roads with <5MSA or consideration in offline cycle track base material.

Potentially up to 90% of excavated subbase material and capping material could be reused as subbase material under footways and cycle track (subject to quality testing). It is assumed that potentially 10% of this material will contain excessive cohesive material during the excavation process (unsuitable for direct reuse). The 10% excess material would likely be sent to a suitable recovery facility as general fill or landscape fill material (Class 2 / 4 material) depending on excavation methods employed by the contractor and existing ground conditions.

Future design stage will undertake additional site investigations to inform the detailed pavement design and associated excavation quantity assessment. Various mitigations could be considered during the design and construction works to offset the net volume of material that will be sent off site to a soil recovery facility including stockpiling of existing subbase, capping layer and topsoil material on site for direct reuse in the proposed works (subject to quality testing, construction sequencing and material availability versus demand given the intermittent nature of the street works). Similarly, there are potentially other opportunities within the proposed pavement design / construction to further offset the net volume of natural aggregate material requirements through consideration for the use of recycled aggregates and reclaimed asphalt material. Suitable recycled aggregates and appropriate site won material could be implemented in the proposed road base / binder layers, subbase layers under footway/cycle tracks, and capping layer material within the road pavement. Adopting these mitigations in the proposed designs may have significant benefits in offsetting the overall quantity of natural aggregate materials requirements and could potentially realise up to 20,633 tonnes of recycled / reused aggregates to improve the overall sustainability of the Proposed Scheme.

It is estimated that an order of magnitude of 1,730 Tonnes of waste arisings from street furniture, trees and materials from within the public domain (17 01 02 Bricks, 17 04 07 Mixed metals, 17 02 03 Plastic, 17 02 01 wood, 17 02 02 Glass) are also likely to result from the nature of the works. These materials will need to be segregated by waste classification on site and sent to a suitable recovery facility for recycling. The principles of prevention and minimisation will be further considered in detailed design / construction stages through value engineering, substitution or reused of materials, and effective methods or control systems (e.g. just in time deliveries / effective spoil management) so that waste production is minimised.

Table 11-5 Summary of Excavation Material Type and Quantities

Materials from C and D Sources	Approximate Waste and Material Quantity (Tonnes)
Concrete, bricks, tiles and similar	9,000
Bituminous mixtures	20,000
Soil and stone	60,000
TOTAL	**89,000**

12 Traffic Signs, Lighting and Communications

12.1 Traffic Signs and Road Marking

12.1.1 Introduction

Signage and road markings will be provided along the extents of the proposed scheme to clearly communicate information, regulatory and safety messages to the road user. In addition, the existing lighting and communication equipment along the route has been reviewed and proposals developed to upgrade where necessary. Refer to the preliminary design drawings TSM_GA Traffic Signs and Road Markings Drawings and LHT_RL Lighting drawing series contained within Appendix B.

12.1.2 Traffic Signage General

A preliminary assessment was undertaken which involved an assessment of major road traffic signage, including requirements for all information signs (TSM Chapter 2), regulatory signs (TSM Chapter 5), warning signs (TSM Chapter 6), and road markings (TSM Chapter 7).

As stated in TSM Chapter 1, in urban areas the obstruction caused by posts located in narrow pedestrian footways should be minimised, ensuring that pedestrian and cycle access is unimpeded by any such signage infrastructure. Therefore, where practicable, signs are to be placed on single poles, or larger signs will be cantilevered from a post at the back of the footway using H-frames where necessary. Passively safe posts will be introduced where practicable to eliminate the need for vehicle restraint systems.

12.1.3 Traffic Signage Strategy

12.1.3.1 General

A preliminary traffic sign design has been undertaken to identify the requirements of the Proposed Scheme, whilst allowing for further design optimisation at the detailed design phase. A combination of information, regulatory and warning signs have been assessed taking consideration of key destinations / centres; intersections / decision points; built and natural environment; other modes of traffic; visibility of signs and viewing angles; space available for signs; existing street furniture infrastructure; existing signs. In line with DMURS, the signage proposals have been ‘kept to the minimum requirements of the Traffic Signs Manual (TSM).

Prior to assessing the requirements for individual signs, a review was carried out on the impact that proposed traffic restrictions and changes to the road layout will have on the key traffic routes in the vicinity of the Proposed Scheme.

Where required, Route Strategy Plans were created which display the following information relating to the Proposed Route: the existing directions signs in the vicinity of the route, the associated existing traffic routes, the routes which traffic will be directed along as a result of the proposed traffic restrictions and road layout amendments, and the proposed traffic sign locations for the new routes. The proposed traffic signs will be located at the decision points for key destinations, which have been determined using the information displayed on the existing signs.

A review of the existing regulatory and warning signs in the vicinity of the route was carried out to identify unnecessary repetitive and redundant signage to be removed. This includes rationalising signage structures by better utilising individual sign poles and clustering signage together on a single pole.

12.1.3.2 Advanced Directional Signage at M50 Approach

On the N4 Lucan Road eastbound and the R148 westbound approaches to the M50 Junction 7, a change to the lane designation is proposed to provide a continuous bus lane across the M50 in both directions. To facilitate this, it is proposed to separate earlier the N4 eastbound traffic heading towards the M50 northbound and the R148 Palmerstown bypass, as well as the R148 westbound traffic heading towards the M50 and the N4.

The relocation of the bus stops for LVSC will allow for an increased length for buses to accelerate and weave with eastbound traffic approaching the M50 interchange, and also provide increased weaving length for all westbound traffic exiting the M50 interchange. The proposed approach to earlier lane designation / full lane destination markings and signage is consistent with the approach already adopted on the M1, N2, N3 and N7 radial approaches to the M50.

12.1.3.2.1 Eastbound

The section of the N4 under consideration is the eastbound carriageway between Junctions 1 and 2 (Scheme Chainage A2050 to A2350). This is located to the north of Liffey Valley Shopping Centre and immediately west of the M50, as shown in Figure 12-1.

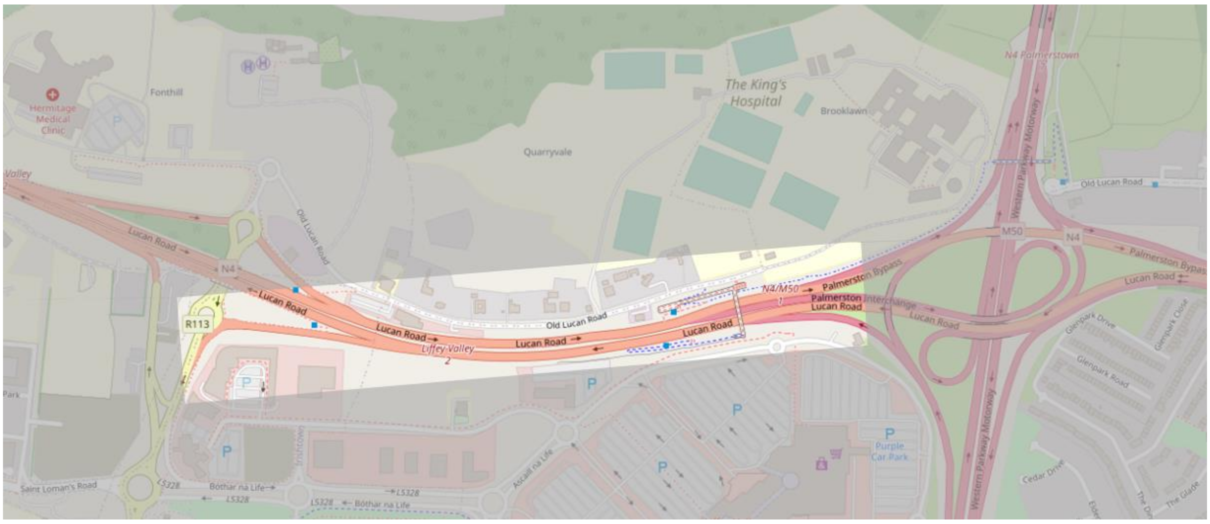

Figure 12-1 Proposed Scheme West of M50

The N4 eastbound carriageway comprises 3 traffic lanes and a bus lane at this location. At junction 2 the carriageway is subject to a speed restriction of 80km/hr and at the end of the Junction 2 eastbound merge a speed restriction of 60km/hr applies. The offside lane is signed for M50 southbound and at the immediate approach to the M50 a second lane is developed on the offside for traffic heading to the M50 southbound. These two offside lanes then separate from the N4. The middle and nearside lanes are signed for the R148 Palmerstown and at Junction 1 (M50 Junction 7), there is a standard diverge lane on the nearside for the M50 northbound. The remaining two lanes for the R148 continue across the M50.

As well as the general traffic lanes, there is a bus lane as far as the exit taper gantry at Junction 1. There is an existing layby bus stop, serving LVSC, 50m before the end of the bus lane, immediately prior to the Exit Taper gantry. Buses leaving this bus stop heading for the R148 towards the city centre currently only have only 50m of bus lane to accelerate before having to weave with the M50 northbound diverge traffic.

The Proposed Scheme relocates the existing the LVSC bus stop upstream to improve acceleration length and align with the proposed new transport interchange at LVSC, and provides continuous bus priority across the M50 by reallocating the left hand lane of the two R148 lanes as a bus lane.

Lane destination markings for the eastbound carriageway between junction 2 and the M50; from junction 2 the nearside lane will be marked for M50 Northbound traffic only, and the central lane will be marked for the R148 traffic only.

Refer to section 12.1.4 for gantry signage requirements.

12.1.3.2.2 Westbound

The section of the R148 under consideration is the westbound carriageway of the Palmerstown bypass approaching the M50 (Scheme Chainage A3250 to A3900). This is located to the south of Palmerstown village and immediately east of the M50, as shown in Figure 12-2.

The R148 westbound carriageway (Palmerstown bypass) comprises two traffic lanes and a bus lane approaching and exiting the junction with the Oval, and this arrangement continues to the junction with

Kennelsfort Road. At the junction itself, there is an additional right turn lane for Palmerstown Village and the bus lane is replaced with a left turn for Cherry Orchard. After this junction there is a short length of bus lane which is replaced with a single lane dedicated for M50 bound traffic and two lanes for N4 bound traffic.

The Proposed Scheme includes provision of westbound bus lane along the R148 Palmerstown bypass, and continuous bus priority across the M50 interchange, by reallocating the left hand lane of the two N4 lanes as a bus lane. To enable safe weaving of buses with M50-bound traffic, it is proposed to facilitate this movement immediately west of the Kennelsfort Road junction as shown in Figure 12-3.

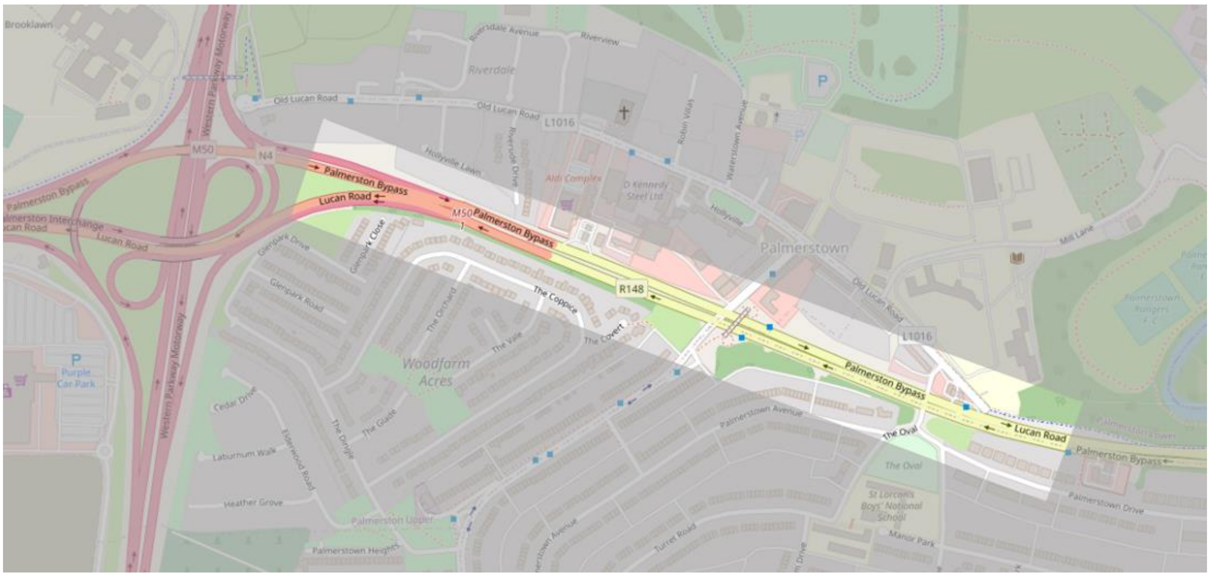

Figure 12-2 Proposed Scheme East of M50

Figure 12-3 Palmerstown bypass, West of Kennelsfort Road Junction

12.1.3.3 Kennelsfort Road Lower / The Oval

The left turn movement from Kennelsfort Road Lower to the R148 Palmerstown bypass eastbound is to be prohibited to facilitate the new signalised crossings on the east side of the Kennelsfort Road junction to serve pedestrian demand and cater for the proposed two-way cycle track that crosses the R148 Palmerstown bypass at this location. In addition, at the signalised junction with the Old Lucan Road / The Oval a new westbound, bus only, right turn lane is provided on the R148 Palmerstown bypass to facilitate new bus services through Palmerstown village.

The proposed route strategy is outlined in Figure 12-4, and the proposed signage is detailed on the TSM_GA series of drawings in Appendix B.

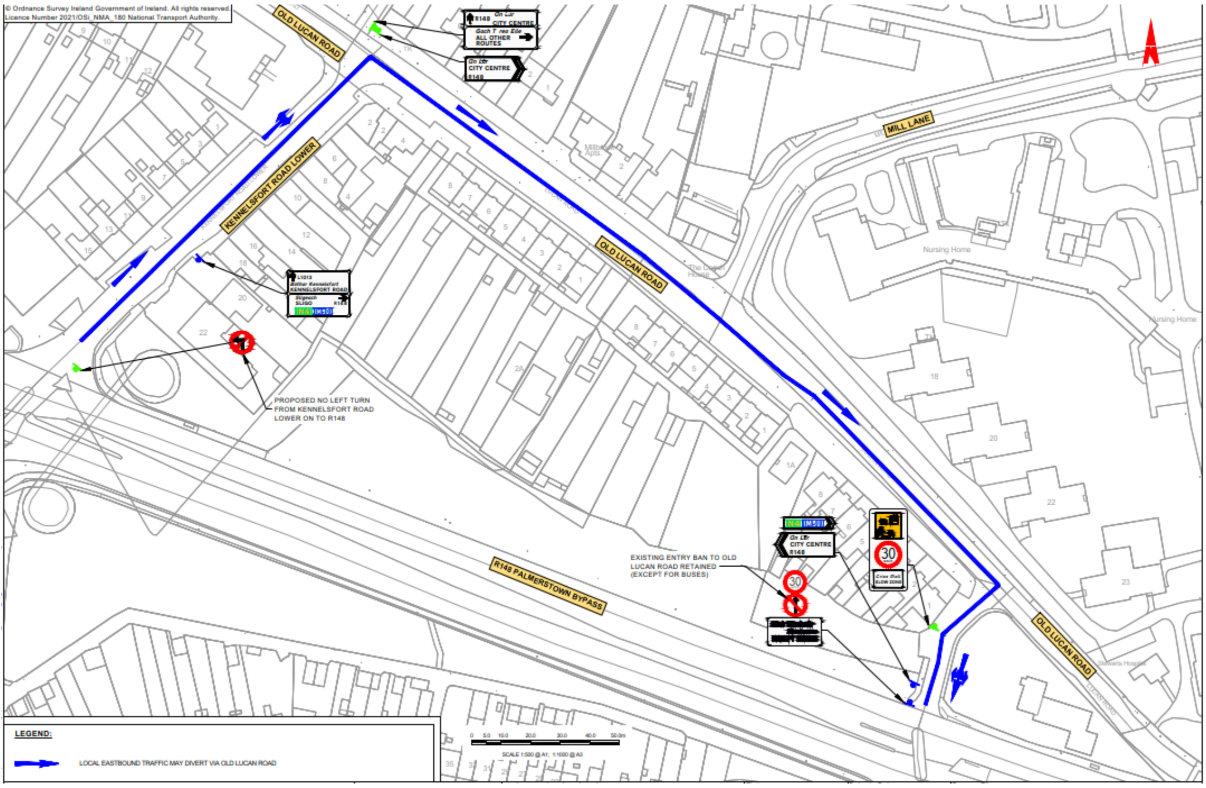

Figure 12-4 Palmerstown Village Route Strategy Plan

12.1.4 Gantry Signage

To achieve the bus priority and safe negotiation length on the N4, M50 Junction 7 approaches, as detailed in section 12.1.3.2, signs on the existing gantries are proposed to be changed to reflect the proposed revised lane destination requirements. This proposed signage strategy is the same as the existing strategy on all other National Primary radial approaches to the M50, namely the M1, N2, N3 and N7. These include full lane destination signage from the preceding junction with no distance plates. There are different numbers of gantries on the approaches M1, N2, N3 and N7 and they are at variable spacings (250-500m).

The provision of the proposed pedestrian bridge will impact the forward visibility to the existing directional information / lane destination sign gantry at Ch. A2350 on the eastbound approach to the M50 Junction 7. This will constitute a departure from standard for the minimum clear visibility distance set out in the TSM chapter 2. To mitigate the reduced visibility and reinforce the revised lane destination arrangement, the proposed scheme includes the provision of a new portal gantry, including additional lane destination signs, immediately west of the new pedestrian bridge. Refer to the departure application in Appendix C for details of the visibility assessment and proposed mitigation.

12.1.5 Road Marking

A preliminary design of road markings has been undertaken in accordance with TSM Chapter 7. Refer to the TSM_GA drawings contained within Appendix B for details. This exercise also included the preliminary road marking design of the following items:

- Bus lanes are provided along the Proposed Scheme and will be marked accordingly;
- Cycle tracks have been provided along the scheme. The pavement will be marked according to best practice guidelines such as DMURS and the NCM with particular attention given to junctions. Advance Stacking Locations (ASLs) have been designed predominantly on the minor side roads, where practicable, to provide a safer passage for cyclists at signal-controlled junction for straight ahead or right turn movements; and
- Pedestrian crossings have been incorporated throughout the design to connect the network of proposed and existing footways. Wider pedestrian crossings have been provided in locations expected to accommodate a high number of pedestrians. DMURS classifies pedestrian crossing

widths in areas of low to moderate pedestrian activity as 2.5m and areas of moderate to high pedestrian activity as 3m.

12.2 Public Lighting

12.2.1 Introduction

A high-level review of the existing lighting provision along the extent of the route has been carried out to understand the impact of the proposed scheme on lighting columns and associated infrastructure. A number of existing columns are proposed to be relocated or replaced to accommodate the Proposed Scheme, as shown on the preliminary lighting drawings series LHT_RL within Appendix B.

12.2.2 Existing Lighting

Light emitting diode (LED) lanterns will be the light source for any new or relocated public lighting provided. The lighting design will involve works on functional, heritage and contemporary lighting installations on a broad spectrum of lighting infrastructure along the Proposed Scheme. This shall include, but not exclusively, luminaires supplied by underground and overhead cable installations and those located on ESB infrastructure.

In locations where road widening and / or additional space in the road margin is required, it is proposed that the public lighting columns shall be replaced and relocated to the rear of the footway to eliminate conflict with pedestrians, and the existing removed once the new facility is operational. Where significant alterations are proposed to the existing carriageways, the existing public lighting arrangement shall be reviewed to ensure that the current standard of public lighting is maintained or improved. The New lighting requirement will be determined by BCID lighting design in accordance with the standards and best practice. To determine whether existing public lighting is to be improved / relocated or where new public lighting is required, an inspection shall be carried out to identify any new column locations required for particular sections of the Proposed Scheme. For existing columns that have specific aesthetic requirements, the intent for the replacement of such columns will include:

- Replacing the existing heritage columns and brackets with identical replica columns and brackets;
- Replacing existing luminaires with approved LED heritage luminaires; and
- Ensuring that the electrical installation is compliant with standards detailed in Section 12.2.3.

12.2.3 New Lighting

All new public lighting shall be designed and installed in accordance with the specific lighting and electrical items set out the following National Standards and guides, including but not limited to:

- Local Authority Guidance Specifications;
- EN 13201: 2014 Road Lighting (all sections);
- ET211:2003 ‘Code of Practice for Public Lighting Installations in Residential Areas’;
- BS 5489-1 ‘Code of practice for the design of road lighting’;
- Volume 1 - NRA Specification for Road Works, Series 1300 and 1400;
- Volume 4 - NRA Road Construction Details, Series 1300 and 1400;
- IS EN 40 - Lighting Columns;
- Institution of Lighting Professionals “GN01 Guidance Notes for Reduction of Obtrusive Light”;
- CC-SPW-01300 - Specification for Road Lighting Columns and CCTV Masts; and
- PLG07 - High Mast for Lighting and CCTV (ILP, 2013 Edition).

All new lighting shall aim to minimise the effects of obtrusive light at night and reduce visual impact during daylight. Lighting schemes shall comply with the ‘Guidance notes for the Reduction of Light Pollution’ issued by the Institution of Lighting Professionals (ILP).

High Mast Lighting (HML) as defined by PLG07 require relocation at N4 Junction 3 off-Slip Road and South Circular Road junction.

12.2.4 Lighting at Stops

The design shall include for the provision of lighting in covered areas, open areas and passenger waiting areas. The location of the lighting column shall be dictated by light spread of fittings to give the necessary level of illumination, (the columns at stops provide clearance for buses).

12.3 Traffic Signal Control

12.3.1 General

See Section 5 of this report for design details relating to traffic signal control equipment and any associated structures, ducting and cabling.

12.4 Traffic Monitoring Cameras

12.4.1 Introduction

A network of digital cameras is proposed to be introduced at key locations along the Proposed Scheme. These cameras will enable the monitoring of traffic flows along the route and provide rapid identification of any events that are causing, or are likely to cause, disruption to bus services on the route and to road users in general.

This preliminary design assumes the use of high-definition (1080p or greater) digital cameras with a digital communications network providing transmission of video and camera monitoring / control functionality.

Additionally, a mains power source will be required at each location where a camera is installed. Further details of the requirements for power and data communications are provided below. The cameras may be fixed position or pan, tilt and zoom (PTZ) depending on the most suitable option for a given location as well as general operational preferences for fixed or PTZ.

The requirement for cameras along the Proposed Scheme route and the exact locations for these cameras will be determined at detailed design stage. The initial design assumption has been for the installation of camera(s) at each traffic signal junction although it is possible that not all such junctions will require a camera and there may also be situations where a camera is required between junctions. However, the design approach outlined below applies irrespective of the camera location or the number of cameras at any given location. The proposed junction signal camera locations are shown on the Junction System Design drawings within Appendix B.

12.4.2 Camera Positioning and Mounting

The precise position of a camera at each selected location will be considered on a site-by-site basis to ensure the optimum view of the road network in the vicinity of the site. In some cases there may be a requirement for more than one camera at a location in order to obtain the required view.

The method of mounting the camera and the height at which it is mounted depends to a large extent on this position. Thus, for example, it may be possible to mount a camera on a traffic signal post (which may require a height extension to that post) or on a street lighting column. If neither of these options is feasible then it will be necessary to consider installation of a dedicated mounting post for the camera. Whichever of these mounting arrangements is used, the camera will typically be mounted at a height between 5m and 10m, with most cameras being mounted at around 6m, although again this depends largely on the scene required to be monitored at each location. It is noted that the existing approximately 20m CCTV pole at the South Circular Road Junction may need to be moved or an alternative camera arrangement installed.

Where a site requires installation of a new mounting post then consideration will be given to using a “tilt-down” post design. This will provide for easier access to the camera for maintenance operatives and will avoid the need for operatives to work at height. However, there may be space restrictions (e.g. other street furniture, nearby trees, walls and buildings) that prevent the safe operation of a tilt-down pole, in which case a “static” post will be proposed. Whichever type of new post is used, where practicable, the design will assume that the post will be mounted in a NAL-type post, or similar, socket installed at footway floor level. This will provide for easier installation as well as replacement, for example where the pole has been damaged and structurally compromised.

12.4.3 Housing of Camera Power and Communication Equipment

The requirements for power and data communications described below require installation of a cabinet and / or feeder pillar to house the termination and control equipment for power and data communications services and for any other camera control equipment that may be needed. Where a camera is located at a traffic signal junction, consideration was initially given to housing the camera power, data comms and camera control equipment within the traffic signal controller cabinet. However, this could lead to practical difficulties in terms of access for maintenance where the traffic signals maintenance provider, the camera maintenance provider and the comms network operator will all require access to the cabinet. This could also lead to operational problems, for example if a camera maintenance operative inadvertently affects traffic signal control by disabling mains power to the cabinet, or if a signals maintenance operative disables camera or comms operation in the same manner.

It was therefore considered appropriate to assume the installation of a separate cabinet for camera equipment from that of the traffic signal control equipment. However, at each traffic signal junction where a camera is installed, consideration will be given to providing a duct between the traffic signal control cabinet and the camera equipment / comms cabinet to allow the connection of the traffic signal control equipment to the data communications network, (further details of which are provided below). This would avoid the need for installation of a dedicated comms cabinet for the traffic signal control equipment.

There are sections of the Proposed Scheme where camera locations at or between junctions may be closely spaced. In such cases consideration will be given to using one camera equipment / comms cabinet to serve both camera locations in order to reduce installation costs and minimize the presence of street furniture. This may require positioning the cabinet (and its power supply) between junctions or running ducting from one junction to another. The exact requirement for this will be investigated on a location-specific basis at detailed design stage. In all cases the consideration of the siting of such roadside equipment shall prioritise the access for pedestrians and cyclists in the area and the aesthetics of the street urban landscape

12.4.4 Camera Power Supply

Modern digital cameras use a low voltage (ELV) supply - typically 12V, 24V or 48V - provided either from a dedicated mains power adapter (converting mains voltage to the required ELV) or a power-over-ethernet (PoE) injector, a device that provides the low voltage over the same cabling (Ethernet) as the data communications for the camera. PoE is generally preferred as it only requires a single cable for both power and communications. In both cases the adapter / injector is located either in the base of the camera mounting post or in a cabinet at the camera location, as described above. Wherever it is located, a mains power supply is required for it.

One advantage of mounting a camera on a street lighting column is that there is a mains power supply readily available such that, subject to availability of space, the camera power adapter may be installed in the lighting column base and connected at that point to the mains supply. There is still, however, a need for a connection from the camera to the data comms network service as described below even though power need not then be provided via the Ethernet connection to this service.

12.4.5 Data Communications

It is increasingly common for operations centres that use digital cameras to require at least high definition (HD) quality (1080p resolution) video images. To achieve this, each camera requires a high bandwidth connection, preferably with a data download speed of 10Mbits/ sec or higher. This connection is normally provided at the camera site either as a “private” connection (i.e. provided by the service owner / operator) or by a commercial service such as Eir or Virgin Media. In either case, this connection is normally terminated at a data comms cabinet installed at the camera location, as described above.

Where it is not practicable to use the existing network for a continuous fibre optic cable network the Proposed Scheme will require a new telecommunications ducting network consisting of two ducts with chambers at 180m centres along one side of the road with spurs to connect to cabinets and equipment. This will require a duct chamber at each camera location to connect the main optical fibre duct network to the camera equipment/comms cabinet. The cabinet will need to be of a design to allow installation of the required optical fibre termination equipment in addition to any camera power / control equipment and mains power supply. The number of items of equipment, and the space and power supply requirements for it, will vary according to the type of service provided. However, it will require at least one mains supply point in the cabinet, and possibly up to three such points. A standard design for this cabinet will be produced at detailed design stage.

Alternatively, each junction could contain a wireless connection to nearby optical fibre (or copper) backhaul point. However, this would require a detailed (site-by-site) understanding of requirements to determine lines-of sight, equipment mounting options / limitations, etc. both at the junction and at the optical fibre / copper backhaul point. The initial approach will therefore be to assume direct connection of each camera to the main optical fibre network and any additional requirement for wireless communication will be considered on a site-by-site basis if it is considered more appropriate to do so rather than using a direct optical fibre / copper connection.

12.4.6 Camera Ducting and Cabling Requirements

Ducting will be required to link the camera equipment / comms cabinet to the camera at each location. Where the camera is located at a traffic signal junction, the ducting used for connecting the traffic signals can be used wherever practicable and if necessary, additional ducting will then be included in order to link the traffic signal ducting to the camera equipment / comms cabinet and to the camera itself.

As mentioned above, Ethernet cabling is most often used to connect the camera to the comms service and this cable may or may not also carry power to the camera. It is generally accepted that an Ethernet cable run of up to 100m between the cabinet and camera is acceptable but beyond this signal degradation can lead to comms issues. In such cases a PoE signal extender can be introduced into the cable run. This does not need any additional power supply as it draws the power it needs from the PoE input in the cable. These devices can be cascaded along the Ethernet cable run to extend the cable distance considerably although it is sensible to coincide the location of these units with duct chambers for ease of installation and to allow for maintenance access. The detailed design stage will consider the need for this approach on a site-by-site basis where there are cable runs in excess of 100m.

12.5 Real Time Passenger Information

12.5.1 General

The design for the Proposed Scheme includes the provision of RTPI at all of the bus stops. This will comprise a “live” display identifying the estimated arrival time of each bus at the stop.

This will require a flag-type display on a dedicated mounting post, as illustrated below in Figure 12-5 Flag Type Display.

Figure 12-5 Flag Type Display

12.5.2 RTPI Display Positioning and Mounting

The RTPI display, where present, is typically located adjacent to the shelter on the same side as approaching buses so that people waiting at the stop can simultaneously view both the display and the oncoming buses. Figure 12-6 below illustrates this.

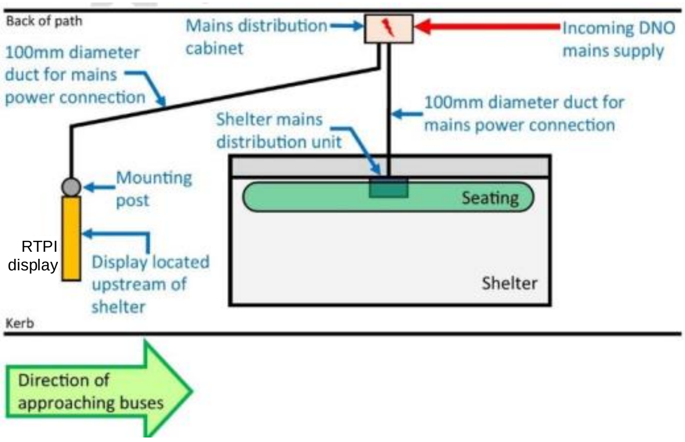

Figure 12-6 Typical Layout for Bus Stop with RTPI Display

The display is often placed around 4-5m from the shelter to maintain pedestrian access to the shelter while also enabling a clear view of the display from within the shelter. However, although this is considered the optimum position for a display, the precise location of it will be dictated by other site-based factors such as pedestrian and cyclist access (both to / from the stop and for those passing by) as well as requirements for other bus stop facilities such as waste bins, cycle storage and signage. Other physical restrictions (e.g. narrow footway, other street furniture, walls and buildings) may also influence the exact location of the display at each stop.

In any case, where an RTPI display is to be installed, the detailed design will assume that the mounting post for the display will be located in a NAL-type, or similar, post socket installed at footway floor level. As for the cameras, this will provide for easier installation as well as replacement, for example where the pole has been damaged and structurally compromised.

12.5.3 Power Supply for RTPI Display and Bus Shelter

The stand-alone design of the proposed RTPI display means that a physical link between the display and the bus shelter is not required. However, the display will nonetheless require a connection to a mains power supply. This can be shared with the supply to the bus shelter, as shown in from a mains distribution cabinet or feeder pillar located at the bus stop, where the mains service provider (DNO) will terminate its incoming connection. This cabinet / pillar will provide mains power to both the RTPI display and the shelter, assuming the bus shelter needs a mains power supply.

The bus shelter will commonly include a mains power distribution unit for all of the equipment in the shelter that requires mains power - usually lighting and /or advertising. Most often this distribution unit is located under the seating although it can vary according to the shelter design. The shelter installer will provide a connection from this unit to the cabinet / pillar containing the mains power supply for the bus stop, as shown in Figure 12-6**.**

12.5.4 Data Communications for RTPI Display

The majority of RTPI systems currently in operation now use the mobile phone (GPRS / 3G / 4G) network as the method of data communication between each display and the central (“back office”) bus location / passenger information system. This comprises a small mobile network comms device (including the SIM card) installed within the RTPI display housing. It is assumed for the purpose of this design that such connectivity will be used for provision of RTPI on the Proposed Scheme, with the mains power for the display - as described above – also providing power for this comms device. In this case no ducting will be required for data comms at the bus stop and the only physical connection to the display (i.e. ducting and cabling) will therefore be as described above for mains power.

12.6 Roadside Variable Message Signs

Consideration was also given to the inclusion of roadside Variable Message Signs (VMS) to provide traffic information to road users. However, it has been confirmed that VMS is not considered a requirement for this route and therefore such signage is not currently included in the design for the Proposed Scheme.

12.7 Maintenance

Maintenance of signs, lighting and communication infrastructure has been considered and allowed for as part of the design process.

12.8 Traffic Signals

12.8.1 Above Ground Infrastructure

12.8.1.1 Traffic Signal Poles

All traffic signal equipment is designed in accordance with Chapter 9 (Traffic Signals) of the TSM. Traffic signal modelling, including LinSig models, determines the phasing and staging of the traffic signals which determines the design and positioning of the traffic signal heads. The TSM clearly defines the requirements and positioning of traffic signal heads, detection equipment, and associated traffic signal poles.

Traffic signal poles typically come in two lengths, 3m and 6m (as measured from the ground), or single or double height poles. Single height poles will be predominantly used on the Proposed Scheme to mount traffic signal heads, push button units, and other equipment. Double height poles will be used at locations where additional visibility of the signals is required by the motorist, e.g. high-speed approaches.

Where existing traffic signal poles do not provide for a sufficient field of view for above ground detection devices, additional traffic signal poles will be erected to mount that detection equipment.

12.8.1.2 Cantilever Traffic Signal Poles

Cantilever poles will be installed on multi-lane approaches where there is a potential for a high sided vehicle, including buses, to block the clear visibility of the primary traffic signal of vehicles in the outer lanes. They will also be installed at locations where a median island is not available to mount a second primary, required to control separate streams on a particular arm of a junction.

Cantilever poles may also be used to provide a mounting structure for secondary signals, where a median is not available and a position on opposing primary pole is outside the required line of sight.

12.8.1.3 Roadside Cabinets

Most equipment locations will require a roadside cabinet to house and protect electronic, electrical and communications equipment. Due to health and safety, design, space, operational and maintenance constraints it is often necessary to separate these cabinets in accordance with their function, including:

- Traffic signal control cabinets;
- Fibre breakout cabinets; and
- Electricity supply metering, mini and micro pillars.

Cabinets are positioned to allow for ease of access by maintenance personnel and to minimise their impact on the receiving environment. When accessing cabinets, maintenance personnel will require a clear view of the associated equipment and of approaching vehicles, pedestrians, and cyclists. Cabinets are often position at the back of footways, to minimise the impact on the effective width of the footway. In all cases the consideration of the siting of such roadside equipment shall prioritize the access for pedestrians and cyclists in the area and the aesthetics of the street urban landscape. They are often clustered together at a junction to minimise the amount of cabling between cabinets and to allow maintenance personnel to quickly shift operations from one cabinet to another.

12.8.2 Under Ground Infrastructure

12.8.2.1 Ducts

Where practicable, existing chambers and ducting will be reused, each device, mounting structure, and cabinet will have associated underground infrastructure including ducts for:

- Power cables – installed equipment will require a power supply to function, this is facilitated by a ducting connection between the electricity supply point and equipment location. This connection is normally a single power supply duct;
- Communication cables – to facilitate the provision of fibre optic cable along the Proposed Scheme it will be necessary to provide a telecommunication ducting network consisting of two communication ducts, with chambers at 180m centres, along one side of the carriageway. This longitudinal ducting will be continuous along the length of the Proposed Scheme, with local duct spurs to connect to cabinets and devices; and
- Device cables – devices will require cabling between field equipment and control equipment. For example, a ring of six ducts will be provided at each junction to allow for cabling between the traffic signal controller and the traffic signal poles. It is necessary when designing the ducting provision that sufficient spare capacity is provided to allow for changes to the field equipment, deployment of additional equipment, or damage to the ducting provision.

12.8.2.2 Chambers

Chambers will be required at the termination points of ducts, at regular intervals along ducts (180m), at changes in direction, and at breakout points for devices. The position of chambers will be designed to be away from carriageways, pedestrian and cycle desire lines, and tactile paving. It is important when positioning chambers that they can be access in a safe manner, without the need, where practicable, for extensive traffic and pedestrian management. Where practicable, existing chambers will be reused.

Individual chambers will be designed and sized with consideration given to the number of ducts and cables that will be routed through the chamber, and the need to provide maintenance loops of cables within the chambers. Unless prior agreement is in place, chambers will not be shared between users.

12.8.2.3 Foundations

All cabinets, poles and mounting structures will require a foundation or mounting frame to be constructed to allow for their installation. It is envisaged that for traffic signal poles, 5m -8m CCTV poles, cantilever signal poles and other lightweight mounting structures that retention sockets will be installed to allow for the easy installation, maintenance and replacement of structures.

For larger structures, such a high CCTV masts, bespoke mass concrete foundations will be designed for incorporation into the works. Cabinet mountings will be designed and constructed in accordance with the manufactures and local authorities' standard details, including the incorporation of required vaults, chambers, earthing rods and mats.

12.8.3 Traffic Signal Priority

12.8.3.1 Overview

Further to the information discussed in Section 4.13 and Section 5.3.3 it is the intention to provide specific detection for buses located a sufficient distance from the junction to allow the traffic signal junctions to respond efficiently to the requested bus priority request. There will be further back up loop or other above ground detection provided to ensure that all vehicles permitted to use the lane will be detected although these would be standard non-priority demands.

The automatic vehicle locating (AVL) system is configured to detect when buses pass defined georeferenced locations or zones. When a bus enters these zones, a demand will be passed to the traffic signalling system. The current system capability allows this to be achieved either using local or network-based communications where the site is controlled using an overarching urban traffic control (UTC) system.

The system provided can interface with all of the junctions along the corridor, and where required other parts of the network. This will require utilising an existing, or updated version, AVL system that communicates both with the Central Dublin Sydney Coordinated Adaptive Traffic System (SCATS), in an updated version of the DPTIM SCATS centralised priority system. Options for local control include direct from optical sensors or using an AVL system interface.

The Proposed Scheme will operate on a service headway approach rather than on specific timetabled service pattern. To support this the AVL priority will need to be developed to provide priority inputs for those services that fall within the defined headway, with others receiving standard inputs. The detailed approach for implementing priority differs somewhat between the various control system however the general principle applied is as follows whereby three levels of priority are possible as shown in Table 12-1.

Table 12-1 Levels of Bus Priority

Level of Priority	Normal actions
Low	Add Phase extensions for buses arriving at the end of green.
Medium	Truncation of all non-priority phases to minimum values. Bonus green compensation for all truncated phases during following cycle, where appropriate. Phase extensions for buses arriving at the end of green.
High	Truncation of the non-priority stage to minimum value. Immediate insertion of bus priority stage. Bonus green compensation for all truncated phases during following cycle, where appropriate. Phase extensions for buses arriving at the end of green.

It is proposed that priority will be achieved using either using demand dependent bus phases that can appear within the normal cyclic operation, or by configuring some stages to be conditional demand types that would not appear when priority is being demanded. This will achieve the high level of priority without losing the overall coordination and compensation times that are needed to balance the time needed for the skipped stages.

As discussed in Section 5, the junction designs for the Proposed Scheme comprise predominately of Junction Types 2, 3 and 4. These junction types facilitate general traffic and bus through movements travelling in unison. This therefore gives BusConnects a high degree of flexibility regarding the level of bus priority applied at the respective junctions along the Proposed Scheme.

12.8.3.2 Infrastructure

Public Transport Priority will be provided through a number of passive and active means. The means of passive priority are discussed in Section 4.13 and are based on the design of the geometry, signing and road markings of the junctions. These include measures such as bus gates and bus lanes. active priority will be facilitated through the detection of the public transport vehicle and communicating their presence to the traffic signal controller for the implementation of measures on site.

The local authorities utilise different controllers and adaptive urban traffic control systems. The systems can operate in several modes including adaptive, linked, vehicle actuated, scheduled plans and fixed time modes. DCC use SCATS traffic signal controllers.

Detection will be based on the use of several different technologies, working in concert to provide comprehensive detection solutions. The detection types will include:

- Embedded Inductive loop detectors – induction detectors will be cut into the road surface at discrete positions around the junction to detect vehicles approaching, or departing from, the junction. The position and number of detectors will be dependent on the lane configuration and the type of traffic signal controller at the junctions;
- Specialised induction detectors can be utilised to detect cyclists on particular approaches to junctions. These detectors use a concentrated induction pattern to detect the passage of cyclists; and
- These embedded induction detectors will require ducting, chambers, and carriageway loop pots, to route the cables associated with the detector to the traffic signal controller.

Above ground detection, including:

- Optical detection – where it is impractical to install embedded inductive loop detectors into the carriageway, optical detection may be installed. Using these devices, a virtual detector is set up in the field of view that trigger alerts to the traffic signal controller. Optical detectors are generally installed on existing traffic signal poles, or cantilever traffic signal masts, to provide a clear view of the approach. Additional poles may need to be installed to provide the optimum field of view for particular approaches; and

- Radar detection – Radar detection is used for pedestrian crossings, pedestrian wait areas, and cycle detection. Similar to the optical detection, virtual detection zones are set up in the radar field of view that trigger alerts to the traffic signal controller. Radar detectors are generally installed on existing traffic signal poles, or cantilever traffic signal masts, to provide a clear view of the approach. Additional poles may need to be installed to provide the optimum field of view for particular approaches.

Push button units (PBU) will be installed on traffic signal poles at pedestrian and cycle crossing points to allow the user to manually alert the traffic signal controller of their presence. The use of on crossing detection can also be configured at key locations to extend pedestrian crossing phases, where necessary.

Additional inputs from the AVL system and dedicated short range communications (DSRC) devices can be provided to notify the Traffic Signal Controller of the presence of particular vehicles.

The traffic signal controllers will detect the presence of vehicles, including identification of particular vehicles classes, and use this data to determine the timing to be applied to the junction in the current and upcoming cycles, including the provision of priority to particular traffic signal phases as programmed into the traffic signal plans.

12.8.4 Communication

Communications will be used to connect on-street devices with the traffic control rooms. The communications will take the form of:

- Fibre optic cable network:
- All local authorities operate fibre optic cable networks. It is envisaged that where appropriate each of these networks will be extended in the Proposed Scheme to provide high bandwidth / low latency communication to traffic signal controllers, CCTV cameras, and other apparatus deployed on the Proposed Scheme;
- Longitudinal ducting, provisionally two communications ducts, will be provided as required along the length of the Proposed Scheme with access chambers at 180m centres;
- Fibre breakout cabinets will be provided at each traffic signal controller, or CCTV camera;
- Microwave wireless point-to-point links - Where it is not practicable to install ducting for fibre optic cable, or there is a need to provide a high bandwidth / low latency communication to a remote site or cell, point-to-point microwave communications will be provided to facilitate the communications link; and
- Cellular subscriber networks (3G / 4G / 5G) - Cellular communications will be provided to low bandwidth devices such as RTPI and VMS.

12.9 Safety and Security

12.9.1 CCTV

CCTV poles will be placed at positions, within the junction, to minimise the impact of solar glare, and to maximise the field of view of the CCTV. The requirement for CCTV along the Proposed Scheme route and the exact locations for these cameras will be determined at detailed design stage. The locations of CCTV have been indicated in the system design drawing for planning purposes. The initial design assumption has been for the installation of camera(s) at each traffic signal junction although it is possible that not all such junctions will require a camera and there may also be situations where a camera is required between junctions. However, the design approach adopted applies irrespective of the camera location or the number of cameras at any given location.

12.9.1.1 Bus Stops

The requirement for a pleasant, safe and secure environment for passengers waiting at Stops and undertaking their journeys is a key component of the proposed public transport service. This is facilitated by the provision of:

- RTPI – each stop will be provided with RTPI showing the estimated time of arrival of subsequent buses, and
- Public lighting – each stop will have public lighting designed to ensure the safe operation of the stops in all lighting conditions and to enhance the sense of security at the stops.

12.10 Maintenance

All traffic signal, CCTV, and communications equipment shall be designed and located to be accessed and maintained frequently. All equipment shall be accessible without disrupting pedestrian, bicycle, or vehicle traffic and without the use of special equipment.

Apparatus will be designed and located to allow for easy access and the safe maintenance of the Proposed Scheme into the future. This will include the provision of:

- Use of retention sockets, where applicable, for the erection of traffic signal, CCTV, above ground detection, and other equipment mounting poles to allow for the ease of installation, maintenance and replacement;
- The use of lightweight equipment poles, where appropriate, such as cantilever signal poles. Consideration will be given to the selection of products that allow for maintenance activities to be undertaken from ground level, such as tilt down poles or poles with wind-down mechanisms;
- Placement of poles and retention sockets within 7m of chambers to provide ease of installation and replacement of cables;
- Locating chambers away from pedestrian desire lines, and areas of tactile paving. This is to provide for a reduced impact of traffic management;
- On longitudinal duct runs, chambers to be placed at 180m centres to allow for the ease of installation and replacement of cables;
- Safe areas to be provided for the access and parking of maintenance vehicles; and
- Locating controller, and other, cabinets in positions that allow for safe access and clear visibility of the operation of the junction.

13 Land Use and Accommodation Works

13.1 Summary of Land Use

The land use along the Proposed Scheme comprises a mix of agricultural, amenity, residential and commercial properties. The various land uses are described in the sections below. The extent of the impact due to the Proposed Scheme on a landowner's holding is shown on the Compulsory Purchase Order (CPO) Deposit Maps. The total area that lies within the proposed road development boundary is approximately 48ha. including the existing roads and footways.

The following is a description of the land use along the Proposed Scheme divided into 3 sections.

13.1.1 N4 Junction 3 to M50 Junction 7 – N4 Lucan Road

Between Junction 3 of the N4 Lucan Road and the M50, the northern side of the Proposed Scheme is predominantly bounded by open agricultural land, amenity lands (Hermitage Golf Club), land / car parking for the Hermitage Medical Clinic, low density residential properties along Old Lucan Road and the grounds of the King's Hospital School. There is one commercial property located between the golf club and medical clinic.

Between Junction 3 and Junction 2 of the N4 the southern side of the Proposed Scheme is bounded by residential development, as well as a small number of commercial properties. Between Junction 2 of the N4 and the M50 the adjacent land use comprises the Liffey Valley Office Campus and the carparks serving the Liffey Valley Shopping Centre,

Lands are required from the properties on the northern side of the Proposed Scheme between N4 Junctions 3 and 2 to facilitate the provision of the proposed two-way cycle track, which will form Primary Cycle Route 6 in the GDA Cycle Network Plan. Land is also required to provide improved bus priority on the approach to the N4 Junction 3 westbound off slip and the upgraded bus stops serving Liffey Valley Shopping Centre and Office Campus. Retaining walls are proposed to minimise the land take from the agricultural land, the Hermitage Golf Club and the Hermitage Medical Centre to the north, and the Liffey Valley Office Campus to the south.

Temporary land take is required within this section to facilitate:

- The construction of retaining walls RW01, RW02 and RW06;
- The construction of new boundary walls to the agricultural land to the north of N4 Junction 3, Sureweld and the Foxhunter site;
- Substantial additional planting at Hermitage Golf Club;
- The construction of the steps and ramps that will connect the new pedestrian bridge and bus stops to the Liffey Valley Shopping Centre; and
- A construction compound at the northern roundabout of the N4 Junction 2.

13.1.2 M50 Junction 7 to R148 Con Colbert Road – R148 Palmerstown bypass and Chapelizod bypass

From the M50 to the start of the Chapelizod Bypass the route of the Proposed Scheme is predominantly bounded by residential development on both sides, as well as the River Liffey Conservation Area on the northern side. There are also a small number of commercial properties on the route over this section.

The R148 Chapelizod Bypass is contained within an established and heavily planted road corridor. At the eastern end of the bypass the Proposed Scheme is bounded by the River Liffey to the north and Liffey Gaels Park to the south.

Lands are required through this section to facilitate the proposed two-way cycle track on the eastern side of Kennelsfort Road Lower and the widening of the Old Lucan Road at its junction with the R148 Palmerstown bypass / the Oval to facilitate a new bus lane for services to Palmerstown village. All other works are contained within publicly owned land that is primarily part of the road corridor.

Temporary land take is required within this section to facilitate:

- The construction of new boundary walls to the Palmerstown Lodge Hotel and Applegreen service station.

13.1.3 R148 Con Colbert Road to City Centre (Frank Sherwin Bridge) – St John's Road West

From the Con Colbert Road to the South Circular Road the Proposed Scheme is contained in a constrained corridor bounded by the National War Memorial Gardens to the north and the Kildare rail to the south. The rail line passes under the South Circular Road and then forms the northern boundary of the Proposed Scheme from that junction to Heuston Station. On the southern side of this section the Proposed Scheme is bounded by the grounds of the Royal Hospital Kilmainham, the Heuston South Quarter development and a number of publicly owned land and buildings, most notably HSE Ireland's head quarters at Dr Steevens Hospital.

Lands are required through this section to facilitate the enhanced bus stops opposite Heuston Station on the south side of St John's Road West at Dr Steevens Hospital.

Temporary land take is required within this section to facilitate:

- The construction of new urban realm / planting scheme at Dr Steevens' Hospital; and
- A construction compound at Liffey Gaels Park.

13.2 Summary of Compulsory Land Acquisition

From the outset of the design of the Proposed Scheme every effort was made to avoid compulsory land acquisition. However, there are a number of public and private lands that are necessary for the construction of the proposed road development and to secure the many benefits for the Proposed Scheme.

Reference should be made to the CPO documents prepared as part of the planning application for further details.

In total approximately 2.03ha. of land will be required to be permanently acquired to construct the Proposed Scheme, of which approximately 1.37ha is currently in public ownership. There will also be an additional 2.47ha of temporary land required to allow for construction of boundary treatment, planting, construction compounds and surface tie in work. This includes approximately 0.88ha currently in public ownership.

13.3 Summary of Impacted Properties

The determination of the lands to be acquired for purposes of constructing the Proposed Scheme was as a result of an iterative design process, including non-statutory public consultation and detailed engagement with potentially impacted owners and occupiers.

The list of properties that are impacted by the Proposed Scheme are summarised below in Table 13-1, Table 13-2 and Table 13-3.

13.3.1 N4 Junction 3 to M50 Junction 7 – N4 Lucan Road

Table 13-1 List of Impacted Properties from N4 Junction 3 to M50

Address	Permanent Land Take	Temporary Land Take
Site in the Townland of Woodville, Lucan Road, Lucan, Co. Dublin	Y	Y
Site of Foxhunter Public House, Ballydowd, Lucan, Co. Dublin, K78 P285	Y	Y
Hermitage Golf Club Access Road, Lucan Road, Lucan, Co. Dublin	N	Y
Hermitage Golf Club, Lucan Road, Lucan, Co. Dublin	Y	Y
Sureweld International Limited, Lucan Road, Lucan, Co. Dublin, K78 EH50	Y	Y
Hermitage Medical Clinic, Old Lucan Road, Fonthill, Co. Dublin, D20 W722	Y	Y
Block B Liffey Valley Office Campus, Dublin 22, D22 X0Y3	Y	Y
Liffey Valley Shopping Centre, Dublin 22, D22 R6K8	Y	Y

13.3.2 M50 Junction 7 to R148 Con Colbert Road – R148 Palmerstown bypass and Chapelizod bypass

Table 13-2 List of Impacted Properties from M50 to R148 Con Colbert Road

Address	Permanent Land Take	Temporary Land Take
Palmerstown Lodge Hotel, 22 Kennelsfort Road Lower, Dublin 20, D20 DC99	Y	Y
Palmerstown Lodge Hotel, 20 Kennelsfort Road Lower, Dublin 20, D20 CX86	Y	Y
Applegreen, Palmerstown Service Station, Lucan Road, Dublin 20, D20 K720	Y	Y
Liffey Gaels Park Sarsfield Road, Dublin 8	N	Y

13.3.3 R148 Con Colbert Road to City Centre (Frank Sherwin Bridge) – St John's Road West

Table 13-3 List of Impacted Properties from Con Colbert Road to Frank Sherwin Bridge

Address	Permanent Land Take	Temporary Land Take
Dr Steevens' Hospital, Steeven's Lane, Dublin 8, D08 W2A8	Y	Y

13.4 Demolition

The existing pedestrian bridge at Ballyowen Road across the N4 Lucan Road will be removed.

At Liffey Valley Shopping Centre the existing pedestrian bridge ramp on the south side will be removed. The residual terrace will remain and be replanted accordingly.

The wing walls on the existing R148 Palmerstown bypass overbridge at Chapelizod Hill Road will demolished to facilitate bridge widening.

Boundary walls and railings will be removed and replaced as part of the works as listed in Table 13-1and Table 13-2 above.

With the exception of the aforementioned, there is no other requirement for the demolition of any notable infrastructure along the extents of the Proposed Scheme.

13.5 Summary of Accommodation Works and Boundary Treatment

The locations for proposed new boundary treatments along the Proposed Scheme have been provided in Table 13-1 and also shown on the SPW_BW Fencing and Boundary Treatment Plans located in Appendix B.

For boundary treatment requirements the following criteria has been used to calculate the area of temporary land take needed during construction:

- Walls < 0.9m – Typically 2m working room offset for temporary land take;
- Fences etc – > 3m offset for temporary land take;
- Significant retaining walls – 5m offset for temporary land take; and
- Specific structures (bridges etc) – as required.

To maintain the character and setting of the Proposed Scheme, the approach to undertaking the new boundary treatment works along the corridor is replacement on a 'like for like' basis in terms of material selection and general aesthetics unless otherwise noted on the drawings.

All reasonable precautions to prevent pollution of the site, works and the general environment including streams and waterways will be taken. All demolition waste to be segregated and, where practicable, sent for recycling. All in accordance with guidelines as set out by the National Construction and Demolition Waste Council (NCDWC).

A waste management plan following guidelines as set out by the NCDWC shall be produced outlining the proposals with respect to waste recycling, segregation and details of landfill proposals with target percentage of each element. The following legislation should be noted:

- Protection of the Environment Act 2003;
- Waste Management (Amendment) Act 2001;
- Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste;
- EU Council Decision on Waste Acceptance (2003/33/EC);
- Waste Management Amendment Act (#2) 2001;
- Protection of the Environment Act No. 27 2003;
- Best practice Guidelines on the preparation of Waste Management Plans for Construction and Demolition Waste; and
- Department of Environment, Heritage and Local Government July 2006.

14 Landscape and Urban Realm

14.1 Overview of Landscape and Urban Realm

Urban Realm refers to the everyday street spaces that are used by people to shop, socialise, play, and use for activities such as walking, exercise or commute to / from work. The urban realm encompasses all streets, squares, junctions, and other rights-of-way, whether in residential, commercial or civic use. When well designed and laid out with care in a community setting, it enhances the everyday lives of residents and those passing through. It typically relates to all open-air parts of the built environment where the public has free access. It would include seating, trees, planting and other aspects to enhance the experience for all. Successful urban realms or public open space tend to have certain characteristics.

- They have a distinct identity;
- They are safe and pleasant;
- They are easy to move through; and
- They are welcoming.

The following are the key policy and strategy documents that have been considered as guidance in developing the proposals for the BusConnects landscape and urban realm proposals.

BusConnects Dublin – Urban Realm Concept Designs

The following document BusConnects Dublin - Urban Realm Concept Designs, https://busconnects.ie/media/2089/busconnects-urban-realm-concept-designs.pdf was used as guidance in developing the proposals. The NTA published this document to present and describe outline objectives for enhancing the public realm of the Core Bus Corridors for walking, cycling and bus infrastructure. The analysis and the design principles set out in this section of the report relate directly to the following objectives;

- Enhance the capacity and potential of the public transport system;
- Enhance the potential for cycling;
- Support the delivery of an efficient, low carbon and climate resilient public transport service;
- Enable compact growth, regeneration opportunities and more effective use of land;
- Improve accessibility to jobs, education and other social and economic opportunities; and
- Ensure that the public realm is carefully considered in the design and development of the transport infrastructure and seek to enhance key urban focal points where appropriate and feasible.

Dublin City Development Plan 2016-2022

Section 9, Sustainable Environmental Infrastructure states in policy SI18 a requirement to use Sustainable Urban Drainage Systems (SuDS) in all new developments where appropriate, as set out in the Greater Dublin Regional Code of Practice for Drainage Works.

Section 10.5.6 Biodiversity, states in policy GIO24 a requirement to support the implementation of the Dublin City Biodiversity Action Plan 2015-2020.

Section 10.5.7 Trees. The Dublin City Tree Strategy provides the vision and direction for long-term planning, planting, protection and maintenance of trees, hedgerows and woodlands within Dublin city. Policy GIO28 states the need to identify opportunities for new tree planting.

Dublin City Tree Strategy 2016-2020

A set of policies for the long-term promotion and management of public trees in Dublin. “Within the city, trees clean the air, provide natural flood defences, mask noise and promote a general sense of wellbeing”.

Dublin City Biodiversity Action Plan 2015-2020

Covers all areas of the City including roadsides and footways and reflects the Strategic Objectives of Ireland’s National Biodiversity Plan (Actions for Biodiversity 2011-2016)

- Strengthen the knowledge base of decision makers to protect species and habitats;
- Strengthen the effectiveness of collaboration between all stakeholders for the conservation of biodiversity in the greater Dublin region;
- Enhance opportunities for biodiversity conservation through green infrastructure and promote ecosystem services in appropriate locations throughout the city; and
- Develop greater awareness and understanding of biodiversity and identify opportunities for engagement with communities and interest groups.

14.2 Consultation with Local Authority

Consultation has taken place with DCC and SDCC throughout the design process. Stakeholders and statutory bodies including the OPW have been consulted through the process as well as through the public consultations and various scheme presentations.

14.3 Landscape and Character Analysis

The landscape and urban realm proposals are derived from analysis of the existing urban realm, including existing character, any heritage features, existing boundaries, existing vegetation and tree planting, and existing materials. The BusConnects Dublin - Public Realm Assessment (Figure 14-1) was undertaken as guidance in developing the proposals. For each section of the route, the team took a broad overview of building style, extents of vegetation and tree cover, the predominant mixes of paving types, appearance of lighting features, fencing, walls, and street furniture was considered. The purpose of this analysis was to assess the existing character of the area and how the BusConnects Infrastructure Dublin proposals may alter this. The outcome of the analysis allowed the urban realm design team to consider appropriate enhancement opportunities along the route. The enhancement opportunities include key nodal ‘Potential Development Opportunities’ (PDO) which focus on locally upgrading the quality of the paving materials, extending planting, decluttering of streetscape and general placemaking along the route. These areas are further discussed in Section 14.7.

Where practicable, a SuDS approach will be taken to assist with drainage along the route. SuDS principles will be used as much as practicable to deal with run-off at, or close to, the surface where rainfall lands.

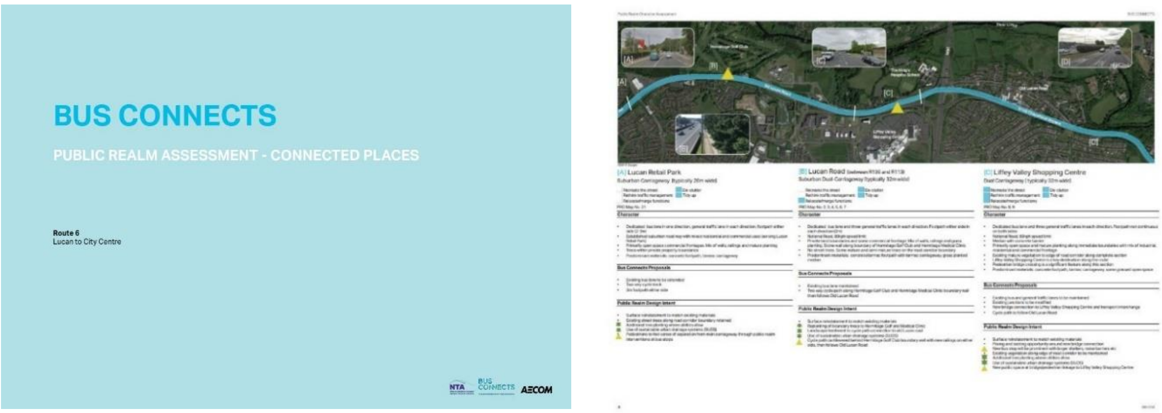

Figure 14-1 Cover Page and Analysis Excerpts from Public Realm Assessment Report

14.4 Arboricultural Survey

14.4.1 Scope of Assessment

An Arboricultural Impact Assessment Report identifies the trees, groups of trees, or hedgerows that may be impacted by the Proposed Scheme, along with suitable mitigation measures, as appropriate. The Tree Protection Plan identified trees to be removed, and the Arboricultural Method Statement set out how retained trees will be successfully protected. A copy of the report has been provided in Appendix D and the inputs from the report have been incorporated in the Landscaping Drawings in Appendix B.

The assessment was informed by an extensive tree survey based on the requirements of BS5837:2012 Trees in relation to design demolition and construction – Recommendations (BS5837).

The Arboricultural Impact Assessment sets out the likely principal direct and indirect impacts of the Proposed Scheme on the trees on or immediately adjacent to the site, and suitable mitigation measures to allow for the successful retention of significant trees, or to compensate for trees to be removed, where appropriate.

The report considered the following:

- Description of the site / route and summary of the trees surveyed;
- Summary of any statutory or non-statutory designations affecting trees within the survey area;
- A brief summary of trees to be removed;
- Outline guidance for the design team and any key considerations, or issues which need to be addressed;
- Schedule of surveyed trees and key;
- Recommendations for tree works and incursions related to the Proposed Scheme; and
- Tree Constraints Plans.

14.5 Hardscape

14.5.1 Design Principles

In the development of the preliminary design proposal, the following elements were analysed and considered:

- The character of each section including building typologies, uses, scale, pedestrian environment, landmarks, landscape character and any other relevant place attributes;
- Assessment of the scheme proposals and any impacts to the local setting that may need mitigation; and
- Preparation of conceptual public realm design responses for each section that are in keeping with the local character and in line with the objectives of the Proposed Scheme in particular; to ensure that the public realm is carefully considered in the design and development of the transport infrastructure and seek to enhance key 'Potential Development Opportunities' where appropriate and feasible.

14.5.2 Typical Material Typologies

Through the process of developing the Preliminary Design a typology and palette of proposed materials was developed to create a consistent design response for various sections of the route. The proposed materials were based on the existing landscape character, existing materials, historical materials while also identifying areas for betterment through the use of higher quality surface materials.

The proposed material typologies employed in the preliminary design are described as:

- **Poured in situ concrete pavement** - Used extensively on existing footways. Concrete pavements can be laid without a kerb, can have neatly trowelled edges and textured surface for a clean, durable, slip resistant surface;
- **Asphalt footway** - Widely used on existing footways and will tie in with other sections of public realm. Laid with a road kerb, can have a smooth finish or textured aggregate surface, provides a strong flexible slip resistant surface. Opportunities to retain good quality kerbs have been explored and tie-in points considered;
- **Precast concrete unit paving** - Either concrete paving slabs or concrete block, there is a very wide variety of sizes and colours available to provide an enhanced public realm. The use / reuse of granite kerbs where appropriate will further enhance the public realm. This type of material use is mostly employed in non-inner-city public realm enhancements;

- **Natural stone paving** - Employed for high quality urban realm areas, mostly in city centre locations. This typology represents natural stone surface treatments such as granite and are used to create enhanced public spaces for major urban realm interventions;
- **Stone or concrete setts** - Proposed for distinguishing pedestrian crossing points either on raised table or at road level;
- **Self-binding gravel** - Proposed for pedestrian paths set away from the road expected to see less traffic. Used for natural areas, for example, paths through wildflower meadows. They provide a defined informal route as an alternative to asphalt or concrete; and
- **No change** - In addition to areas with proposed material changes, there were also areas identified where no change in materials would be required. For example, where pavement has recently been laid and is in good condition. The design also explores opportunities where good quality kerbs such as granite kerbs could be reused, which would have both cost and sustainability advantages.

Other design responses include:

- **Boundary treatments** to both commercial and residential properties. Opportunity exists to take the best examples of existing boundary treatment and reinstate them, while improving other sections of the road frontage;
- **Tree pit enhancements** will be undertaken, using materials such as self-binding gravel. Consideration has also been given to the construction of tree pits to include in-ground root protection systems to improve both the vitality of the trees and the life span of the pavements; and
- **Street furniture** is mostly confined to replacing or relocating existing furniture, there is opportunity at Potential Development Opportunity (PDO) areas to provide additional street furniture where it would most enhance the communal spaces.

14.6 Softscape

14.6.1 Tree Protection and Proposed Planting

The first priority of the landscape strategy is to protect existing trees along the route, where practicable. As such, the initial conservation of the existing has been considered. The arboricultural survey identified the quality of existing trees. The information was overlaid on the proposed routes to inform the design process. No-dig construction is proposed where the Proposed Scheme will be in close proximity or under the canopy of existing trees to reduce impact of road works. Review and re-design of the alignment and extent of proposals through sensitive areas has minimised the loss of high-quality trees.

The following key areas are some of the more significant examples of potential conflicts where the road layout was reconfigured to preserve the trees.

- **Lucan Road, Chainage C150 to CC280**

Trees will be protected during road widening to introduce the cycle track by erection of a piled wall to reduce the extent of site works and limit potential damage to the root zone.

- **N4, Chainage A500- A900**

Introduction of the two-way cycle track will result in the loss of a row of existing trees at the Hermitage Golf Course. The overall extent of tree cover will be increased by planting approximately 200 semi mature, native trees.

- **Old Lucan Road, Chainage J300 – J500 and J750 - J800**

Resurfacing works to the footway and cycle track will be undertaken under the canopies of existing trees by using hand excavation only. A proprietary 3D cellular confinement system will be used to allow the new pavement to be installed without and protect the rootzone of trees along the boundary of the route.

- **Palmerstown bypass, Chainage A3750 – A3950**

In the area of the loss of a group of seven trees at the bus shelter adjacent to the existing foot bridge infill planting of 32 new semi mature trees is proposed.

- **Junction of Chapelizod bypass with Con Colbert Road, Chainage A7550**

The potential temporary site compound at Liffey Gaels Park has been configured to preserve the existing trees.

- **Junction of Con Colbert Road with Memorial Road, Chainage A7850**

The pedestrian crossing has been configured to preserve the median trees.

- **St John's Road West Chainage A8800 to A9100**

Existing trees in a narrow grass strip will be protected and retained by means of allowing only hand dig under the tree canopies and by laying the new footway and cycle tracks over a cellular confinement system.

- **St John's Road West Chainage A9500 to A9500**

Existing trees in front of Dr Steevens' Hospital are being retained, except for one relatively young tree to be removed for the road widening. Planting of new trees are being introduced in keeping with the formal character of the building entrance.

14.6.2 Tree Loss and Proposed Planting

Despite the best efforts to protect trees, especially trees of a mature and significant stature there will be inevitable impacts on local trees. In total there will be 301 trees lost, refer to Table 14-1 below. This loss has been addressed through a substantial tree planting plan with a net increase of 164 additional semi-mature trees along the Proposed Scheme, as outlined in the planting strategy (section 14.6.3) below.

Table 14-1 Summary of Trees Retained, Removed and Proposed as part of the Proposed Scheme

Retained Street Trees	Removed Street Trees	Proposed Street Trees	Total Trees in Development
Total retained in development	Total identified tree numbers lost	Street trees planted	Proposed Scheme
1402	**-301**	**465**	**1566**

14.6.3 Planting Strategy

The planting strategy has been developed to meet the objectives of the Proposed Scheme and the needs of the Dublin City Tree Strategy and the Dublin Biodiversity Action Plan. To have an influence on the local environment to improve amongst others: air quality; stormwater runoff; health and well-being; and habitat provision.

- Where practicable the initial conservation of existing biodiversity has been considered. The Arboricultural Survey identified the quality of existing trees. The information was overlaid on the proposed routes to inform the design process;
- Opportunities have been identified to enhance biodiversity through green infrastructure;
- Promote the role of street trees planting consistent with the recommendations of the Dublin City Tree Strategy; and
- Develop the role of SuDS opportunities within the scheme in coordination with the drainage engineers. Refer Drainage, Hydrology and Flood Risk Section 9 of this report.

14.6.4 Typical Planting Typologies

Several typologies were developed to address the above issues. Details of the proposed tree species and planting regime are provided on the ENV_LA Landscaping General Arrangement Drawings in Appendix B. Additional information on suitable plant species is also provided in Section 14.7.7.

- **New Street Trees** - Large canopy trees with 4.5m clear stem planted in urban tree pit systems to allow for protection of the soil structure and good root development.

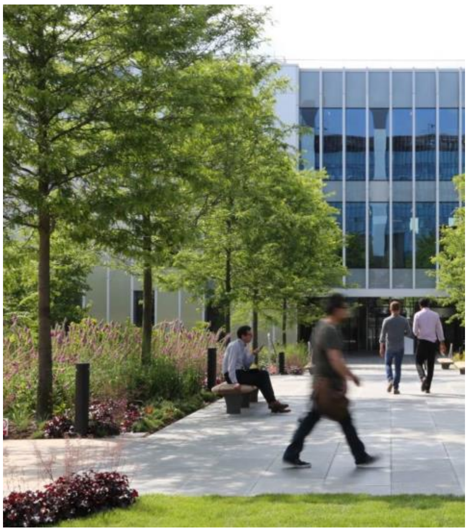

Figure 14-2 Tillia Cordata (Semi Mature tree)

Figure 14-3 Semi Mature Street Trees

- **Central Median Screen Planting** - Combination of tree and shrub planting to reduce head light glare where appropriate and add a corridor of planting.

Figure 14-4 St John's Road West Existing Dense Planting to Median

- **Replacement Planting to Boundaries** - Direct replacement of trees and hedgerows lost to road widening, or introduction of hedgerows to soften fence lines. Reconsider the species to be planted for long term sustainability, disease resistance and enhanced biodiversity.

Figure 14-5 Replacement of Boundaries (For Example Interface with Hermitage Golf Club)

- **Native Woodland Planting (Woodland Copses)** - Opportunity for dense native species mixes exist in spaces not readily accessible at junctions or wider verges. Promote native trees with understorey woodland fringe planting and swathes of bulbs.

Figure 14-6 Woodland Copses

- **Species Rich Grassland Planting** – Substantial areas of grass verges and underutilised open space are associated with the existing national roads, given constraints on planting due to services, sightlines and ground conditions it is proposed where practicable to reinstate grasslands as a species rich sward with improved biodiversity and benefits for pollinators and native wildlife.

Figure 14-7 Species Rich Meadow Grassland

- **Commercial Boundary Planting** - Commercial boundaries vary greatly; however, they are mostly of robust nature, concerned more with security than visual appearance. Therefore, they offer great opportunity for introduction of new green infrastructure in hedgerows and boundary trees. They can offer an immediate visual improvement to the appearance of many areas and likewise provide opportunity for improved biodiversity.

Figure 14-8: Commercial Boundaries Provide Opportunities for New Tree Planting and Hedgerows

14.7 Proposed Urban Realm Design

14.7.1 General Introduction to Proposed Design

The Urban Realm design is presented at 1:500 scale on combined hard and soft landscaping general arrangement drawing layout plans presented on the ENV_LA landscaping general arrangement series in Appendix B Separate (illustrative) drawings will be provided below to further illustrate proposals for Potential Development Opportunities (PDO) areas, (placemaking, enhancement opportunities).

Much of the route of the Proposed Scheme already has a priority bus lane in place, lined with mature trees, and a planted median. The overall aim is to enhance the tree lined route and improve open spaces.

The primary opportunities for improved urban realm were identified at the junctions where landscape proposals were developed as described below.

14.7.2 Section 1: N4 Junction 3 to M50 Junction 7 – N4 Lucan Road

The proposed scheme starts at Junction 3 of the N4. The character here is of an established suburban roadway with mixed residential and commercial uses. Frontages are primarily open space commercial frontages with a mix of boundary types. There are mature trees within private property boundaries. An existing 'Welcome to Lucan" sign will be relocated along with existing bike lockers and a bike maintenance station, hedge and tree planting will enhance the appearance of the junction as a local gateway to Lucan.

Along the N4 (Lucan Road) it is proposed to maintain the existing bus lanes ensuring disruption to the public realm along this stretch is minimal. Boundary planting along the Hermitage Golf Club will be removed to accommodate the cycletrack and replaced with infill planting to the roadside and additional infill woodland planting to the southern edge of the fairway. The existing stone wall will be reconstructed to the new boundary and 15m high sports netting will be provided between the new boundary wall and the infill planting (refer to Figure 14-9).

Additional bus stops are to be provided in the vicinity of the Liffey Valley Shopping Centre. To better serve the increased capacity a new footbridge is proposed 200m west of the existing footbridge. Changes to the layouts around both the existing and proposed bridges have been proposed to improve the accessibility. Introduction of native woodland planting to the N4 roadside embankments will provide visual screening of the footbridge ramps. Further opportunities for tree planting are limited at the M50 Junction 7, but existing native woodland planting will be maintained.

Figure 14-9 Design Intent Sketch - Segregated Two-way Cycle Track Proposed Adjacent to Hermitage Golf Club

On the south side of the N4 a pedestrian priority zone is provided between the existing foot / cycle bridge over the N4 adjacent to the Mount Andrew estate and Ballyowen Lane. From there a quiet street cycle treatment is proposed through Hermitage Park, along Hermitage Road to R136 Ballyowen Road. Existing trees are retained along Hermitage Road, Ballyowen Lane and at the junction with the westbound service road. New street tree planting of maples and tulip trees is proposed on the Old Lucan Road adjacent to the SDCC Depot to provide contrasting species and a variety of summer and autumn colours.

14.7.3 Section 2: M50 Junction 7 to Con Colbert Road

From the M50 junction with the R148 the proposed scheme segregates the bus lanes from the cycleway, with the former routed along the R148 Palmerstown bypass, while the cycle track and footways follow the Old Lucan Road. Traffic calming measures are introduced along the Old Lucan Road with paved raised tables to improve pedestrian access. On the bypass existing vegetation is to be retained, and further tree planting is proposed to open grassland near the Palmerstown Lodge, at the junction with Kennelsfort Road, and the junction with Old Lucan Road and the Oval.

The cycle track can be accommodated within the existing public realm and avoid any loss of trees (refer to Figure 14-10). In addition, a new segregated two-way cycle track is proposed to run along the east side of Kennelsfort Road Lower before crossing the R148 Palmerstown bypass.

Figure 14-10 Design Intent Sketch - Two-way Cycle Track Along the Full Length of Old Lucan Road by Reallocating Road Space

14.7.4 New Bus Stop Access at Chapelizod bypass

The Chapelizod Hill Road ramp and walkway look to create a connection from Chapelizod Hill Road to the proposed Chapelizod bypass bus stops. This has been achieved on the Northern side of the bypass by utilizing a switch back ramp arrangement with integrated steps. The ramp is integrated into the buffer planting edge using green wall systems to create a soft interface with the existing context while retaining existing tree planting. High quality paving will delineate the ramp access on Chapelizod Hill Road, connecting the ramp access space and creating a newly defined area in the public realm. Ornamental planting within the ramp structure will create a pleasant walking area to the new bus stops on the R148 Chapelizod bypass. The walkway on the south side of the bypass will integrate into the existing landscape to create a gradual walking route and steps to the proposed bus stop. Existing planting will be retained and supplemented to further enhance the walkway into the urban realm.

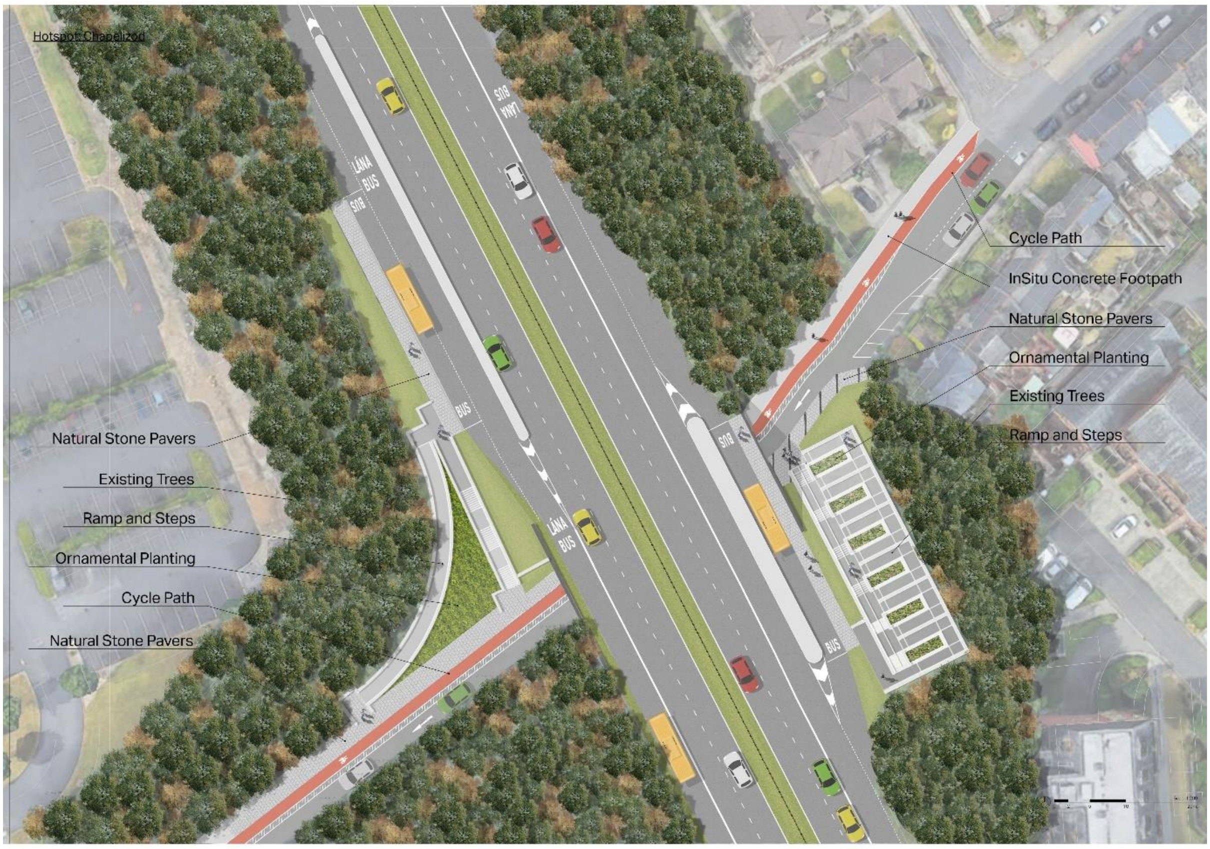

Figure 14-11: PDO Design Intent - Chapelizod Ramps

14.7.5 Section 3: R148 Con Colbert Road to Frank Sherwin Bridge – St John's Road West

Some reallocation of space has been required to accommodate cycle tracks on Con Colbert Road, however the impact on the public realm along this stretch has been minor and it is proposed to retain the existing mature vegetation fronting the Irish National War Memorial Gardens opposite the R839 Memorial Road junction. This is a significant junction and will provide improved pedestrian access to the Irish National War Memorial Gardens and opportunity for an enhanced entrance feature. New concrete paving to footways that will connect R839 Memorial Road to the new bus stop locations on either side of R148 Con Colbert Road. Additional tree planting is proposed to the existing median to soften and complement the character of the area.

In order to improve the standard of pedestrian and cyclist facilities at the South Circular Road junction, the number of general traffic lanes through the junction will be reduced in the eastbound, northbound and southbound directions and the R111 South Circular Road is widened along the western edge through the junction to facilitate the inclusion of segregated cycle tracks in each direction. The proposed junction reconfiguration will impact on all of the existing landscaped islands; however, additional trees have been proposed where practicable.

On the R148 St John's Road West between the R111 South Circular Road junction and Heuston Station the existing eastbound lane configuration of one bus lane and one single general traffic lane is proposed to be maintained. In the westbound direction of R148 St John's Road West, a continuous bus lane is to be provided instead of one of the two general traffic lanes.

Along St John's Road West additional trees will need to be removed and replaced so that facilities for both taxis and bicycles can be provided on the approaches to Heuston Station. An urban realm landscaping improvement is proposed along the affected length of the road as far as the train station. This includes the removal of the pedestrian guard railing and new planting, which will result in a net increase in the number of trees along the road (refer to Figure 14-12 and Figure 14-13).

Figure 14-12 Design Intent Sketch - Additional Tree Planting, Improved Pedestrian Connection and Inclusion of a Cycle Track

14.7.6 Interface at Heuston Station and Dr Steevens' Hospital

The scheme will incorporate an upgrade and declutter of the public realm around Heuston Station to include wayfinding, street furniture and new natural stone paving throughout. The existing pedestrian guardrail within the median will be replaced with ornamental shrubs. Raised pedestrian crossing points will be paved with natural stone to improve pedestrian connectivity. The existing heritage lighting columns and post boxes to be retained and relocated within the proposed scheme.

Adjacent to Dr Steevens' Hospital the existing boundary with St John's Road West will be re-configured to create a public realm space that responds sensitively to the surrounding architecture whilst creating a public realm space that balances the needs of cyclists / pedestrians and bus stop locations. The proposed road alignment has been designed to maintain the majority of existing trees, in particular a large Category A tree located at the northwest corner of the existing lawn. The introduction of formal tree planting and hedgerows along with raised seated edges will help re-define this interface. The existing pedestrian path from Steeven's Lane will be maintained and incorporated into the new public realm, (refer to Figure 14-13).

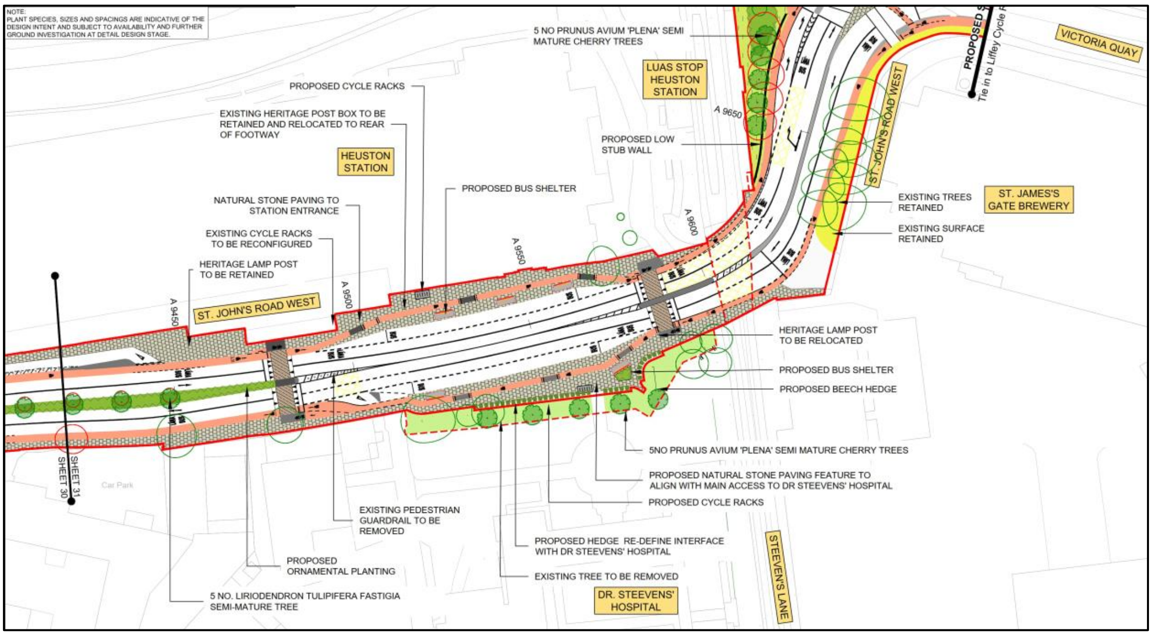

Figure 14-13 Public Realm Improvements at Heuston Station and Dr Steevens' Hospital

14.7.7 Selection of Plant Species

The selection of appropriate species has considered planting suitable for wildlife, visual diversity, plant form and function. Specific trees with poor track record in the urban environment, or that are prone to disease and not suitable for urban realm projects, have been avoided.

Trees that are not suitable for urban realm environments are listed and in Table 14-2 below. Trees, shrub / hedging, climbers and other planting species suitable for urban realm environment with benefit for wildlife are shown in Table 14-3, Tables 14-4, Table 14-5 and Table 14-6 below.

Table 14-2 List of Trees Not Suitable for Urban Realm Environment

Latin Name	***Common Name***	***Reason***
Prunus serralata	Japanese Cherry	Unless it is planted in a 3m wide grass verge
Acer platanoides	Norway Maple	Unless it is planted in a 2m wide grass verge minimum
Acer saccharinum	Silver Maple	Brittleness
Fraxinus spp.	Ash	Dieback Disease
Quercus species	Oak	Must be local origin (Ireland) and not imported due to Processionary Moth issue.
Acer pseudoplatanus	Sycamore	Unless it is planted in large grass verge
Aesculus hippocastanum	Chestnut	Leaf miners and bleeding cankers diseases.

Table 14-3 Trees Suitable for Urban Realm Environment with Benefit for Wildlife

Latin name	**Common name**	**Benefit**
Acer campestre	Field Maple	Attractive to a number of invertebrates and fruits are eaten by small mammals.
Alnus glutinosa	Common Alder	Attractive to bees and butterflies.
Arbutus unedo	Strawberry Tree	Attractive to pollinators in October, when flowering. Fruits are eaten by birds.
Betula pendula	Silver Birch	Excellent for insects and to attract insect-eating birds. Catkins are a good food source for a variety of birds.
Carpinus betulus	Hornbeam	Attractive to a number of invertebrates. Seeds eaten by birds. Can provide a dense nesting cover.
Cercis siliquastrum	Judas Tree	Attractive to pollinators.
Malus species	Apples	Attractive to a number of invertebrates and seeds are good for young birds.
Prunus avium	Wild or Sweet Cherry	Berries provide a valuable food source for birds.
Prunus padus	Bird Cherry	Berries provide a valuable food source for birds.
Quercus species	Oaks	Attractive to a range of invertebrates and are important for insect eating birds. Acorns are eaten by a variety of birds and mammals.
Sorbus aria	Common Whitebeam	Attractive to pollinators.

Latin name	Common name	Benefit
Sorbus aucuparia	Rowan	Attractive to a number of invertebrates and berries are eaten by birds.
Sorbus torminalis	Wild Service Tree	Attractive to pollinators.
Tilia cordata	Small-leaved Lime	Attractive to pollinators.

Table 14-4 Shrub and Hedging Species Suitable for Urban Realm Environment with Benefit for Wildlife

Latin name	Common name	Benefit
Buxus sempervirens	Common Box	Attractive to pollinators. Can provide a dense nesting cover.
Ceanothus species	Lilac Bush	Provide nectar and pollen for butterflies, bees and other pollinators in their dense flower clusters in spring.
Cornus sanguinea	Dogwood	The flowers produce a scent that is attractive to many species of invertebrates. The berries are eaten by some species of birds.
Corylus avellana	Hazel	Reddish-brown nuts in a green husk are seen on hazel in the late summer and autumn; but these are generally eaten quickly by birds and mammals.
Crataegus monogyna	Hawthorn	Provides a source of nectar and berries providing food for birds including thrushes. If allowed to grow dense it will provide good nesting opportunities for birds.
Euonymus europaeus	Spindle	Spindle produces flowers that provide a good source of food for bees and other insects. The fruits attract aphids which in turn attract insect-eating birds.
Hebe species	Hebe	Most species of hebe provide nectar and are visited by several species of bees.
Hypericum androsaemum	Tutsan	Flowers attract insects especially bees while the berries are eaten by birds and small mammals.
Ilex aquifolium	Holly	The berries are greatly enjoyed by birds and mammals. Holly also plays a crucial part in the life cycle of the beautiful butterfly the holly blue, which lays eggs on holly leaves in spring and is a frequent visitor to gardens in town. Requires male and female plants to produce berries.
Lavandula angustifolia	English Lavender	This plant is much favoured by bees for the nectar and pollen whilst the seeds attract birds.
Ligustrum vulgare	Privet	Wild privet is the preferred choice for wildlife and may provide nesting sites for blackbirds and other species. Left to grow a little less tidily than many gardeners allow, the structure will become more open and also offer nesting opportunities for many more species. Good for bees and butterflies.
Mahonia species	Mahonia	Flowering occurs in autumn, winter and early spring benefiting winter-active pollinators (like bumblebees or some hoverflies). Flowers produce abundant nectar. Berries are eaten by birds.

Latin name	Common name	Benefit
Pyracantha coccinea	Scarlett Firethorn	Very valuable to birds as a source of food and as a nesting site. Also, a good security plant due to the thorns.
Rosa species	Roses	Provides nectar for bees and butterflies. Hips are valuable for small birds and mammals.
Salix aegyptiaca	Musk Willow	Winter-flowering shrub pollinated by bees and other insects.
Sambucus nigra	Common Elder	Provides flowers for insects and berries for birds.
Sarcococca confusa	Sweet Box	Flowering in winter, followed by black berries eaten by birds.
Thymus species	Thyme	The rose-purple flowers grow in long, whorled, upright spikes and are very attractive to bees, hoverflies and butterflies.
Viburnum spp	Viburnum	Excellent for attracting hoverflies and are a good source of nectar for bees. The shiny berries provide a food source for birds and mammals alike.

Table 14-5 Climbers Suitable for Urban Realm Environment with Benefit for Wildlife

Latin name	Common name	Benefit
Clematis vitalba	Clematis 'Old Man's Beard'	Provides nectar for bee and butterflies.
Hedera helix	Ivy	Provides a late nectar source and cover / hibernating sites for many species of invertebrates.
Humulus lupulus	Hop	Provides nectar for bee and butterflies.
Jasminus officinale	Summer Jasmine	Night-scented. The scent from jasmine at night can attract bats.
Lonicera periclymenum	Honeysuckle	The flowers of the honeysuckle attract night flying moths and other insects which in turn can provide food for bats. Honeysuckle can provide nest sites for small garden bird species while the bark is often used in nest building by species including the House Sparrow.

Table 14-6 Other Planting Species Suitable for Urban Realm Environment with Benefit for Wildlife

Latin name	Common name	Benefit
Abelia chinensis	Bee Bush or Chinese Abelia	Attractive to pollinators. Flowering in October.
Ajuga reptans	Bugle	Bugle is excellent for ground cover under shrubs since it prefers semi-shade, and is attractive to a wide range of insects.
Anemone nemorosa	Wood Anemone	Provides a good early source of pollen and nectar for bees and other insects.
Armeria maritima	Thrift, Sea Pink	Attractive to pollinators.
Aster novi-belgii	Michaelmas Daisy	Attractive to a range of bees, butterflies, moths and birds.

Latin name	Common name	Benefit
Aubrieta deltoidea	Purple Rock-cress	Provides a good early food source for bees and adds colour to edges of flower beds, prefers full sunlight.
Bergenia purpurascens	Elephant's Ear or Purple Bergenia	Attractive to pollinators.
Campanula glomerata	Clustered Bellflower	Attractive to pollinators.
Conopodium majus	Pignut	Attractive to pollinators.
Crocus tommasinianus	Early Crocus	As a winter-flowering species, it provides a good early source of pollen and nectar for bees and other insects.
Cynoglossum officinale	Hound's Tongue	Attractive to pollinators.
Digitalis purpurea	Foxglove	Attractive to pollinators.
Filipendula vulgaris	Dropwort	Attractive to pollinators.
Galanthus nivalis	Common Snowdrop	As a winter-flowering species, it provides a good early source of pollen and nectar for bees and other insects.
Hyacinthoides non-scripta	Bluebell	Provides a source of pollen and nectar for bees and other insects. Ensure that suppliers do not provide either Spanish bluebell or the hybrid between this and bluebell (or any other hybrids) and have not stripped native bluebells from the wild.
Hypericum perforatum	Perforate St John's Wort	Attractive to pollinators.
Lathyrus pratensis	Meadow Vetchling	Attractive to pollinators.
Leucanthemum vulgare	Ox-eye Daisy	Attractive to pollinators.
Linaria vulgaris	Common Toadflax	Attractive to pollinators.
Lunaria biennis	Honesty	Attractive to butterflies.
Malva moschata	Musk Mallow	Attractive to pollinators.
Matthiola longipetala	Night-scented Stock	Night-scented. emits a pleasant scent in the evening and through the night attracting night-flying pollinators and insects and therefore bats.
Monarda didyma	Bergamot	Provides a good source of pollen and nectar.
Nicotiana	Tobacco Plant	Attractive to night pollinators like moths (beneficial for bats).
Oenothera biennis	Evening Primrose	Particularly attractive to night flying insects (therefore can attract bats).
Persicaria bistorta	Common Bistort	Attractive to pollinators.
Rudbeckia hirta	Black-eyed Susan	Attractive to pollinators. Flowering in October.
Silene vulgaris	Bladder Campion	Attractive to pollinators.
Thalictrum flavum	Meadow Rue	Attractive to pollinators.

Latin name	Common name	Benefit
Viola riviniana	Dog Violet	Flowers from April to June and is attractive to bees and other insects.

The tree planting schedule for the Proposed Scheme is shown in Table 14-7.

Table 14-7 Tree Planting Schedule

Scientific name	Common names	Specification	Size Girth	Comments	Qty.
Acer x freemanii 'Autumn Blaze'	Freeman Maple	Semi-Mature	20-25cm girth	Single stem tree, 2.2m clear stem, 4 x transplanted, 2m wide. Rootball, under ground guyed planted in cellular root management system	68
Acer platanoides 'Obselisk'	Columnar Norway Maple	Semi-Mature	20-25cm girth	Single stem tree, 2.2m clear stem, 4 x transplanted, 2m wide. Rootball, under ground guyed planted in cellular root management system	34
Betula pendula	Silver birch	Semi-Mature	20-25cm girth	Single stem tree, 2.2m clear stem, 4 x transplanted, 2m wide. Rootball, under ground guyed planted in cellular root management system	33
Betula pendula	Silver birch	Standard	14-16cm girth	Single stem tree, 4.0-4.50m height, 1.8m clear stem, 1.8m wide. Rootballed double staked planted in softworks with 2.0m diametre backfilled treepit.	35
Betula pubescens	Downy birch	Standard	14-16cm girth	Single stem tree, 4.0-4.50m height, 1.8m clear stem, 1.8m wide. Rootballed double staked planted in softworks with 2.0m diametre backfilled treepit.	27
Corylus avellana	Hazel	Standard	14-16cm girth	Single stem tree, 4.0-4.50m height, 1.8m clear stem, 1.8m wide. Rootballed double staked planted in softworks with 2.0m diametre backfilled treepit.	27
Fagus sylvatica	Beech	Standard	14-16cm girth	Single stem tree, 4.0-4.50m height, 1.8m clear stem, 1.8m wide. Rootballed double staked planted in softworks with 2.0m diametre backfilled treepit.	27
Liriodendron tulipifera Fastigiata	Upright tulip Tree	Semi-Mature	20-25cm girth	Single stem tree, 2.2m clear stem, 4 x transplanted, 2m wide. Rootball, under ground guyed planted in cellular root management system	25

Prunus avium 'Plena'	Wild Cherry	Semi-Mature	20-25cm girth	Single stem tree, 2.2m clear stem, 4 x transplanted, 2m wide. Rootball, under ground guyed planted in cellular root management system	59
Prunus padus	Bird Cherry	Standard	14-16cm girth	Single stem tree, 4.0-4.50m height, 1.8m clear stem, 1.8m wide. Rootballed double staked planted in softworks with 2.0m diametre backfilled treepit.	35
Sorbus aria	Whitebeam	Standard	14-16cm girth	Single stem tree, 4.0-4.50m height, 1.8m clear stem, 1.8m wide. Rootballed double staked planted in softworks with 2.0m diametre backfilled treepit.	27
Sorbus aucuparia 'Asplenifolia'	Rowan / Mountain Ash	Semi-Mature	20-25cm girth	Single stem tree, 2.2m clear stem, 4 x transplanted, 2m wide. Rootball, under ground guyed planted in cellular root management system	16
Sorbus aucuparia 'Asplenifolia'	Rowan / Mountain Ash	Standard	14-16cm girth	Single stem tree, 4.0-4.50m height, 1.8m clear stem, 1.8m wide. Rootballed double staked planted in softworks with 2.0m diametre backfilled treepit.	35
Tilia cordata 'Greespire'	Small-leaved lime	Semi-Mature	20-25cm girth	Single stem tree, 2.2m clear stem, 4 x transplanted, 2m wide. Rootball, under ground guyed planted in cellular root management system	17
				Proposed Trees	465
				Felled Trees	301

15 Scheme Benefits / How We Are Achieving the Objectives

This section sets out the manner in which the Proposed Scheme described herein will achieve the following objectives as set out:

- Enhance the capacity and potential of the public transport system by improving bus speeds, reliability and punctuality through the provision of bus lanes and other measures to provide priority to bus movement over general traffic movements;
- Enhance the potential for cycling by providing safe infrastructure for cycling, segregated from general traffic wherever practicable;
- Support the delivery of an efficient, low carbon and climate resilient public transport service, which supports the achievement of Ireland's emission reduction targets;
- Enable compact growth, regeneration opportunities and more effective use of land in Dublin, for present and future generations, through the provision of safe and efficient sustainable transport networks;
- Improve accessibility to jobs, education and other social and economic opportunities through the provision of improved sustainable connectivity and integration with other public transport services; and
- Ensure that the public realm is carefully considered in the design and development of the transport infrastructure and seek to enhance key urban focal points where appropriate and feasible.

Despite the relatively good provision of bus lanes along the sections of road between junctions, bus services are regularly delayed due to congestion arising from the lack of bus priority at key locations, such as the M50 interchange, Kennelsfort Road junction and the South Circular Road junction. This leads to journey time unreliability being experienced along the corridor at certain times during the day.

During design development, information obtained from the Bus Routes Automatic Vehicle Location (AVL) data over a typical period in 2019 indicated that there is a reasonably consistent journey time along the majority of this corridor, which reflects the presence of existing bus lanes. However, as noted above there is some noticeable variation in journey time, for example between the N4 Junction 2 (Hermitage Clinic) and the R148 Palmerstown bypass / The Oval junction, at certain times during the day. This is consistent with observations on site and the lack of bus priority across the M50 and through the highly congested junctions on the Palmerstown bypass. Within the extents of the Proposed Scheme route, bus lanes are currently provided on approximately 67% and 77% of route westbound and eastbound respectively, of which significant portions of the route are shared with cyclists.

Issues related to frequency, reliability and a complex network have persisted for many years and will continue to do so without further intervention. In November 2021 BusConnects Dublin introduced high frequency public bus services along the route which will be improved by the Proposed Scheme, including the proposed C-Spine (C1, C2, C3, C4), and existing bus routes including the 52 bus route, as well as regional bus services. In addition to this there are multiple other bus services which run along this corridor intermittently, providing interchange opportunities with other bus services. The Proposed Scheme interventions will seek to make these services more reliable, particularly in peak times, thus providing a more attractive and sustainable alternative mode of transport. The introduction of segregated cycle facilities that help achieve optimum bus speeds to improve on the punctuality and reliability of the bus service. Similarly, the use of active bus signalling measures will improve continuity of bus journey times through certain junctions along the route.

Without the interventions of the Proposed Scheme there would likely be an exacerbation of the issues which informed the need for the Proposed Scheme itself. The capacity and potential of the public transport system would remain restricted by the existing deficient and inconsistent provision of bus lanes and the resulting sub-standard levels of bus priority and journey-time reliability. Thus, the unreliability of bus services would continue. As such the Proposed Scheme is actively enhancing the capacity and potential of the public transport system, and supports the delivery of an efficient, low carbon and climate resilient public transport service, which supports the achievement of Ireland's emission reduction targets.

A key objective of the Proposed Scheme is to enhance the potential for cycling along the route. Without the provision of safe cycling infrastructure, intended as part of the Proposed Scheme, there would continue to be an insufficient level of safe, segregated provision for cyclists who currently, or in the future would be attracted to use the route of the Proposed Scheme.

In terms of the need to improve facilities for cyclists along the route of the Proposed Scheme, the design intent is that segregated facilities should be provided where practicable to do so. Within the extents of the Proposed Scheme segregated cycle facilities are currently only provided on approximately 10% and 10% of the route westbound and eastbound respectively, while non segregated cycle facilities are provided on only approximately 20.5% and 11% of the route westbound and eastbound respectively. The remaining extents have no dedicated cycle provision or cyclists must cycle within the bus lanes provided.

The Proposed Scheme is implementing safe, segregated infrastructure throughout and as such is greatly enhancing the potential for cycling.

Within the extents of the Proposed Scheme there are a number of amenities, village and urban centres which will be enhanced as part of the proposed works. In order to improve accessibility to jobs, education and other social and economic opportunities through the provision of an integrated sustainable transport system, there needs to be a high quality pedestrian environment, including specifically along the route of the Proposed Scheme. There are a number of uncontrolled crossings along the route of the Proposed Scheme, particularly at side roads which are generally of poor standard, including lack of provision for the mobility and visually impaired. There are multiple incidences of 'patch repairs' along footways that in some instance has led to undulating, uneven surfaces caused by settlement of patch repair material. This is often a hazard to pedestrians, particularly the mobility impaired. A number of submissions were also received as part of the non-statutory consultation in which members of the public indicated specific locations where the existing provision is unsafe for pedestrians – many of which are proposed to be addressed by the Proposed Scheme.

The Proposed Scheme includes significant improvements to the pedestrian environment, both along links and at both junctions and crossings by the provision of enhanced footway widths and additional pedestrian crossing facilities. As such the Proposed Scheme will improve accessibility to jobs, education and other social and economic opportunities not only through improvement to the public transport network and cycling infrastructure but through improvements to the pedestrian environment.

The landscape and urban realm proposals for the Proposed Scheme are based on an urban context and landscape character analysis of the route. The proposals have been informed through discussions with local authorities and stakeholders.

The overall landscape and public realm design strategy for the Proposed Scheme was developed to create attractive, consistent, functional and accessible places for people alongside the core bus and cycle facilities. It aims to mitigate any adverse effects that the proposals may have on the streets, spaces, local areas and landscape through the use of appropriate design responses. In addition, opportunities have been sought to enhance the public realm and landscape design where practicable.

Through a combination of the above benefits, such as the provision of safe and efficient sustainable transport networks, improved infrastructure for walking and cycling, and urban realm strategies, the Proposed Scheme specifically facilitates improvements to encourage more journeys generally at a local level by active travel, including connecting to and from bus stops for all pedestrians, and in particular improving facilities for the mobility and visually impaired. Bus stops have also been carefully designed to incorporate cycle parking, where practicable, providing an integrated sustainable solution for combining active travel with longer distance trips by bus. Therefore, it is considered that the Proposed Scheme as described enables compact growth, regeneration opportunities and more effective use of land in Dublin, for present and future generations.

It is therefore considered that the design of the Proposed Scheme wholly achieves the objectives set out herein. In doing so it fulfils the aim of the Proposed Scheme in providing enhanced walking, cycling and bus infrastructure on key access corridors in the Dublin region, enabling the delivery of efficient, safe, and integrated sustainable transport movement along this corridor.

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