Clongriffin to City Centre Core Bus Corridor Scheme

December 2021

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
BCPDGB	BusConnects Preliminary Design Guidance Booklet
BJTR	Bus Journey Time Report
CBC	Central Bus Corridor
CBR	California Bearing Ratio
CPO	Compulsory Purchase Order
DCC	Dublin City Council
DEHLG	Department of Environment, Heritage and Local Government
DLAM	Dublin Local Area Model
DM	Do Minimum
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
EPR	Emerging Preferred Route
FCC	Fingal County Council
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
HGV	Heavy Goods Vehicle
HP	High Pressure
KFPA	Kerbs, Footways and Paved Areas
LED	Light Emitting Diode
LP	Low Pressure
MCA	Multi-Criteria Assessment
NCDWC	National Construction and Demolition Waste Council
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
PRO	Preferred Route Option
RSESs	Regional Spatial and Economic Strategies
SDRAs	Strategic Development and Regeneration Areas
SSD	Stopping Sight Distances
STMG	Sustainable Transport Measures Grants
SuDS	Sustainable (Urban) Drainage Systems
TII	Transport Infrastructure Ireland

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, the 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 16 of the busiest corridors in Dublin.

Clongriffin to City Centre Core Bus Corridor of the CBC Infrastructure Works (herein after called the 'Proposed Scheme') measures approximately 5.7 km from end to end.

The Proposed Scheme begins at the Mayne River Avenue / Malahide Road Junction and continues towards Dublin City Centre via Northern Cross, Coolock, Artane, Donnycarney, Marino and Fairview where it terminates at the Marino Mart/Fairview. In addition to the primary corridor an 800m alternative cycle route is proposed between the Malahide Road and Fairview. The start of the scheme ties into a separate project being developed by DCC namely, The Belmayne Main St & Belmayne Avenue Scheme, which provides bus and cycle linkages to Clongriffin Dart Station. The Proposed Scheme is routed via Malahide Road to the junction with Clontarf Road at Marino Mart/Fairview. From here the Proposed Scheme ties into a separate project, the Clontarf to City Centre Cycle & Bus Priority Project being developed by DCC. The Clontarf to City Centre Cycle & Bus Priority Project will provide segregated cycling facilities and bus priority infrastructure along a 2.7km route that extends from Clontarf Road at the junction with Alfie Byrne Road, to Amiens Street at the junction with Talbot Street in the City Centre.
Refer to Figure 1-1 for overall layout of the Proposed Scheme.

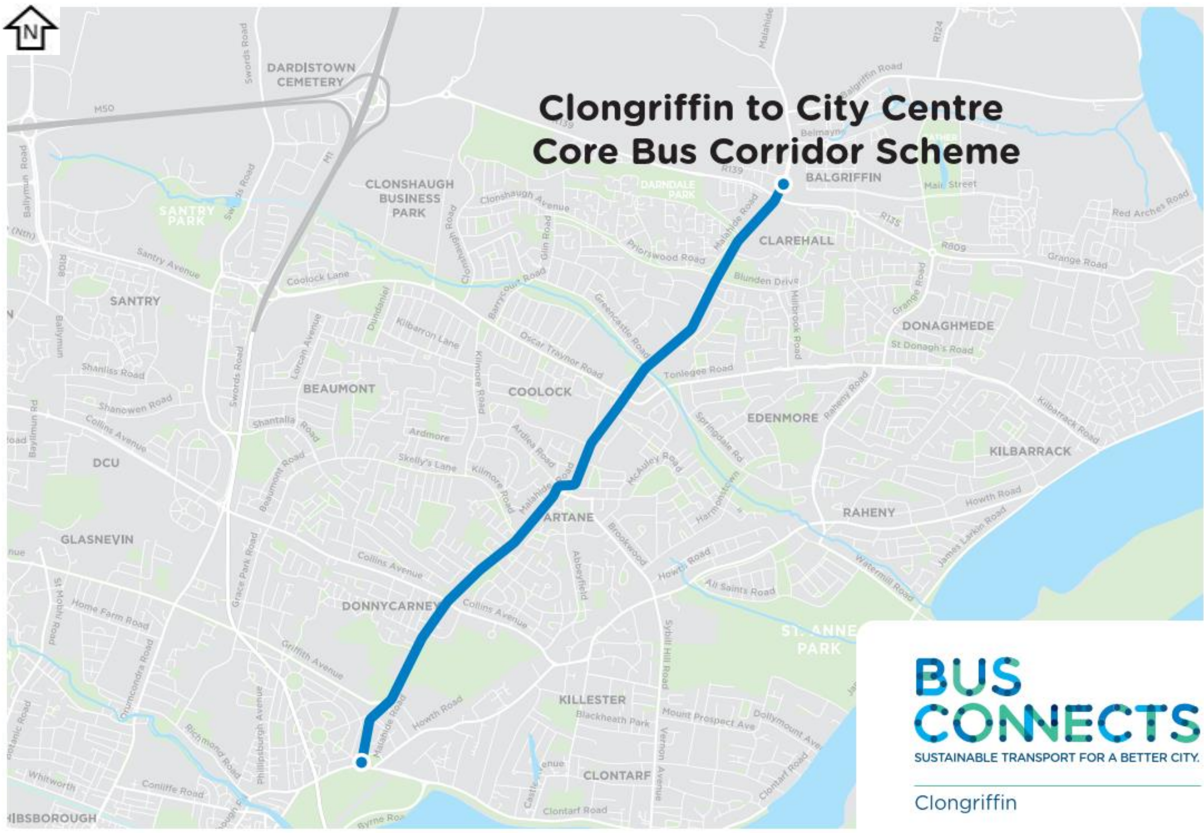

Figure 1-1: Proposed Scheme Route Overview

1.2 Project Aim and Objectives

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

In accordance with the CBC Infrastructure Works the Proposed Scheme 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 Core Bus Corridors

(CBCs) were initially identified for redevelopment. This is shown Figure 1-2 below (extract from Transport Strategy for the Greater Dublin Area 2016-2035).

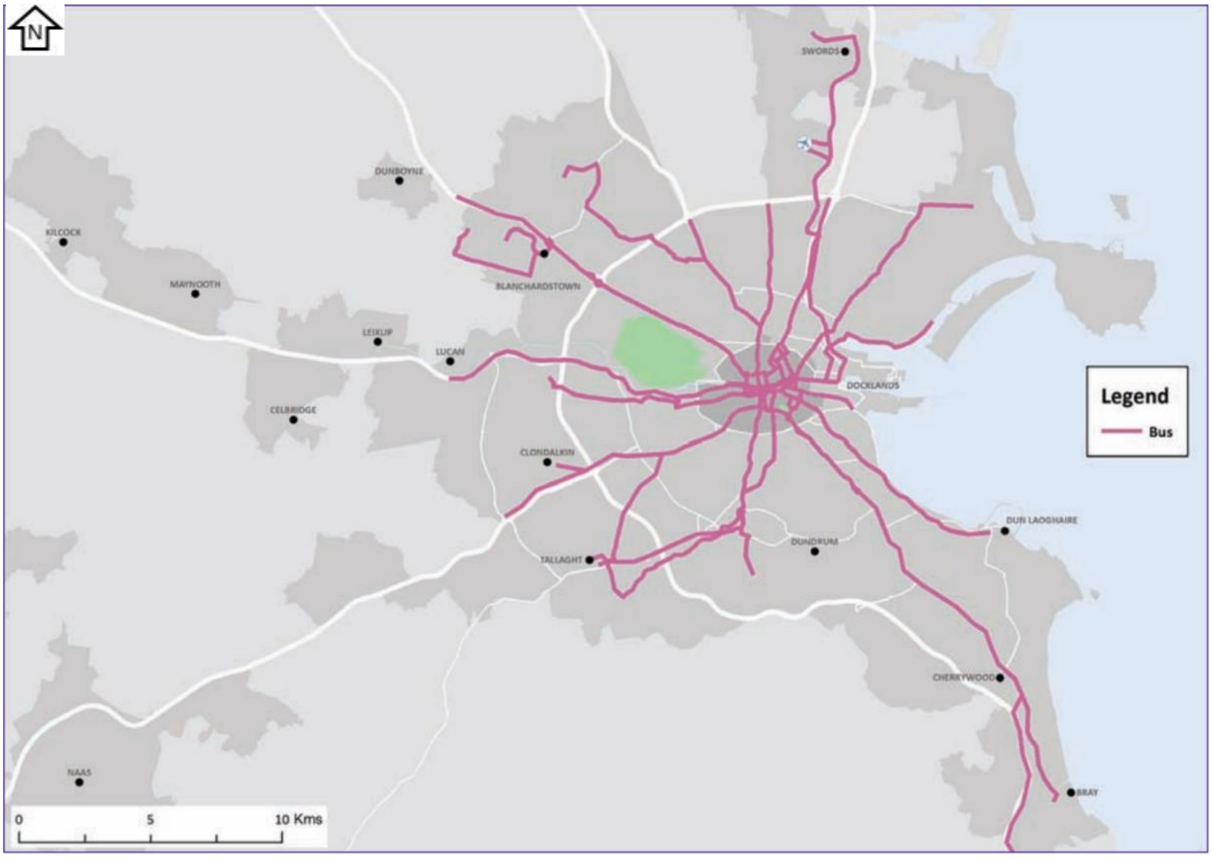

Figure 1-2: 2035 Core Bus Network – Radial Corridors

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 Clongriffin 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.

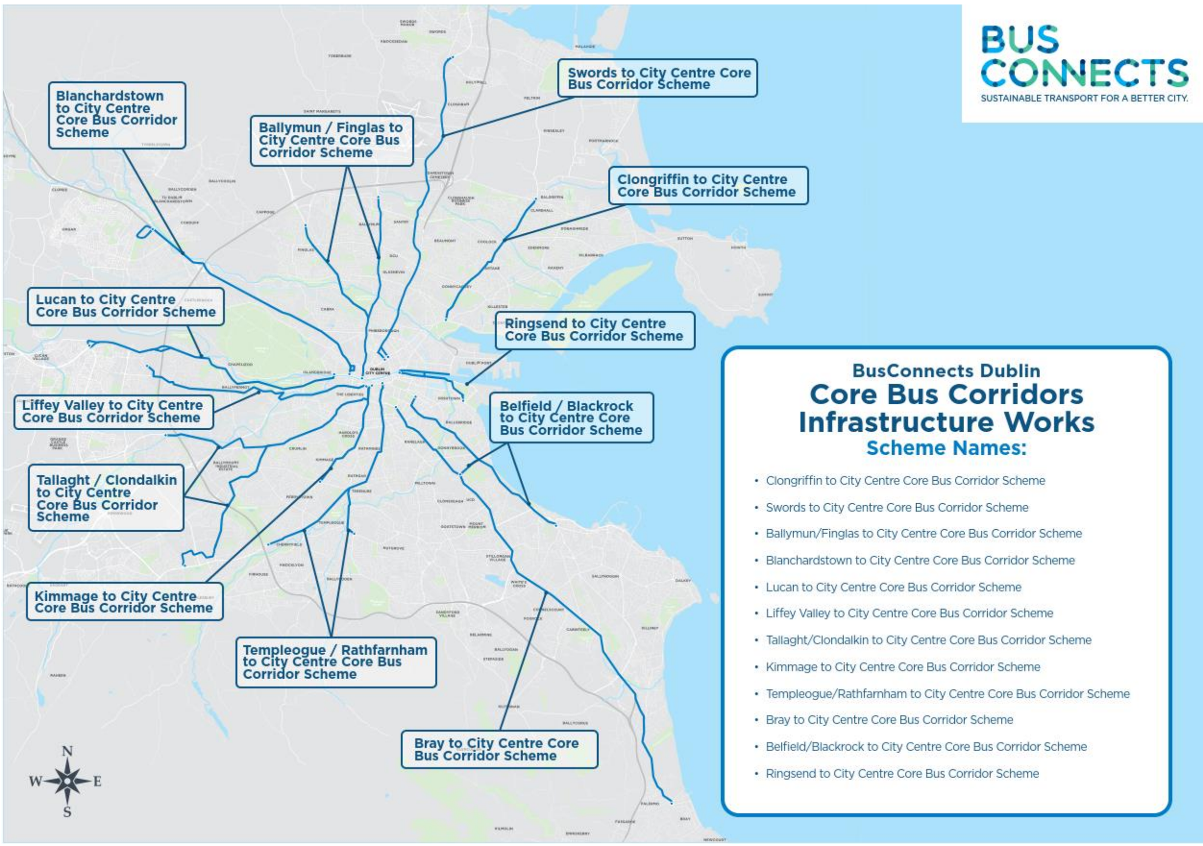

Figure 1-3: BusConnects Radial CBC Network

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, designer's 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:

- November 2018 to May 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.

Consultation with the principal project stakeholders (i.e. 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 land owners (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.

1.7 Purpose of the Preliminary Design Report

The purpose of the Preliminary Design Report (PDR) is to outline the design intent of the scheme. 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 proposed 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) & Site Location Plans (1:2500@A1)	Defines the full extent of the works & 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 & 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)	Whilst this series is not applicable to the Proposed Scheme it has been used on other routes to provide additional details relating to proposed bridge structure/underpass works in addition to structural retaining walls along the route.
BLD_ZZ	**Bus Interchange (Varies)**	**Whilst this series is not applicable to the Clongriffin Scheme it has been used on other routes to provide additional details relating to proposed bus interchange details including architectural layouts and site elevations and sections.**

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 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 Design** – 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 structures 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: Scheme Benefits/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 & Midland Regional Assembly, Regional Spatial & Economic Strategy (2019-2031);
- Greater Dublin Area Cycle Network Plan;
- Transport Strategy for the Greater Dublin Area (2016-2035);
- DCC Development Plan (2016-2022);
- Clongriffin-Belmayne Local Area Plan (2012-2022) (DCC); and
- Belmayne – Belcamp Masterplan 2020.

For further information on how the Proposed Scheme meets the policies outlined above refer to the Scheme Planning Compliance Report (*BCIDE-JAC-ENV_ZZ-0001_XX_00-RP-ES-0004*).

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), its purpose is to provide guidance for the various design teams involved in CBC Infrastructure Works, to ensure a consistent design approach across the project.

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 have been noted within Section 4.16.

3 The Proposed Scheme

3.1 Scheme Description

The Proposed Scheme is routed along the R107 Malahide Road from Mayne River Avenue – R107 Malahide Road Junction to the junction with Marino Mart - Fairview and also routed via the junction with Malahide Road-Brian Road along Carleton Road, St Aidans Park, Haverty Road and Marglann Marino, all in the County of Dublin. From here the scheme ties into a separate project, Clontarf to City Centre Cycle & Bus Priority Project currently proposed by DCC

The Proposed Scheme, is described below, split into the following two sections to reflect the sub-urban and urban nature of the route;

- Section 1: Mayne River Avenue to Gracefield Road – Malahide Road; and
- Section 2: Gracefield Road and Clontarf Road–Malahide Road

It is noted that the Clongriffin DART Station to Malahide Road via Clongriffin Main Street portion is no longer proposed to be included as part of this project. It is noted that Clongriffin Main Street already has dedicated Bus lanes and the scheme proposed by DCC, Belmayne Main Street and Belmayne Avenue Scheme, also incorporates dedicated Bus lane and cycle infrastructure.

3.1.1 Section 1: Mayne River Avenue to Gracefield Road – Malahide Road

The Proposed Scheme commences at Mayne River Avenue / Malahide Road Junction along the Malahide Road to Gracefield Road / Malahide Road junction. The following junctions will be upgraded to provide bus priority and enhanced pedestrian and cyclist facilities:

- Malahide Road/R139 Clarehall Avenue (Northern Cross Junction);
- Malahide Road/Entrance to Clarehall Shopping Centre;
- Malahide Road/Blunden Drive/Priorswood Road;
- Malahide Road/Greencastle Road;
- Malahide Road/Tonglegee Road/Brookville Crescent; and
- Malahide Road/Gracefield Road.

The Proposed Scheme commences at the Mayne River Avenue / Malahide Road Junction, where the future Belmayne Main Street/Malahide Road bus only junction will provide the gateway to Clongriffin Station from Malahide Road. The Clongriffin Corridor is the busiest, non-interurban, bus route corridor in Dublin carrying over 8,400 passengers in the peak periods, as part of the NTA's New Dublin Area Bus Network the D Spine will replace the radial services from Clongriffin Dart Station to the city centre along this high frequency corridor. The Proposed Scheme will require widening of the carriageway into the median and verge to facilitate the construction of the proposed cycle track and/or footpaths. The lane widths of the carriageway have been reduced to 3m to minimise the impact of the widening. Along this section of the scheme no residential driveways or gardens are impacted though both local authority and private land will need to be acquired.

The Proposed Scheme does impact a number of existing trees in the verge and median and the scheme has proposed compensatory planting to alleviate for the loss of existing trees.

Continuous bus priority will be provided on the Malahide Road in both directions from the Mayne River Avenue / Malahide Road junction to the Gracefield Road / Malahide Road junction. To facilitate bus turnaround at the end of the D5 route on Blunden Drive a new bus turnaround facility has been provided on Priorswood Road.

All signalised junctions have been reconfigured to provide bus lane continuity along Malahide Road, enhanced bus priority signalling measures as well as enhanced crossing and through facilities for cyclists and pedestrians.

It is proposed to reduce the speed limit from 60km/h to 50km/h along the section between Mayne River Avenue / Malahide Road up to the Ardlea/Malahide Road junction where the existing speed limit transitions to 50 kmph. This proposed reduction in speed limit has been implemented due to the reduction in lane widths and consideration of the number of pedestrian crossing facilities and junctions along this section.

A continuous footway, typically 2m wide, will be provided along both sides of Malahide Road between Mayne River Avenue and Gracefield Road including upgrading of the existing pedestrian crossings and the addition of two additional crossings in the vicinity of Ayrefield Drive and Mask Avenue.

It is proposed to upgrade the existing Northern Cross junction. This modification will involve the removal left slip lanes and reconfiguration of the pedestrian crossing including the inclusion of cycling facilities which has been improved to provide more segregation for cyclists approaching and through the junction

Between Clarehall Avenue and Blunden Drive, a single bus lane and two general traffic lanes will be maintained in each direction. Between Blunden Drive and Gracefield Road a single bus lane and a single traffic lane will be maintained. In the vicinity of Belcamp Lane the heritage milestone will be protected and relocated.

Between Malahide Road and Buttercup Park it is proposed to utilise the green area as the construction compound for the scheme. This will necessitate the closure of the green for the duration of the works. The area will be landscaped once the compound is no longer required.

It is proposed to upgrade the existing roundabout on Blunden Drive to a fully signalised cycle protected junction. This modification will involve the removal of some median hedging and trees though compensatory planting will be placed at the junction. The layout of this junction has been improved to provide more segregation for cyclists approaching and through the junction. In the vicinity of the junction low height retaining walls, less then 1m high, will be installed to minimise impact on the existing green space on the western side of Malahide Road either side of Priorswood Road.

A new offline footway and two-way cycle track is proposed at Ayrefield Drive. This will require land take to facilitate the proposal and provides an excellent opportunity for local residents to avail of direct connectivity to the corridor with a proposed new bus stop also located in the immediate vicinity.

Cycle tracks will be provided on both sides of the carriageway the length of Malahide Road apart from a section where southbound cyclists are proposed to be redirected on to the adjoining quiet street, St. Brendan’s Avenue. Cyclists can then re-join the Malahide Road at Gracefield Road junction and along Brookville Park where the cycle track is adjacent to Brookville Park.

It is proposed to upgrade the existing roundabout at Gracefield Road to a fully signalised junction This will provide improved bus priority through the junction while also allowing for the construction of improved pedestrian facilities and protected cycle infrastructure

Utility and drainage works will be required at various locations throughout the section resulting from the road widening and pavement works.

3.1.2 Section 2: Gracefield Road and Clontarf Road–Malahide Road

On this section between Gracefield Road junction and Clontarf Road junctions, it is proposed to upgrade the following junctions on the Malahide Road:

- Malahide Road/Kilmore Road;
- Malahide Road/Killester Avenue;
- Malahide Road/Elm Mount Road;
- Malahide Road/Collins Avenue;
- Malahide Road/Casino Park;
- Malahide Road/Copeland Avenue/Griffith Avenue; and
- Malahide Road/Clontarf Road.

All signalised junctions have been reconfigured to provide bus lane continuity along Malahide Road, with traffic signalling improvements for bus priority, as well as enhanced crossing and through facilities for cyclists and pedestrians.

Between Gracefield Road junction and Killester Avenue, it is intended to provide a continuous bus lane with a single general traffic lane in each direction. Dedicated cycle tracks and upgraded footway facilities will be provided through this section. There is currently only intermittent cycleway marking on this section. To accommodate this cross section, limited areas of land take will be required from private properties. The proposed works will also require the removal of existing trees currently located on private properties and public land. It is proposed to replace any boundary walls or railings on a like for like basis. Along this section on street parking will be removed between Gracefield Road and Danieli Road. A new pedestrian crossing is also being proposed in the vicinity of Danieli Road. In the vicinity of St David's Wood the heritage milestone will be protected and the boundary wall between the green area and Malahide Road lowered to allow better visibility between the proposed footpath/cycle track at the back of the green area and the Malahide Road.

Between Killester Avenue junction and Collins Avenue, it is intended to provide a continuous bus lane with a single general traffic lane in each direction. Dedicated cycle tracks and upgraded footpath facilities will be provided through this section. There is currently infrequent cycleway marking on this section. The existing road between these junctions requires widening to accommodate the desired lane widths and bus stop facilities. It is proposed to utilise the existing park footpath in Maypark (Donnycarney Park) as the proposed footpath with the proposed inbound cycle track following the line of the existing inbound footpath. The existing railing along Maypark will need to be set back along the line of the proposed footpath. Between Maypark and Collins Avenue it is proposed to utilise land take from private properties to facilitate the proposed works.

Between Collins Avenue Junction and Griffith Avenue Junction it is intended to provide a continuous bus lane with a single general traffic lane in each direction. Currently, there are no continuous dedicated cycle tracks in both directions on this section of the Malahide Road. Dedicated cycle tracks and upgraded footway facilities will be provided through this section. To accommodate these additional facilities, road widening works will be required. This widening will involve land take between Donnycarney Church and Clancarthy Road. The proposed works will also require the removal of existing trees currently located on traffic islands or between the existing road and footpath, although opportunities to enhance the streetscape have been identified as part of this review and compensatory planting has been proposed to alleviate for the loss of trees. In the vicinity of Donnycarney Church urban realm enhancements have been proposed.

Between Griffith Avenue junction and Clontarf Road junction, it is proposed to continue the bus and general traffic lanes in both directions. There are currently only three traffic lanes on this section of road. To facilitate the new four lane arrangement, it is intended remove existing on street parking on the inbound lane between Crescent Place and Marino Crescent and to utilise limited land take from adjacent properties at the following locations:

- Between Copeland Avenue and Marino Avenue;
- Between Charlemont Road and Crescent Place; and
- Between Crescent Place and St. Aidan's Park.

In the vicinity of Griffith Avenue the heritage milestone will be protected and relocated.

It is intended to provide an alternative cycle route through a parallel, less trafficked route along Brian Road, Carleton Road and Haverty Road. Cyclists will then re-join Marino Mart and tie-in with the Clontarf to City Centre Cycle & Bus Priority Project. It is proposed to close Haverty Road for vehicular traffic at St Aidan's Park end of the street. This proposal will reduce traffic on Brian Road, Carleton Road and Haverty Road thus improving the cycling level of service in this section. The proposal will help prevent current rat-running but will also necessitate residents of Haverty Road to utilise Marino Park Avenue and Margam Marino when accessing Haverty Road.

The proposed bus lane works will tie into the proposed bus and cycle facilities on Clontarf Road, which is being advanced by DCC. This Proposed Scheme provides continuous bus lanes and cycle tracks in toward the city centre.

Subject to consultation with landowners it is proposed to replace any boundary walls or railings on a like by like basis.

3.2 Associated Infrastructure Project and Developments

A number of infrastructure projects are planned within the vicinity of the Proposed Scheme which will interface with the proposals. These are outlined in the following sections.

3.2.1 Belmayne Main Street and Belmayne Avenue Scheme.

The Belmayne Main Street and Belmayne Avenue Scheme, proposed by DCC, ties in at the northern end of this proposed scheme at Mayne River Avenue/Malahide Road Junction. This scheme is to include the construction of a new main street, complete with bus and cycle lane infrastructure to tie into the Proposed Scheme. This scheme aims to provide upgraded facilities for all road users within the extents of the study area. This includes facilities for cyclists, pedestrians as well as public transport. Bus lanes will extend from Malahide Road via a Bus Gate and tie into the existing Bus Lanes on Clongriffin Main Street which extend to Clongriffin Dart Station The tender assessment by DCC is complete, and the contract will be awarded once funding approval is in place.

3.2.2 Clontarf to City Centre Cycle & Bus Priority Project

The Clontarf to City Centre Cycle & Bus Priority Project, proposed by DCC, ties in at the southern end of this proposed scheme at Clontarf Road/Malahide Road Junction. Integration with this scheme will allow for safe onward travel to the city centre for cyclists. The Clontarf to City Centre Cycle & Bus Priority Project will provide segregated cycling facilities and bus priority infrastructure along a 2.7km route that extends from Clontarf Road at the junction with Alfie Byrne Road, to Amiens Street at the junction with Talbot Street. The route is identified as a primary route in the Greater Dublin Area Cycle Network Plan, published by the NTA in 2013. The scheme has been awarded for construction start 2022.

3.3 Integration

One of the key objectives of the Proposed Scheme is to enhance interchange between the various modes of public transport operating in the city and wider metropolitan area, both now and in the future.

Route options within the previous PRO study area had therefore been developed with this in mind and, in so far as possible, seek to provide for improved existing or new interchange opportunities with other transport services including:

- DART stations along the route, notably Clongriffin and Clontarf Road stations;
- Existing Dublin Bus services at numerous locations along the route, including routes 14, 15, 27, 27a, 27b, 27X 42, 43;
- Greater Dublin Area Cycle Network Plan (GDACNP);
- Future public transport proposals such as DART Interconnector and Metro North;
- Metropolitan Light Rail – LUAS, DART, Metro;
- The DART connects with the Clongriffin to City Centre CBC at Clongriffin Dart Station; and
- Interface with the New Dublin Area Bus Network.

The Clongriffin Corridor is the busiest, non-interurban, bus route corridor in Dublin carrying over 8,400 passengers in the peak periods (2017 Quality Bus Corridor Monitoring Report, NTA). The primary bus routes along the Clongriffin Corridor are indicated in Figure 3-1 and listed below:

- Route 14 - Beaumont (Ardlea Rd.) to Dundrum Luas Station;
- Route 15 - Clongriffin to Ballycullen Rd;
- Route 27 - Clare Hall to Jobstown;
- Route 27a - Eden Quay to Blunden Drive;
- Route 27b - Eden Quay to Harristown;
- Route 27x - UCD Belfield towards Clare Hall;

- Route 42 - Talbot St. towards Sand's Hotel (Portmarnock); and
- Route 43 - Talbot St. to Swords Business Park.

The following routes also cross the Malahide Road

- Route 17a - Blanchardstown to Naomh Barróg GAA; and
- Route 104 - Clontarf DART Station to Dublin City University (DCU).

Figure 3-1: Dublin Bus Existing Services

Figure 3-2 is an extract from New Dublin Area Bus Network maps and shows the different interfaces along the Proposed Scheme which is primarily routed along the D Spine. The principal interfaces with the associated bus routes are listed below.

- Malahide Road/R139 Clarehall Avenue; (Northern Cross Junction) - D1, D2, D3, N8, L80, 20 & 21;
- Malahide Road/Blunden Drive/Priorswood Road - D1, D2, D3, L80, 20 & 21;
- Malahide Road/Greencastle Road - D1, D2, D3, 20 & 21;
- Malahide Road/Tonlegee Road - D1, D2, D3, N6, 20 & 21;
- Malahide Road/Gracefield Road - D1, D2, D3, D4, D5, 20 & 21;
- Malahide Road/Collins Avenue - D1, D2, D3, D4, D5, N4, 8, 20 & 21;
- Malahide Road/Copeland Avenue/Griffith Avenue - D1, D2, D3, D4, D5, N2, 20 & 21; and

- Malahide Road/Clontarf Road - D1, D2, D3, D4, D5, H Spine,6, 8, 10, 20 & 21.

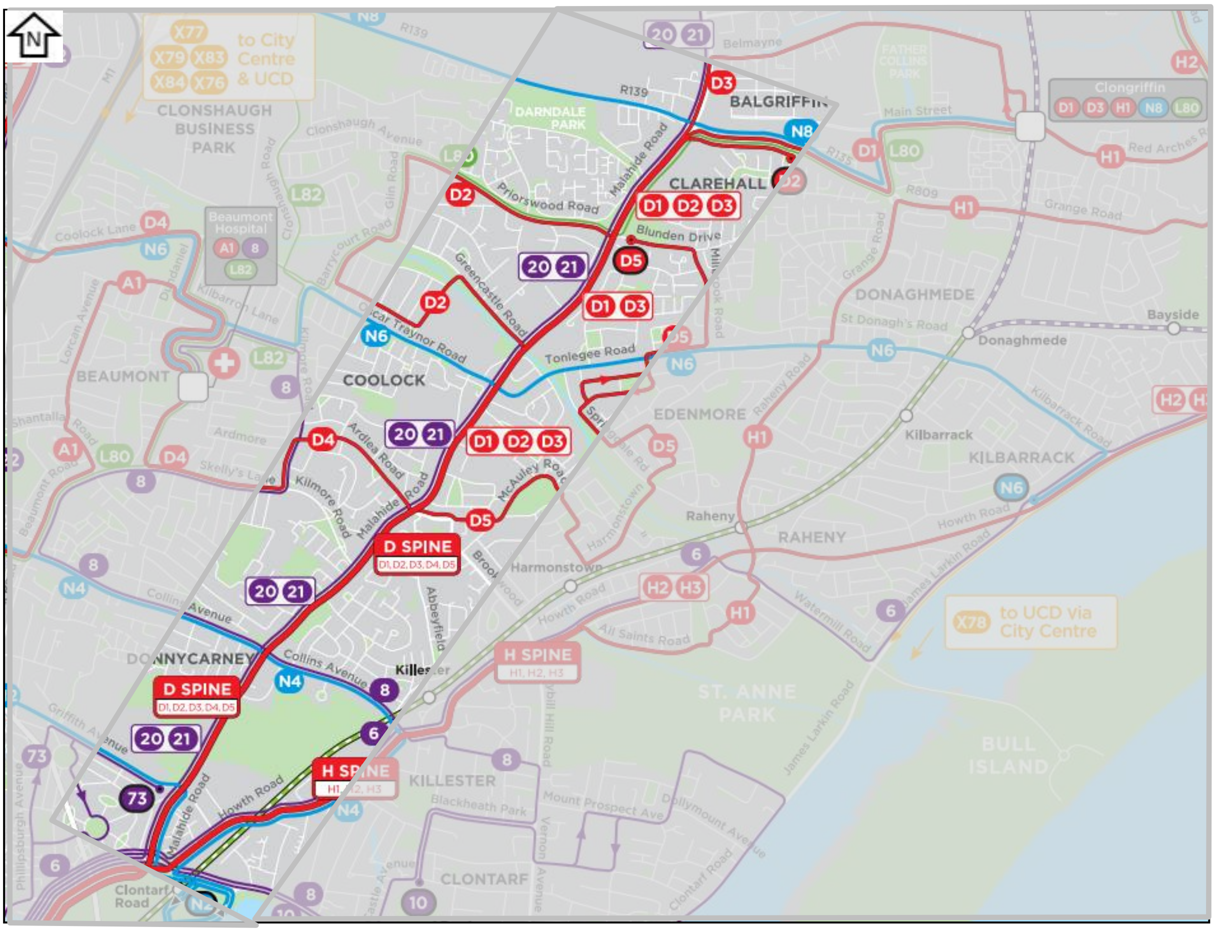

Figure 3-2: Extract from New Dublin Area Bus Network Maps

A key objective of the Proposed Scheme is to improve pedestrian and cyclist facilities along the route. In general, suitable level of service should be proposed for these modes. Where it is considered impractical to construct cycle facilities along a particular section of the scheme, such facilities would need to be provided along suitable alternative routes and as outlined in the GDACNP.

The Proposed Scheme interfaces with the GDA Primary Route 1C along the Malahide road from Mayne River Avenue to Clontarf Road. Suitable protected junction designs have been proposed at the locations where the Proposed Scheme interfaces with the following GDA cycle routes as can be seen in Figure 3-3:

- Malahide Road/Greencastle Road with the Santry River Greenway;
- Malahide Road/Tonlegee Road with the N05 Secondary Route;
- Malahide Road/Gracefield Road with the 1F Secondary Route;
- Malahide Road/Collins Avenue with the NO4 Primary Route;
- Malahide Road/Copeland Avenue/Griffith Avenue with the NO3 Secondary Route; and
- Malahide Road/Clontarf Road with the 1A Secondary Route.

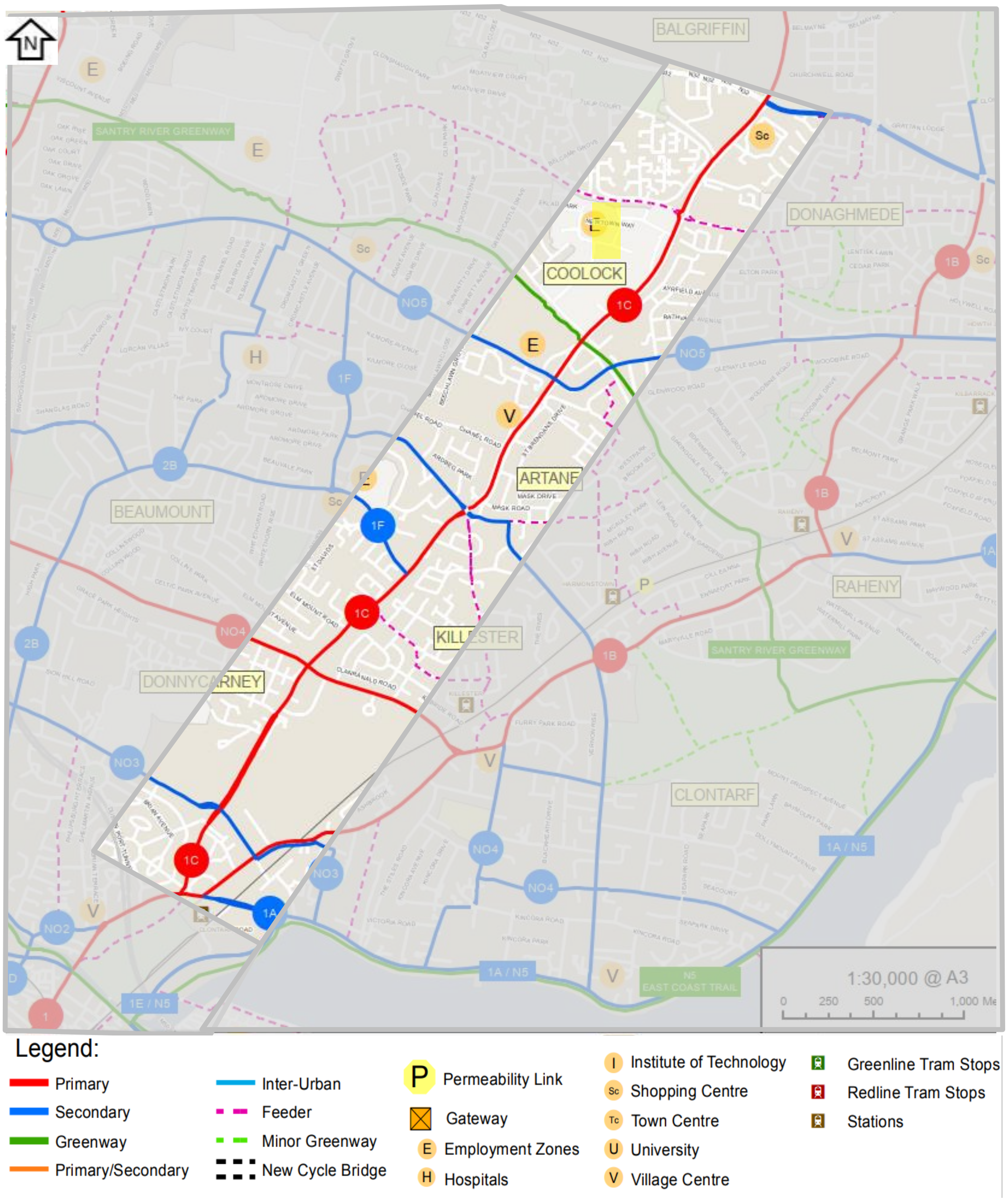

Figure 3-3: GDA Cycle Network Interaction with the Proposed Scheme

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.

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 possible 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
- Construction Standards for Road and Street Works in DCC; and
- BusConnects Preliminary Design Guidance Booklet (BCPDGB) – See Appendix O

Table 4-1 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(footpaths), 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		Link Street/Local Streets	DMURS (Figure 3.3)
Footpath	Footway Widths	Nominal footway widths in low pedestrian activity areas and pinch point areas.		• 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 footpaths		• 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 footpaths 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 footpaths		• 1 in 50 nominal gradient	NDA[1] (Section 1.5.1.1)
		Existing footpaths 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 & absolute minimum 0.3m buffer	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 & 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
	Ramps	Transition to cycle track to carriageway		• 60mm drop at 1:20 gradient (2.4m long)	NCM 4.10

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
		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	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
	Nominal with flow Bus Lane Widths	Nominal lane widths adjacent to cycle track/footpath		• 3m min width & lane widening as required by vehicle tracking assessment on tight bends	BCPDGB (Section 5.1)
		Bus lanes adjacent to on street parking (no cycle track/footpath)		• 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		• 50 km/h	DMURS (Section 4.1.1 & Table 4.1)
	Visibility	Forward Visibility Stopping Sight Distance (SSD) (Buses & HGV vehicles).	50 km/h	• 49m	DMURS (Table 4.2 – 50km/h)
	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		• 50 km/h	DMURS (Section 4.1.1 & Table 4.1)
	Traffic Lane Width	Min carriageway lane width	50 km/h	• 3m min width & lane widening as required by vehicle tracking assessment on tight bends	BCPDGB (Section 5.1)
			60 km/h	• 3.25m min width	
	Visibility	Forward Visibility Stopping Sight Distance (SSD) (cars & smaller vehicles).	50 km/h	• 45m	DMURS (Table 4.2 – 50 km/h)
		Forward Visibility Stopping Sight Distance (SSD) (Buses & HGV vehicles).	50 km/h	• 49m	DMURS (Table 4.2 – 50km/h)
		Visibility to regulatory signage	Up to 50 km/h	• 60m recommended clear	TSM (Table 5.1)

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
	Horizontal Curvature	Minimum radius with adverse camber of 2.5%	50 km/h	• 104m	DMURS (Table 4.3)
	Vertical Curvature	Crest curve K value	50 km/h	• 4.7	DMURS (Table 4.3)
		Sag curve K value	50 km/h	• 6.4	DMURS (Table 4.3)
	Longitudinal Gradient	Longitudinal gradient		• 0.5% minimum grade • 5% desirable maximum grade • 8.3% absolute maximum grade	DMURS (Section 4.4.6)
	Cross Fall	Cross-fall		• 2.5% nominal	DMURS (Section 4.4.6)
All - Junctions	Visibility	Intra-junction visibility envelope		• 2.5m behind stop lines, inclusive of all signal heads	DN-GEO-03044 (TII DMRB TD50/04) Section 2.10 & 2.14. Figs 2/2 and 2/3.
		Priority junction side road visibility distance (safe gap stopping distance)		• X Value = 2.4m • 45m SSD (cars & smaller vehicles) • 49m SSD (HGV/Buses)	DMURS (Figure 4.63) DMURS (Figure 4.63 / Para 4.4.5)
		Visibility to primary traffic signals	50 km/h	• 70m desirable min • 50m absolute min	TSM (Table 9.1)
	Corner Radii	Few larger vehicles (local streets)		• 1m -3m radius (subject to vehicle tracking assessment & 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 & 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 & 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)

Cross Section Element	Design Parameter	Description	Design Speed (km/h)	Adopted Design Parameter(s)	Reference(s)
	Pedestrian Crossings	Signalised crossing type/length *(subject to confirmation by traffic modelling and site constraints)*		• 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)
		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		• 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 scheme, taking account of the design speed and nature of the locations.

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 two way cycle track is 3.25m with a 0.5m buffer between the cycle track and the carriageway. 2m is a desirable minimum width for footpaths with 1.2m being a minimum width at pinch points. A typical CBC cross section is shown on Figure 4-1.

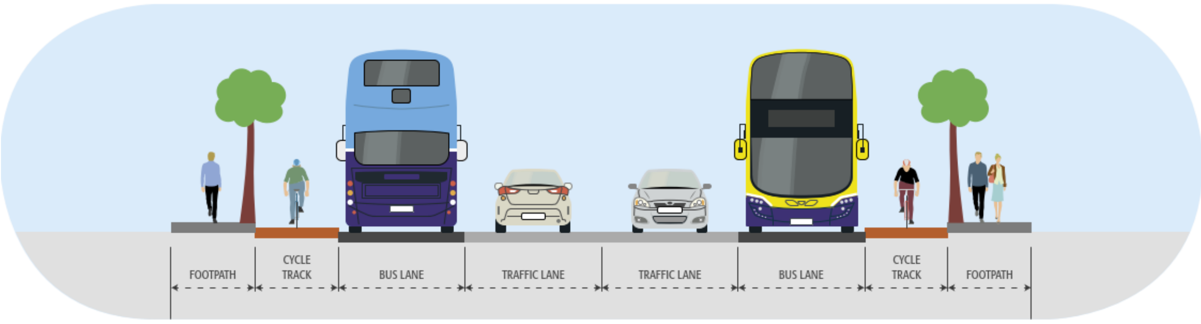

Figure 4-1: Typical CBC Cross Section

A detailed scheme breakdown of existing and proposed 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 are 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.

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

Chainage Reference	Existing Inbound Carriageway / Proposed Inbound Carriageway: Footway Width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Existing Outbound Carriageway / Proposed Outbound Carriageway: Footway Width (m)	Cycle Lane/ Track Width (m)	Bus Lane Width (m)	Traffic Lane Width (m)	Existing Conditions Notes / Proposed Scheme Notes
(Alignment A) Mayne River Avenue to Clarehall Avenue – Malahide Road									
CH. A2950 to CH. A3200	1m - 1.3m	1.5m segregated shared path	N/A	3 x 3.2m lanes	2m-3m	N/A	N/A	2 x 3.2m lanes	No inbound/outbound bus lane in the existing conditions, with suboptimum cycle/ped facilities inbound (cycle track with white line segregation). No designated cycle facilities outbound. Existing outbound footpath and parking not taken in charge.
	2m	2m fully segregated cycle track	3m	3 x 3m lanes	2m	2m cycle track	3m	1 x 3m lane	Road widening into verge area to facilitate a new inbound and outbound cycle track and new inbound bus lane. Existing outbound traffic lane converted to bus lane. Existing outbound parking retained. Land take required both inbound (~2m) and outbound (varies up to 15m) along this section.
(Alignment A) Clarehall Avenue to Clarehall Shopping Centre– Malahide Road									
CH. A3225 to CH. A3500	1.8m-3m	1.25m-1.5m	3m	2 x 3.2m / 3 x 3.2/2.4m lanes	1.3m-2.3m	1.3m	3m	2 x 3.2m / 3 x 3.2m	On road cycle lanes provided in both directions with cycle lanes terminating 50-100m on the southern side of Northern Cross junction. Existing streaming/orphan cycle lane at inbound offline bus stop. No cycle bypass at existing outbound bus stop (inline bus stop). Existing inbound bus lane extents curtailed by approximately 55m for left turning traffic.
	2.2m-7m	1.5m-2m segregated	3m	2 x 3m / 3 x 3m lanes	2m-4m	2m segregated	3m	3 x 3m / 2 x 3m lanes	Road widening into verge and median area to facilitate segregated cycle tracks. Existing inbound bus stop revised to inline with island bypass for cyclists. Existing outbound bus stop relocated closer to the Belcamp Lane intersection due to the revised bus lane arrangement (lane 2) to facilitate the potential for left turn queuing for M50. Two outbound locations for land take required (varies up to 3.5m and 2m) in Council lands along this section to facilitate new widened footpath & cycle infrastructure.
(Alignment A) Clarehall Shopping Centre to Blunden Drive– Malahide Road									

Chainage Reference	Existing Inbound Carriageway Proposed Inbound Carriageway				Existing Outbound Carriageway Proposed Outbound 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. A3525 to CH. A3975	1.5m-2m	1.3m	3m	2 x 3m / 3 x 3m lanes	1.2m-2m segregated	1.4m	3m	4 x 3m / 2 x 3m / 3 x 3m lanes	On road cycle lanes provided in both directions with cycle lanes terminating and transitioning to shared (white line segregated) facility to the north of Blunden Drive roundabout. Outbound footway provided only for part of section. Existing inbound and outbound inline bus stops with no cycle segregation. Existing inbound/outbound bus lane extents curtailed by approximately 55m at the northern end of Blunden Drive roundabout.
	2m-3.9m	1.75m-2m segregated	3m	2 x 3m / 3 x 3m lanes	2m-2.5m	1.5m-2m segregated	3m	4 x 3m / 2 x 3m / 3 x 3m lanes	Modifications to existing central median to provide improved alignment for new signalised junction. New inbound dedicated left turn lane with bus lane to stop line provided for bus priority on inbound arm of Blunden Drive junction. Road widening into verge area to facilitate outbound segregated cycle track. Outbound footway provided along whole section with require a low height (less than 1m) retaining wall. Outbound bus stop relocated closer to the Priorswood Road intersection. Outbound land take required (varies) to facilitate the new bus stop and footpath in council lands. The proposed primary site compound will be located in Buttercup Park with significant additional planting proposed as part of the permanent works.
(Alignment A) Blunden Drive to Greencastle Road– Malahide Road									
CH. A4010 to CH. A4880	1.5m-3m	1.4m	3m	1 x 3m / 2 x 3m / 3 x 3m lanes	1.2m-4.4m	1.4m	3m	2 x 3m / 1 x 3m lanes	On road cycle lanes provided in both directions with cycle lanes terminating and transitioning to shared (white line segregated) facility to the south of Blunden Drive roundabout. Existing inbound and outbound offline bus stops with streaming/orphan cycle lanes and similarly streaming lanes exist on the outbound direction at the entrance to Malahide Road Retail Centre. Existing inbound/outbound bus lane extents curtailed by approximately 55m at the southern end of Blunden Drive roundabout.
	2m-4m	1.5m-2m segregated	3m	1 x 3m / 2 x 3m / 3 x 3m lanes	2m-4.4m	1.5m-2m segregated	3m	4 x 3m / 1 x 3m / 2 x 3m lanes	Modifications to existing central median to provide improved alignment for new signalised junction and new inbound and outbound segregated cycle track. One new inbound island bus stop added. Other – inbound and outbound island bus stops relocated closer to the Greencastle Road intersection. Proposed side entry treatment for side roads throughout this section. No landtake required.
(Alignment A) Greencastle Road to Tonlegee Road– Malahide Road									

Chainage Reference	Existing Inbound Carriageway Proposed Inbound Carriageway				Existing Outbound Carriageway Proposed Outbound 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. A4875 to CH. A5150	1.3m-0m-2.5m	1.4m	3m	1 x 3m / 3 x 3m lanes	2m-3.7m	1.4m	3m	3 x 3m / 1 x 3m lanes	On road cycle lanes provided in both directions with non-cycle protected parallel parking on outbound and streaming/orphan lanes on inbound approach to Tonlegee Road Junction. Existing inbound footpath terminates with pedestrians diverted to Dunree Park between CH A4900 and CH A5025. Existing informal parking layby area on outbound nearside lane.
	2m- 0m - 2.5m	2m segregated	3m	1 x 3m / 3 x 3m lanes	2m-3.7m	1.5m-2m segregated	3m	3 x 3m / 1 x 3m lanes	Narrowing of central median to provide widening and segregation of inbound and outbound cycle track. Inbound segregation traffic island between straight lane and right turn lane removed. Inbound bus stop removed. Outbound island bus stop relocated closer to the Brookville Crescent junction Existing footpath diversion to Dunree Park maintained to retain existing trees in verge with localised footway widening improvements. Existing informal parking removed on Malahide Road and relocated to Brookville Park. The existing old Malahide Road cul-de-sac will be converted to a new landscaped pocket park area with additional tree planting proposed. Inbound land take required (varies up to 2.5m) at junction area to provide improved pedestrian and cycle facilities.
(Alignment A) Tonlegee Road to Gracefield Road– Malahide Road									
CH. A5180 to CH. A6050	2m	1.4m	3m	1 x 3m / 2 x 3m lanes	2m-0m	1.4m	3m	2 x 3m / 1 x 3m lanes	On road cycle lanes provided in both directions with cycle lanes transitioning to offline cycle tracks at Gracefield road roundabout. Existing streaming/ orphan cycle lane at inbound offline bus stop. No cycle bypass at existing outbound bus stop (inline bus stop). Existing on street non cycle protected parallel parking on the outbound direction adjacent to Coolock Village. Existing footpath terminates at Coolock Village.

Chainage Reference	Existing Inbound Carriageway Proposed Inbound Carriageway				Existing Outbound Carriageway Proposed Outbound 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)	
	2m-4.5m	1.5m-2m segregated/ 4.75m quiet street	3m	1 x 3m / 2 x 3m / 3 x 3m lanes	2m-5m (0m)	1.5m-2m segregated/ fully segregated	3m	3 x 3m / 2 x 3m / 1 x 3m lanes	Realigned central reserve to provide widening and segregation inbound and outbound cycle track with inbound cyclists diverted to St Brendans Avenue to protect existing mature trees. Road widening into outbound verge area to provide widening and fully separated cycle track. Inbound bus stop relocated closer to the Tonlegee Road intersection. Outbound bus stop removed. Existing inbound parking consolidated with the taxi stand on outbound with a new toucan crossing. Outbound cycle track adjacent to Brookville Park (CH A5600 - A5950) with revised parking proposals being implemented to segregate cycling and parking. Existing footpath arrangement at Coolock Village retained with pedestrians diverted to parallel side street due to level differences, existing trees and low pedestrian flow.
(Alignment A) Gracefield Road to Kilmore Road– Malahide Road									
CH. A6075 to CH. A6530	2m-6m	1.4m / shared with bus lane	3m	1 x 3m lane	1.5m-7m	1.3m	3m – 0m	2 x 3m / 1 x 3m lanes	On road cycle lanes provided in both directions with cycle lanes transitioning to offline cycle tracks at Gracefield road roundabout. Inbound cycle track shared with bus lane (shared use) on approach to Kilmore Road Junction (~120m). Informal parking on both inbound and outbound directions with no cycle segregation. Inbound and outbound bus stops provided with no cycle segregation. Outbound bus lane missing for 150m north of Kilmore Road junction.
	2m-5m	1.5m-2m segregated	3m	1 x 3m lane	2m-7m	1.5m-2m segregated	3m	3 x 3m / 1 x 3m lanes	Road widening into verge area to facilitate a new inbound and outbound segregated cycle track. Existing inbound informal parking to removed and existing outbound parking to be revised to facilitate formalised cycle protected parallel parking. Additional turn lane added in outbound direction to facilitate the flexibility for independent signalling of left turn movements onto Ardlea Road without compromising bus priority. Proposed new toucan crossing provided mid link to improve accessibility from Danieli Road to nearby shops. Inbound bus stop removed and relocated behind the Kilmore Road intersection. New outbound bus stop added downstream of Kilmore Road. Land take of private property is required both inbound (up to 1.8m and ~1m) and outbound (varies up to 4.5m) to facilitate the new bus and cycle lane infrastructure.

Chainage Reference	Existing Inbound Carriageway Proposed Inbound Carriageway				Existing Outbound Carriageway Proposed Outbound 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) Kilmore Road to Killester Avenue– Malahide Road									
CH. A6550 to CH. A6790	1.5-2m	shared with bus lane	3m	1 x 3m lane	1.8m-2m	1.4m / shared with bus lane	3m	2 x 3m / 1 x 3m lanes	No dedicated segregated cycling facilities in this section. Inbound and outbound cycling shared with bus lane for majority of the section with a streaming/orphan lane introduced on the outbound approach to Kilmore Road junction. Inbound and outbound inline bus stops provided in this section with no cycle segregation.
	2m	1.5m-2m segregated	3m	1 x 3m lane	2m	2m segregated/ fully segregated	3m	2 x 3m / 1 x 3m lanes	Road realignment and widening into green area on outbound side to facilitate segregated inbound cycle track with island bus stop. New cycle track and footpath proposed through green area on outbound, with existing bus stop relocated northern side of Kilmore Road Junction. A hardstrip area will be maintained on outbound road nearside to facilitate street lighting and utilities. The existing milestone will also be retained in this section. Outbound land take into green area required (varies up to 23m).
(Alignment A) Killester Avenue to Collins Avenue East– Malahide Road									
CH. A6810 to CH. A7285	2.5m	shared with bus lane / 1.4m	3.5m (shared use) / 3m	1 x 3m/2 x 3m lanes	2m-3m	shared with bus lane / 1.2m	3.5m	2 x 3m / 1 x 3m lanes	No dedicated segregated cycling facilities in this section. Inbound and outbound cycling shared with bus lane for majority of the section with on road cycle lanes and ASLs introduced on the inbound/outbound approach to Collins Avenue/Killester Avenue junctions. Existing bus lanes curtailed on inbound and outbound approaches to junctions both junctions for left turning traffic. Inbound and outbound inline bus stops provided in this section with no cycle segregation.
	2m-3m	1.5m-2m segregated	3m	1 x 3m / 3x 3/ 2.5m lanes	2m-4m	1.5m-2m segregated	3m	2 x 3m / 1 x 3m lanes	Road realignment and widening into inbound verge area to facilitate a new inbound and outbound segregated cycle track from bus lanes. Proposed inbound right turn box at Collins Avenue to provide flexibility for signalling solutions at this junction Inbound footpath realigned via Maypark/Donnycarney Park to mitigate impacts on existing mature trees. Inbound land take required (varies up to 4.2m and 3.5m).

Chainage Reference	Existing Inbound Carriageway Proposed Inbound Carriageway				Existing Outbound Carriageway Proposed Outbound 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) Collins Avenue East to Casino Park– Malahide Road									
CH. A7310 to CH. A7740	2m-5.5m	shared with bus lane / 1.4m	3.5m (shared use)/ 3m	1 x 3m / 2 x 3m lanes	2m-3m	shared with bus lane / 1.4m	3.5m (shared use)/ 3m	3 x 3m / 1 x 3m lanes	No dedicated segregated cycling facilities in this section. Inbound and outbound cycling shared with bus lane for majority of the section with on road cycle lanes and ASL's introduced on the outbound approach to Collins Avenue junction. Existing parking on outbound nearside parking lane adjacent to retail/private business premises with no cycle segregation.
	2m-5.5m	1.5m-2m segregated	3m	1 x 3m / 2 x 3m lanes	2m-4m	1.5m-2m segregated	3m	3 x 3m / 1 x 3m / lanes	Realignment of central reserve and carriageway narrowing to provide new inbound and outbound cycle track. Inbound road widening into verge area to provide footway and cycle track along section. Outbound bus stop relocated behind the Casino Park intersection. Inbound land take required (varies up to 1.7m and 2m) Existing parking modified on outbound nearside lane to provide cycle segregation and accommodate footpath area outside retail/businesses.
(Alignment A) Casino Park to Copeland Avenue– Malahide Road									
CH. A7755 to CH. A8220	2m-3.5m	1.4m	3m	1 x 3m / 2 x 3m / lanes	3m-4m	1.4m	3m	2 x 3m / 1 x 3m lanes	On road cycle lanes provided in both directions. Inbound and outbound inline bus stops provided in this section with no cycle segregation.
	2m-5.5m	1.5m-2m segregated	3m	1 x 3m / 2 x 3m lanes	2.5m-3.4m	1.5m-2m segregated	3m	2 x 3m / 1 x 3m lanes	Realignment and reducing central reserve to provide widening and segregation inbound and outbound cycle track. Outbound bus stop relocated closer to the Griffith Avenue intersection and another one behind Griffith Avenue intersection. No landtake required.
(Alignment A) Copeland Avenue to Clontarf Road– Malahide Road									
CH. A8240 to CH. A8725	2m-2.5m	shared with bus lane	3m / 3.5m	1 x 3m / 2 x 3m lanes	2m-4m	1.4m	N/A	2 x 3m / 1 x 3m lanes	No designated cycle lanes on inbound route. Shared bus and cycle lane facility provided on inbound. On road outbound cycle lane provided with streaming/orphan lanes on approach to the Griffith Avenue/Copeland Avenue junction. No cycle lanes provided on the immediate downstream approach side of the Clontarf Junction. No outbound bus lane provided for a significant portion of this section. The inbound bus lane only operational between 07:00 to 10:00 hrs in this section and is shared with parking bays in addition to cycle lanes. Inbound and outbound inline bus stops provided in this section with no cycle segregation.

Chainage Reference	Existing Inbound Carriageway Proposed Inbound Carriageway				Existing Outbound Carriageway Proposed Outbound 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 - 2m-3m	N/A	3m	1 x 3m / 2 x 3m lanes	1.8m- 2m	2 x 1.75m segregated	3m	2 x 3m / 1 x 3m lanes	Road realignment and widening into verge area to provide 24 hour inbound and outbound bus lanes. Two way cycle facilities provided on the outbound nearside with cyclists diverted to Brian Road – Carleton Road – Haverty Road – Marglann Marino. Existing outbound cycle track and part of footpath converted to bus lane. Existing inbound and outbound bus stop removed. Existing inbound parking removed. Inbound land take from private property required to facilitate two bus lanes (up to 1m and ~0.8m).
(Alignment D) Priorswood Road (CH A3975)									
CH. D50 to CH. D286	1.8m	1.3m segregated	N/A	1 x 4.5m lane	1.8m – 0m	1.3m segregated	N/A	1 x 4.5m	Shared Cycle tracks provided (white line segregation). No footpath exists between chainage D125 to D250 in the eastbound direction. Existing cycle tracks transition to carriageway.
	2m-3.6m	2m segregated	N/A	1 x 4.5m lane	2m – 4.5m	2m segregated	N/A	1 x 4.5m / 2 x 3m	Realignment of existing inbound cycle track and existing inbound and footpaths. Segregated cycle track added at the entry to the intersection with Malahide Road. Road islands removed (CH. D150). Bus turning head added at CH. D250.
Ayrefield Drive (CH A4400)									
CH. A4400	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Green area. No designated cycle/pedestrian facilities.
	N/A	2.25m segregated	N/A	N/A	2m	2.25m segregated	N/A	N/A	Provided two-way cycle and pedestrian connection between Malahide Road and Ayrefield Drive adjacent to new bus stop facility and toucan crossing on Malahide Road.
Dunree Park (CH A4900 – A5050)									
CH. A4900 to CH. A5050	1.4m-3m	N/A	N/A	1 x ~ 2.8m lane	2m	N/A	N/A	1 x ~ 2.8m lane	No designated cycle facilities.
	1.4m-3m	N/A	N/A	1 x ~ 2.8m lane	2m-4m	N/A	N/A	1 x ~ 2.8m lane	Improved pedestrian traffic by widening outbound footpaths and provide two new uncontrolled pedestrian crossings at Dunree Park.

Chainage Reference	Existing Inbound Carriageway Proposed Inbound Carriageway				Existing Outbound Carriageway Proposed Outbound 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)	
Brookville Park/Old Malahide Road (CH A4950 – A5150)									
CH. A4950 to CH. A5150	2m-2.3m	N/A	N/A	1 x ~2.6m lane	1.4m-2m	N/A	N/A	1 x ~2.6m lane	Parallel residential local road with informal parking on Brookville Park. Old Malahide Road cul-de-sac area unused.
	2m-2.3m	N/A	N/A	1 x ~2.6m lane	1.4m-2m	N/A	N/A	1 x ~2.6m lane	Provided new formalised parking spaces along Brookville Park. New urban realm landscaping works at Old Malahide Road cul-de-sac with Improved pedestrian traffic by adding new green spaces and inbound segregated footpaths connecting Malahide Road, Brookville Park and old Malahide Road.
St Brendans Avenue (CH A5250 – A6000)									
CH. A5250 to CH. A6000	2m-2.5m	N/A	N/A	1 x 2.4m lane	2m	N/A	N/A	1 x 2.4m lane	No designated cycle facilities.
	2m-2.5m	2.4m lane (quiet street treatment)	N/A	1 x 2.4m lane (quiet street treatment)	2m	2.4m shared path	N/A	1 x 2.4m lane	Calming traffic at St. Brendan's Avenue by implementing new and extending existing raised tables. Provided cycle traffic by implementing shared use with car traffic. Improved pedestrian traffic by widening outbound footpaths connecting St. Brendan's Avenue and Malahide Road.
Brookville Park (CH A5550 - A5950)									
CH. A5550 to CH. A5950	N/A	N/A	N/A	1 x 2.4m lane	2m-4m	N/A	N/A	1 x 2.4m lane	Informal car parking along Brookville Park outbound footpath.
	N/A	2m cycle track	N/A	1 x 2.4m lane	2m-2.5m	N/A	N/A	1 x 2.4m lane	Road realignment with parking areas removed and reallocated on outbound nearside to implement a new fully segregated cycle track adjacent to Malahide Road. Reorganization and arrangement of outbound parking spaces with localised footpath narrowing (no inbound parking spaces provided).
(Alignment B) Brian Road/Carleton Road/Haverty Road/Marglann Marino (CH A8300)									
CH. B20 to CH. B675	2.2m-5.4m	N/A	N/A	1 x 3.5m / 1 x 2.3m lanes	2m–3.6m	N/A	N/A	1 x 2.3m / 1 x 3.5m lanes	No designated cycle facilities with informal parking throughout.

Chainage Reference	Existing Inbound Carriageway Proposed Inbound Carriageway				Existing Outbound Carriageway Proposed Outbound 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)	
	2.2m-5.4m	shared with Road	N/A	1 x 3.5m / 1 x 2.3m lanes	2m–3.6m	shared with Road	N/A	1 x 2.3m / 1 x 3.5m lanes	Existing kerb lines generally maintained with additional traffic calming measures and lane marking and pavement resurfacing works implemented to create a suitable quiet street environment for cyclists. Haverty road proposed to be closed to general traffic to reduce rat-running of vehicles along this portion and lower traffic volumes for the quiet street environment.
(Alignment C) St Aidan's Park (CH A8700)									
CH. C25 to CH. C86	1.8m-3.5m	N/A	N/A	1 x 2.4m lane	2m-3.8m	N/A	N/A	1 x 2.4m lane	No inbound/outbound bus lane and cycle track in the existing conditions.
	1.8m-3.5m	N/A	N/A	1 x 2.4m lane	2m-3.8m	N/A	N/A	1 x 2.4m lane	Realignment of junction with Malahide Road and provision of raised table side entry treatment for improved pedestrian priority in vicinity of bus stop on Malahide Road.

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 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 below is also used to inform the appropriate design speed, extracted from DMURS Chapter 4.

PEDESTRIAN PRIORITY — VEHICLE PRIORITY

FUNCTION	CENTRE	N'HOOD	SUBURBAN	BUSINESS/ INDUSTRIAL	RURAL FRINGE
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

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 reduced speed limit from 60km/h to 50km/h from Mayne River Avenue junction to the existing Artane Roundabout. This has been proposed in light of future developments in the area in addition to the proposed reduction in lane widths, increased frequency of pedestrian crossings and cycle infrastructure. A review of the Road Safety Audit (RSA) incident data has also indicated that a reduction in speed limit along could be beneficial for reducing the potential for incidents occurring along this section of the route.

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)
A 2950 to A 6050	Malahide Road R107 from Mayne River Avenue junction to Ardlea Road (Artane Roundabout)	Arterial/ Link	Business/ Industrial/ Suburban	60	50	50
A 6050 to A 8725	Malahide Road R107 from Ardlea Road (Artane Roundabout) to Clontarf Road (Marino Mart)	Arterial/ Link	Suburban	50	50	50

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 practicably possible. 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 possible. 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 footpath 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 possible 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 and 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 SSD, notwithstanding localised adjustments in the horizontal alignment at CH A3800 to A4100 and A5900 to A6150 have been undertaken to facilitate the conversion of the existing Blunden Drive and Artane Roundabouts to new signalised junctions.

4.6 Summary of Vertical Alignment

Due to the nature of the proposed design i.e. the majority of the design proposals involve 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 possible 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."

Visibility concerns associated with adverse vertical crest and sag curves have 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 driver to stop safely, should an object enter its path, is based on the Stopping Sight distance (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 a rule of thumb is that a driver sitting in a low vehicle (eye height 1.05m) must be able to see an object 0.26m high from the SSD distance.

SSD = perception distance + reaction distance + braking distance.

The SSD standards which have been applied to the proposed design in accordance with the design guidance given within DMURS are shown in Table 4-4. The desirable minimum forward visibility requirements were achieved for the Proposed Scheme.

Table 4-4 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 Proposed Scheme objectives of improving facilities 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 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 was 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 Figure4-3

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;
- 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 A 5150 on Brookville Crescent/Tonlegee Road;
- CH A 4850 on Greencastle Road and Odeon Cinema Entrance;
- CH A 7275 on Collins Avenue East/Collins Avenue; and

- CH A 8225 on Copeland Avenue

4.9 Pedestrian Provision

DMURS defines the footpath cross section by three distinct areas. The ‘footway’ area is designated as the main throughfare within the footpath 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 footpath. The assessment of these areas is further discussed in Chapter 13.

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

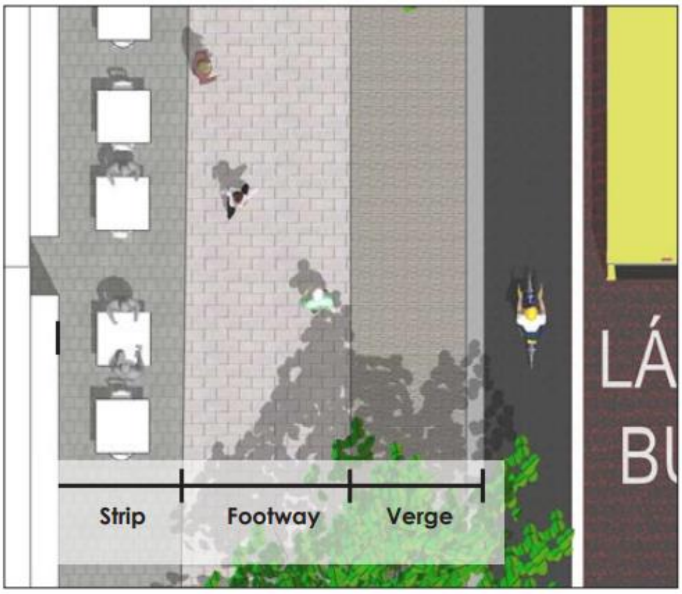

Figure 4-4: Key Components of the Footpath

4.9.1 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 footpath regime.

At specific pinch points, Building for Everyone: A Universal Design Approach, defines acceptable minimum footpath 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 footpath is reduced. For the majority of the Proposed Scheme extents minimum lane widths have been adopted throughout.

Throughout the scheme, footway widths of 2m 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.

4.9.2 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.

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 crossfalls 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 footpath extents.

4.9.3 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 footway are likely to be constrained by the longitudinal gradient of the adjacent carriageway with little scope to vary the footway separately. There are no designated ramps for the Proposed Scheme with longitudinal grading generally falling within the acceptable range.

4.9.4 Pedestrian Crossings

The adopted pedestrian crossing design parameters have been provided in Table 4-1.Where possible, 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.

4.10 Accessibility for Mobility Impaired Users

The aim 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 informed the approach to Universal Design in developing the Proposed Scheme:

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

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.

A detailed scheme breakdown of the relevant existing and proposed footways have 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, where by 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.

4.11 Cycling Provision

One of the core objectives of the Proposed Scheme is to provide segregated cycling facilities along the routes. 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 NCM published by the NTA.

The desirable minimum width for a single-direction, with-flow, raised-adjacent cycle track is 2m. 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 Preferred Route is approximately 5.7km long and includes 10km+ of new cycle tracks. The preliminary design drawings included within Appendix B show the improved extent of cycle provision, which is summarised below:

- 77% Existing cycle priority (outbound) (4% cycle track, 73% advisory cycle lane,);
- 65% Existing cycle priority (citybound) (4% cycle track, 61% advisory cycle lane);
- 100% Proposed cycle priority (outbound) (93% cycle track, 7% quiet street); and
- 100% Proposed cycle priority (citybound) (82% cycle track, 18% quiet street/offline cycle track).

4.11.1 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 Figure4-5 below, taken from the BCPDGB.

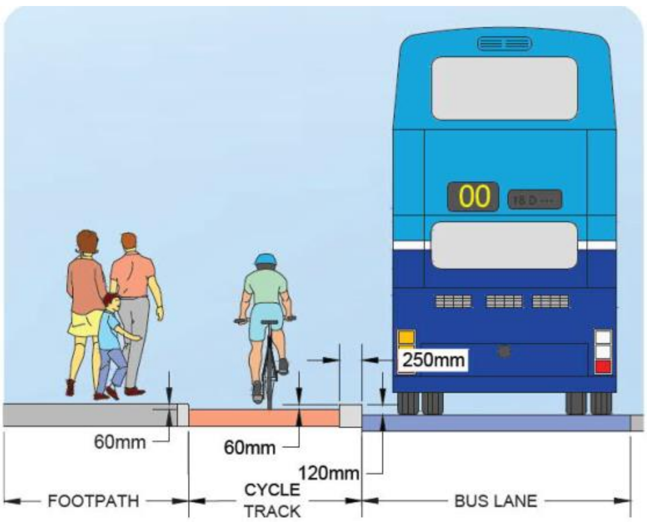

Figure 4-5: Fully Segregated Cycle Track

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

- Malahide Road, from CH A 2950 at the tie in with DCC's Belmayne Main Street and Belmayne Avenue Scheme to CH A 8340 on Brian Road (except for the citybound St. Brendan's Avenue quiet street section)

The desirable minimum width for a single-direction, with-flow, raised-adjacent cycle track is 2m. This is based on the NCM width calculator and allows for overtaking within the cycle track. The minimum width is 1.5m, 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).

4.11.2 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 scheme. 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.

4.11.3 Offline Cycle Track

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

- CH A 4400 at Ayrefield Drive a two-way cycle facility is proposed to provide connectivity to/from the main cycle route;
- CH A 5600 to CH A 5900 outbound cycle track constructed on Brookville Park to provide enhanced segregation and mitigate tree loss in verge area;
- CH A 5950 to CH A 6040 inbound cycle track constructed offline to provide enhanced segregation by gradual transition from the St Brendan's Avenue quiet street to the Gracefield Road/Ardlea Road junction and mitigate tree loss in verge area.
- CH A 6575 to CH A 6775 outbound cycle track to provide enhanced segregation and mitigate tree loss in verge area.

4.11.4 Quiet Street Treatment

Where the Proposed Scheme 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 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 St. Brendan's Avenue, Brian Road, Carleton Road, Haverty Road and Marglann Marino with a view to providing an alternative safe route for cyclists.

Additional traffic calming measures have been proposed at all of the above locations including the proposed road closure for through traffic at Haverty Road.

4.11.5 Treatment of Constrained Areas

At some locations along the scheme, the desired cycleway width cannot be achieved, and localised narrowing is required.

Providing a standard width would require additional land take from either surrounding private properties or pedestrian areas. Due to the high foot traffic in this area, it is preferable to provide a reduced cycleway width; This has occurred at the following locations

- Citybound between A-6400 to A-6500 – Reduced to 1.5m;
- Citybound between A-6600 to A-6640 – Reduced to 1.5m;
- Citybound between A-6880 to A-6920 – Reduced to 1.5m;
- Citybound between A-7140 to A-7270 – Reduced to 1.75m;
- Citybound between A-7440 to A-7550 – Reduced to 1.5m;
- Outbound between A-6220 to A-6200 – Reduced to 1.5m;
- Outbound between A-6580 to A-6350 – Reduced to 1.5m;
- Outbound between A-6920 to A-6880 – Reduced to 1.5m;
- Outbound between A-7270 to A-7140 – Reduced to 1.75m; and
- Outbound between A-7540 to A-7460 – Reduced to 1.5m.

It is also noted that cycle tracks narrow to minimum 1.5m width to slow flow of cyclists when approaching mini bus islands and 1m at the bus stop island.

4.11.6 Cycle Parking Provision

As noted in Section 4.13 bike racks will generally be provided, where practicable, at island bus stops and key additional locations as noted in the Landscape drawings.

4.12 Bus Provision

The Preferred Route is approximately 5.7km long from end to end. The updated scheme design drawings show the improved extent of bus provision:

- 68% Existing bus priority (outbound);
- 79% Existing bus priority (citybound);
- 100% Proposed bus priority (outbound); and
- 100% Proposed bus priority (citybound).

4.12.1 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 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.

Over the majority of the route a 3m wide lane is 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.

4.12.2 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 this scheme.

4.12.3 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 this scheme, but it is noted that DCC has proposed a bus gate at the junction of Belmayne Main Street and Malahide Road as part of the Belmayne Main Street and Belmayne Avenue Scheme.

4.13 Bus Stops

The below flow chart outlines the process for examining the Proposed Scheme and assessing and reporting on the bus stops along the route, as shown in Figure 4-6, below. 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.

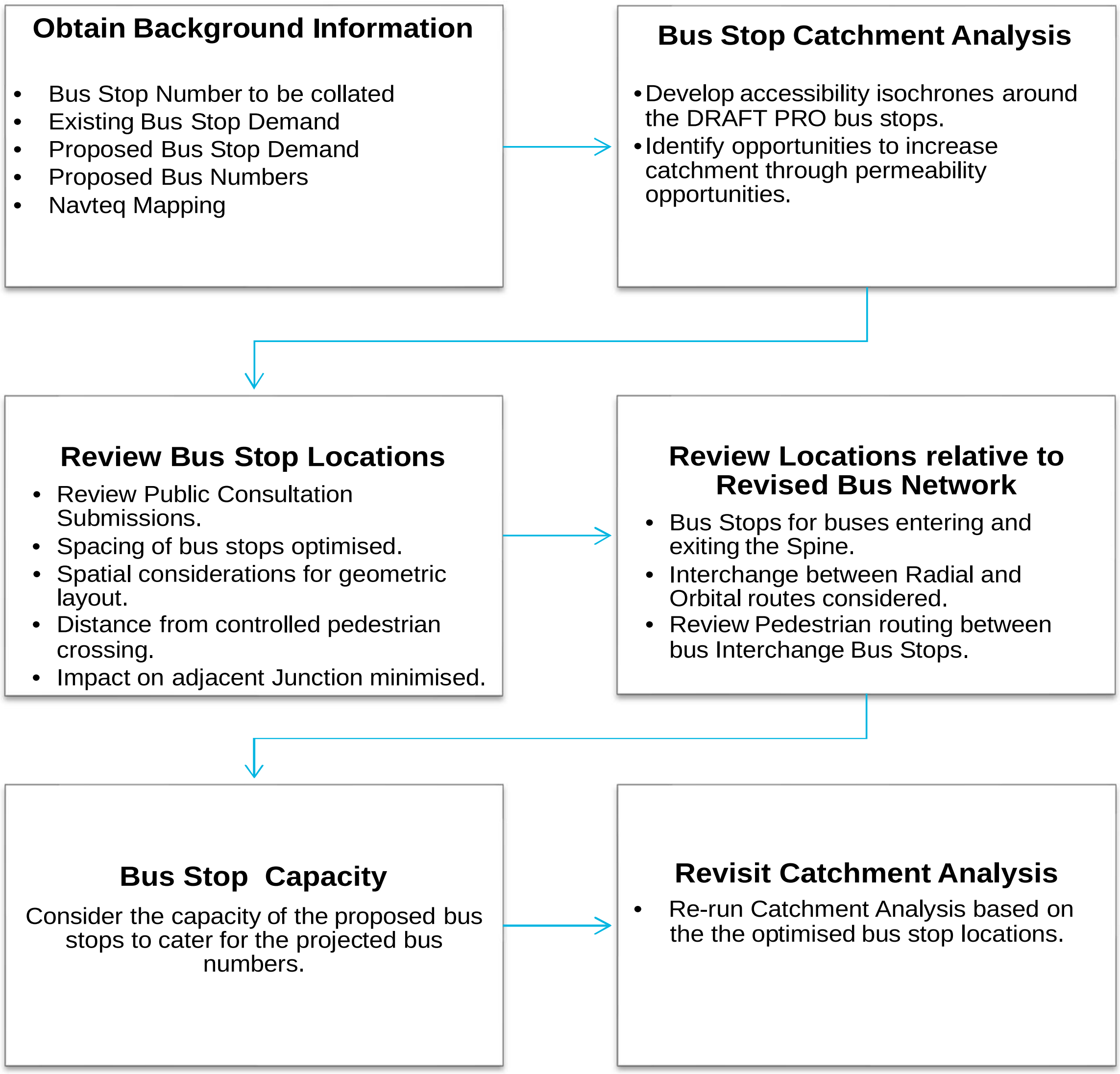

Figure 4-6: Bus Stop Location Assessment Process

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 waiting and passengers are clearly visible to each other;
- Located close to key facilities;
- Located close to main junctions without affecting road safety or junction operation;
- Located to minimise walking distance between interchange stops;
- Where there is space for a bus shelter;
- Located 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.

Boarding of passengers, layout of stations is not being examined as they are either not relevant in this case or dealt with elsewhere as part of the overall BusConnects programme.

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 result in jaywalking. Locations with no or indirect pedestrian crossings should be avoided. Their optimum location is a short distance from a controlled crossing point.

4.13.1 Bus Stop Summary

Table 4-6 below provides an overview of the key changes to the locations for bus stops along the route. 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.

Table 4-6 Clongriffin to City Centre Bus Stop Summary

Inbound							
Existing				Proposed			
No.	**Bus Stop No.**	**Chainage**	**Distance between Stops (meters)**	**No.**	**Bus Stop No. / Location**	**Chainage**	**Distance between Stops (meters)**
1	4563	A3375	N/A	1	4563	A3375	N/A
2	1218	A3675	300	2	1218	A3675	300
3	1270	A4100	425	3	1270	A4025	350
4	1272	A4600	500	4	New	A4440	415
5	1201(1273 GA)	A4925	325	5	1272	A4790	350
6	1274	A5225	300	6	1274	A5225	435
7	1199	A5675	450	7	New	A5475	250
8	1276	A5825	150	8	1276	A5805	330
9	1277	A6125	300	9	1277	A6125	320
10	1219	A6350	225	10	New	A6575	450
11	1220	A6725	375	11	1221	A7025	450
12	1221	A7025	300	12	664	A7375	350
13	664	A7375	350	13	665	A7675	300
14	665	A7675	300	14	666	A7975	300
15	666	A7975	300	15	667	A8275	300
16	667	A8275	300	16	668	A8700	425
17	668	A8700	425				
		Average Distance:	**333**			Average Distance:	**355**

Outbound							
Existing				Proposed			
No.	**Bus Stop No.**	**Chainage**	**Distance between Stops (meters)**	**No.**	**Bus Stop No. / Location**	**Chainage**	**Distance between Stops (meters)**
1	1205	A3425	N/A	1	1205	A3550	N/A
2	6115	A3650	225	2	New	A3925	375
3	1203	A4075	425	3	New	A4375	450
4	1202	A4725	650	4	1202	A4925	550
5	1201	A4975	250	5	1201	A5100	175
6	4385	A5300	325	6	1200	A5525	425
7	1200	A5525	225	7	1199	A5775	250
8	1199	A5775	250	8	1198	A6175	400
9	1198	A6175	400	9	New	A6500	325
10	1197	A6650	475	10	1196	A6950	450

Outbound							
Existing				Proposed			
No.	Bus Stop No.	Chainage	Distance between Stops (meters)	No.	Bus Stop No. / Location	Chainage	Distance between Stops (meters)
11	1196	A6950	300	11	4382	A7375	425
12	4382	A7375	425	12	New	A7800	425
13	672	A7575	200	13	671	A8000	200
14	671	A8000	425	14	New	A8300	300
15	670	A8175	175				
16	669	A8500	325				
		Average Distance:	**338**			Average Distance:	**365**

4.13.2 Island Bus Stops

The preferred bus stop arrangement for the Proposed Scheme is the island bus stop arrangement, Figure 34 of the BCPDGB, is shown below in Figure 4-7.

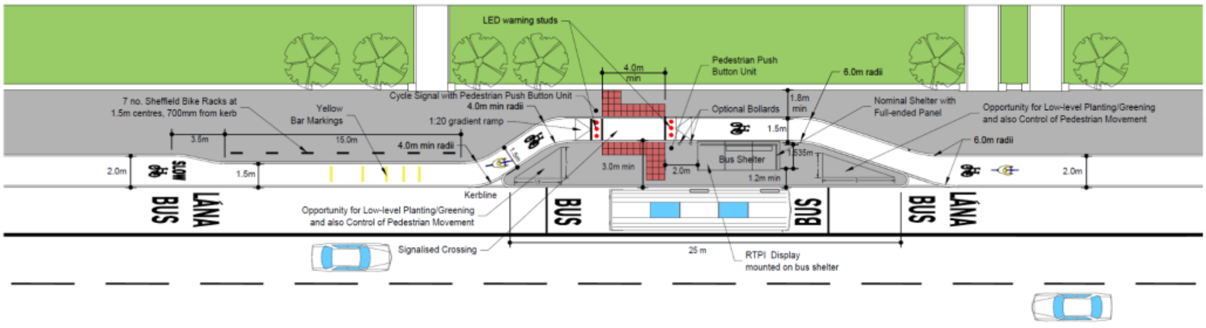

Figure 4-7: Example of an Island Bus Stop

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 potential 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 could be 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 could also be featured at the crossing points.

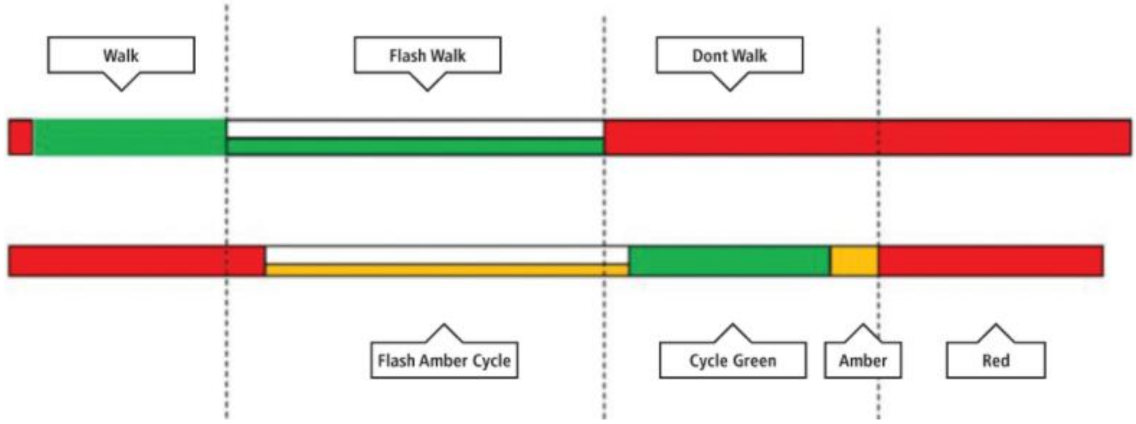

Figure 4-8: Example of Nested Pelican Sequence

A 1:20 ramp is provided on the cycle track to raise the cycle track to the level of the footpath/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 nominated at 1 in 3 to provide for a 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, where practicable, in the immediate vicinity as shown in Figure 4-7 to promote the use sustainable mode interchange at bus stops for longer distance trips.

Figure 4-9: 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

Citybound/ Outbound	Bus Stop Name	Bus Stop No.	Chainage	Bus Stop Type
Citybound	Malahide Road – Clarehall Shopping Centre	4563	A 3380	Island Bus Stop
Citybound	Malahide Road – Blunden Drive/ Priorswood Road	Relocated Bus Stop	A 4040	Island Bus Stop
Citybound	Malahide Road – Ayrefield Drive	New Bus Stop	A 4450	Island Bus Stop
Citybound	Malahide Road – Tonlegee Road/ Brookville Crescent	1274	A 5220	Island Bus Stop
Citybound	Malahide Road – St. Brendan's Drive	New Bus Stop	A 5500	Island Bus Stop
Citybound	Malahide Road – Mask Avenue	1276	A 5800	Island Bus Stop
Citybound	Malahide Road – Collins Avenue	664	A 7370	Island Bus Stop
Outbound	Malahide Road – Belcamp Lane	Relocated Bus Stop	A 3550	Island Bus Stop
Outbound	Malahide Road – Blunden Drive/ Priorswood Road	New Bus Stop	A 3920	Island Bus Stop
Outbound	Malahide Road – Retail Centre	New Bus Stop	A 4380	Island Bus Stop
Outbound	Malahide Road – Greencastle Road	Relocated Bus Stop	A 4820	Island Bus Stop
Outbound	Malahide Road – Tonlegee Road/ Brookville Crescent	Relocated Bus Stop	A 5100	Island Bus Stop
Outbound	Malahide Road – Coolock Village	1200	A 5520	Island Bus Stop
Outbound	Malahide Road – Brookville Park	1199	A 5770	Island Bus Stop
Outbound	Malahide Road – Kilmore Road	New Bus Stop	A 6500	Island Bus Stop
Outbound	Malahide Road – Collins Avenue	4382	A 7370	Island Bus Stop
Outbound	Malahide Road – Casino Park	New Bus Stop	7800	Island Bus Stop
Outbound	Malahide Road – Brian Road	New Bus Stop	A 8300	Island Bus Stop

4.13.3 Shared Landing Area Bus Stops

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 4.13.2. 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 footpath and tactile paving provided to minimise pedestrian/cyclist conflict. Shared landing area bus stops were required in a number of locations along the CBC route due to localised space constraints. See Table 4-8 below, for the locations of bus stops of this type. An example of a shared landing area bus stop is shown in Figure 4-10.

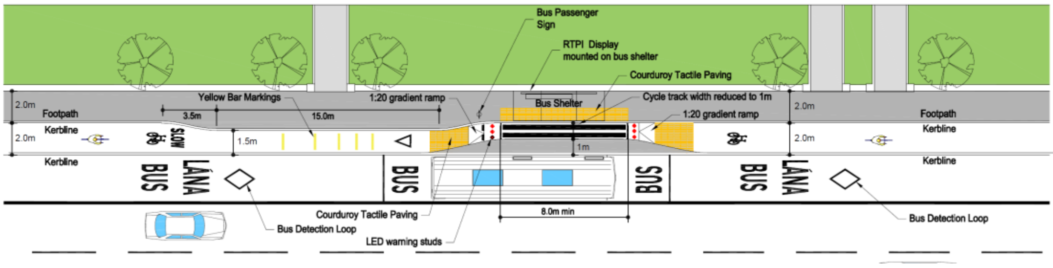

Figure 4-10: Example of a Shared Landing Area Bus Stop

Table 4-8 List of Shared Landing Area Bus Stops

CItybound/ Outbound	Bus Stop Name	Bus Stop No.	Chainage	Bus Stop Type
Citybound	Malahide Road – Grove Park	1218	A 3670	Shared Landing Bus Stop
Citybound	Malahide Road – Greencastle Road	Relocated Bus Stop	A 4800	Shared Landing Bus Stop
Citybound	Malahide Road – Gracefield Road/ Ardlea Road	1277	A 6130	Shared Landing Bus Stop
Citybound	Malahide Road – Kilmore Road	New Bus Stop	A 6600	Shared Landing Bus Stop
Citybound	Malahide Road – Elm Mount Road	1221	A 7020	Shared Landing Bus Stop
Citybound	Malahide Road – Casino Park	665	A 7670	Shared Landing Bus Stop
Citybound	Malahide Road – Tonlegee Road/ Brookville Crescent	1274	A 5220	Shared Landing Bus Stop
Citybound	Malahide Road – Collins Avenue	664	A 7370	Shared Landing Bus Stop
Citybound	Malahide Road – Mount Temple School	666	A 7970	Shared Landing Bus Stop
Outbound	Malahide Road – Gracefield Road/ Ardlea Road	1198	A 6170	Shared Landing Bus Stop
Outbound	Malahide Road – Elm Mount Road	1196	A 6950	Shared Landing Bus Stop
Outbound	Malahide Road – Casino Park	New Bus Stop	A 7800	Shared Landing Bus Stop
Outbound	Malahide Road – Mount Temple School	New Bus Stop	A 8000	Shared Landing Bus Stop

4.13.4 Inline Bus Stop

Inline bus stops are used on the Proposed Scheme where there are no adjacent cycling facilities provided due to the presence of offline cycle facilities. Inline bus stops are provided at the following locations listed in Table 4-9.

Table 4-9 List of Inline Bus Stops

Citybound/ Outbound	Bus Stop Name	Bus Stop No.	Chainage	Bus Stop Type
Citybound	Malahide Road – Marino Avenue	667	A 8300	Inline Bus Stop

4.13.5 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, when re-entering general traffic lanes, 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.

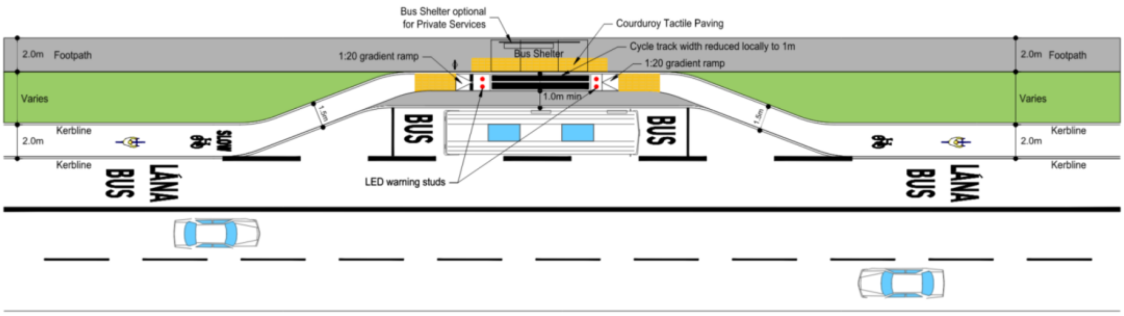

Figure 4-11: Example of a Layby Bus Stop

Layby bus stops are used at the following locations along the Proposed Scheme listed in Table 4-10

Table 4-10 List of Layby Bus Stops

Citybound/ Outbound	Bus Stop Name	Bus Stop No.	Chainage	Bus Stop Type
Citybound	Malahide Road – Marino Crescent	668	A 8700	Layby Bus Stop

4.13.6 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 footpath/island widths required to accommodate the full end panel shelter is 3.3m with an absolute minimum width of 3m to facilitate a min. 1.2m clearance at the end panel for pedestrians. Alternative arrangements for more constrained footpath widths are considered in the following sections.

Figure 4-12: 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 footpath locations. Figure4-13 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 footpath/island widths required to accommodate the full end panel shelter is 2.75m with an absolute minimum width of 2.4m to facilitate a min. 1.2m clearance at the end panels for pedestrians.

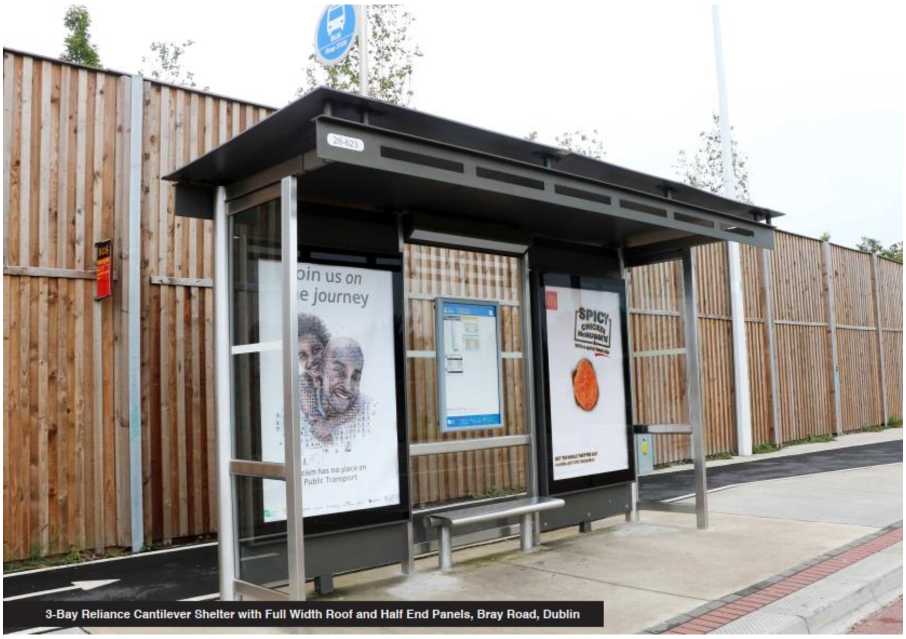

Figure 4-13: Example of a 3-Bay Reliance Cantilever Shelter with Full Width Roof and Half End Panels (Source: JCDecaux)

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 footpath widths for the narrow roof configuration are 2.75m (with end panel) and 2.1m (no end panel). The absolute minimum footpath widths for these shelters are 2.4m (with end panel) and 1.8m (no end panel) to requirements for boarding and alighting passengers in consideration of wheelchair, pram, luggage and other such similar spatial requirements.

Figure 4-14: 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 footpath. 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.

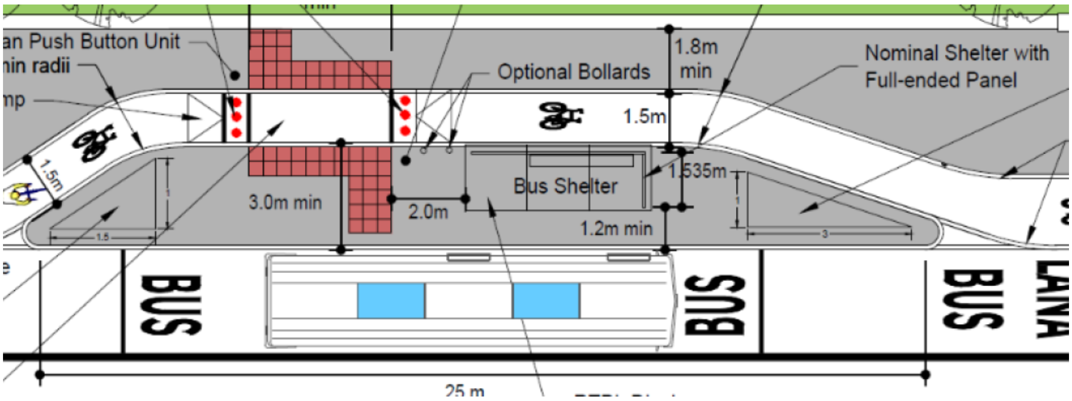

Figure 4-15: Preferred Shelter Location (On Island)

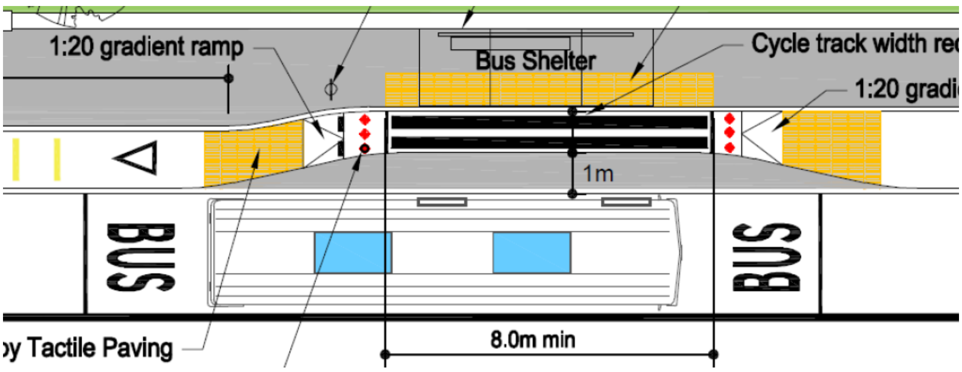

Figure 4-16: Alternative Shelter Location Back of Footpath (Narrow Island with Adequate Footpath Widths)

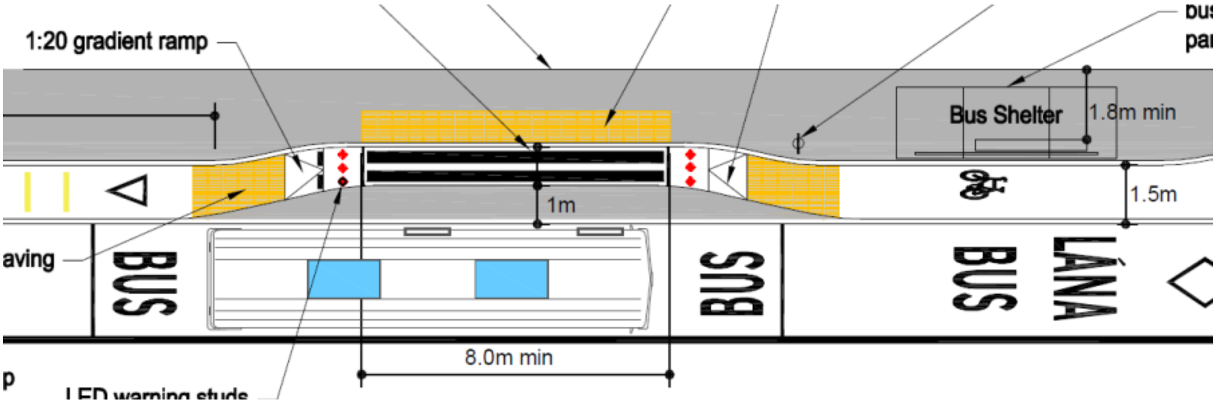

Figure 4-17: Alternative Shelter Location Downstream of Island (Narrow Island with Narrow Footpath Widths at Landing Area)

4.14 Parking and Loading

As part of the ongoing 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 parking survey data, which could not be obtained due to ongoing movement restrictions as a result of the international Covid-19 pandemic, information was obtained by site visits and desktop studies. Quantification of the number of existing parking spaces and their potential removal along the scheme is a critically 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 measure 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.

4.14.1 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 and further discussed in detail in 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 4-11 below.

Table 4-11 Summary of Parking Amendments

Locality	Parking type	Existing Parking Provision	Proposed Parking Provision	Change
Coolock	Disabled permit parking	0	1	+1
	Informal parking	237	207	-30
Artane	Designated paid parking	9	3	-6
	Disabled permit parking	1	1	0
	Illegal parking	15	8	-7
	Informal parking	295	278	-17
Donneycarney	Designated paid parking	91	75	-16
	Disabled permit parking	0	2	+2
	Illegal parking	29	19	-10

4.14.2 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:

- In the Northern Cross area, existing access locations to car parks of business will be affected by the new scheme.
- In the Coolock area, the scheme designates parking for homeowners which is expected to reduce the amount of informal parking by 30 parking spaces that currently obstructs pedestrians and cyclists.
- In the Artane area where customer parking will be reduced from seven adjacent parking spaces and 13 informal parking spaces across the road to four adjacent parking spaces;
- In the Donneycarney area 14 designated paid parking spaces will be removed along the R107 Malahide Road at the junction to Marino Crescent which serves business along the road;
- The introduction of a cul-de-sac along Haverty Road would result in reduced collisions with parked cars, due to considerably less cars entering the cul-de-sac; and
- The provision of improved bus priority, cycle infrastructure and footpaths has the potential to lead to a general reduction/requirement for cars ownership in the area.

4.15 Turning Bans

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

At the northern end of the Proposed Scheme the existing speed limit on the R107 Malahide road is 60kph between Mayne River Junction and the exit to the Hilton Hotel where it reduced to 50kph, through Northern Cross Junction the speed limit is 50kph and increases to 60kph from Clarehall Shopping Centre to the Artane Roundabout. Between the Artane Roundabout and the Clontarf Road the speed limit is 50kph. As discussed in Section 4.3 it is proposed to reduce have a consistent 50kph speed limit along the Malahide Road from Mayne River Avenue.

A summary of the turning bans along the Proposed Scheme are shown in Table 4-12

Table 4-12 Summary of Turning Bans

Chainage	Minor Road	Major Road	Existing/ Proposed	Turning Ban	Notes
3000	Belmayne Main Street (Bus Gate)	Malahide Road	Proposed	No right turn onto major road	New Junction. Only buses exiting minor road and are not proposed to turn Right
3600	Belcamp Lane	Malahide Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
4100	Newton Road	Malahide Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
4700	Crown Decorating Centre	Malahide Road	Existing	Left turn only onto major road	Existing Turn Ban used to regulate Traffic flow
5550	St Brendan's Drive	Malahide Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
5550	Brookville Park	Malahide Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
5925	Brookville Park	Malahide Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
6300	Danieli Road	Malahide Road	Existing	No left turn onto minor road	Existing Turn Ban used to regulate Traffic flow
6500	Kilmore Road	Malahide Road	Existing	No right turn onto minor road (except cycles)	Existing Turn Ban extended to 24hr used to regulate Traffic flow
6750	Killester Avenue	Malahide Road	Existing	No left turn onto minor road (MON-SAT 07:00-10:00)	Existing Turn Ban used to regulate Traffic flow
8000	Dublin Fire Brigade Training Centre	Malahide Road	Existing	No right turn onto major road	Existing Turn Ban used to regulate Traffic flow
8250	Copeland Avenue	Malahide Road	Existing	No right turn onto minor road	Existing Turn Ban used to regulate Traffic flow
8300	Brian Road	Malahide Road	Existing	No right turn onto minor road	Existing Turn Ban used to regulate Traffic flow
B 450	Haverty Road	St. Aidan's Park	Proposed	No entry to Haverty Road (except cycles)	Haverty Road closed to vehicular traffic.

4.16 Relaxations Departures and Deviations

The terms relaxation and departure are derived from the DMRB and 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, 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.

4.16.1 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 aims and objectives of the 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 footpaths, and cycle tracks and limiting vehicles' speed through the use of tight kerb radii on all internal junctions within the development;
- 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;

- The implementation of traffic calming measures and side entry treatments promote pedestrian activity on the junction side arms; and
- Addressing the legacy rat-running at Haverty Road with the introduction of a road closure will improve the local setting for residents and cyclists.

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 table of identified deviations relating to the road geometry, alongside those identified for other technical design elements, is included within Table 4-13 below.

Table 4-13 Summary of Deviations

Chainage	Major Road	Minor Road	Description of Deviation	Justification of Deviation
7275	Malahide Road	Collins Avenue	Right Turn lane and Right Turn Pocket on the inbound carriageway is 2.5m wide.	Low flow turning right and Traffic will be controlled by traffic Signals

4.17 Road Safety and Road User Audit

Road Safety Audits (RSA) have been undertaken at various stages through out 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 & 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 possible); and
- **Stage 4**: Early operation at 2 to 4 months' post road opening with live traffic.

In line with the above a Stage 1 RSA was undertaken as part of the EPR selection process and two Stage 1 RSAs were undertaken as part of the preliminary design development. The three RSAs have been included in Appendix M complete with the proposed designer's responses.

The Stage 1 RSA was reviewed in light of the scheme development and had identified various elements of the EPR scheme that were subsequentially improved with design development, including the introduction of cycle protected junctions, tie ins for cycle infrastructure on side roads and buffer zones for parking and pedestrian segregation measures.

The Stage 1 RSAs represents the response of an independent audit team to various aspects of the scheme in April 2020 and December 2021. 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.

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 possible. 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 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;
- 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 possible. 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, controlled crossing for pedestrians is provided across part of the junction, whilst some of the traffic movements that are now in conflict with the pedestrian movement, are allowed to run at the same time. This facility has the advantage to allowing pedestrians to cross during the cycle whilst having less effect on traffic capacity.

To minimise pedestrian delays at junctions, it was important that proposed junction cycle times are kept as short as possible. The cycle times at all signalised junctions in the DS scenarios for 2028 and 2043 are proposed to be reduced in comparison to the DM cycle times, as shown in the summary Table 5-1.

Table 5-1 Do Minimum and Do Something Cycle Times

Junction	DM Cycle Time (seconds)	DS Cycle Time (seconds)
Mayne River Avenue	N/A – New junction	120
R107 Malahide Road / R139	160	120
Malahide Road -Clarehall Shopping Centre	120	120
Malahide Road -Blunden Drive	N/A – Existing roundabout	120
Malahide Road -Greencastle Road	156	120
Malahide Road -Tonlegee Road	120	120
Malahide Road-Ardlea Road	N/A – Existing roundabout	120
Malahide Rd-Kilmore Road	162	100
Malahide Road - Killester Avenue	164	120
Malahide Road - Elm Mount Road	124	100
Malahide Road-R103 Collins Avenue	135	120
Malahide Road- Casino Park	115	110
Malahide Road-Griffith Avenue	127	120
Malahide Road-Clontarf Junction	127	120

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 possible 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.

In certain junctions an orbital cycle track is provided i.e. at the Northern Cross (Malahide Road / Clarehall Avenue). At these locations, controlled crossing points are proposed to allow pedestrians to cross the cycle track. Left turning cyclists can effectively bypass the junction, while giving way to pedestrian crossings as well as cyclists already on the orbital cycle track.

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 four 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 inbound and outbound 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.

A full Junction Type 1 hasn't been applied to the Proposed Scheme, however the Proposed Scheme has a number of 'hybrid' junctions, which comprise of a Junction Type 1 and another junction type, as shown in Figure 5-1 below.

Appropriate road markings and signage will be considered to inform road users of the requirement for taxis and buses to merge with general traffic if they are turning left. A sample of such road markings is shown in Figure 19 of BCPDGB.

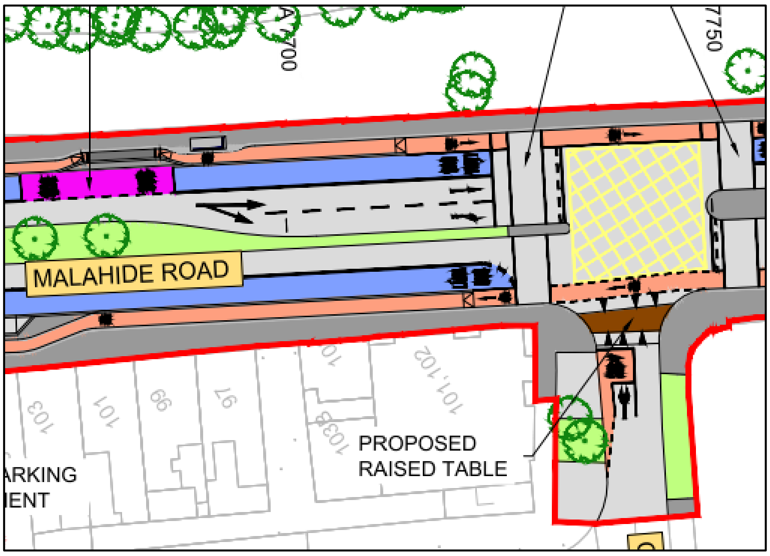

Figure 5-1: Junction Type 1

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 inbound and outbound 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.

In this instance, left turners are held and mainline cyclists proceed with the bus phases. Mainline cyclists can proceed also with the straight ahead general traffic if left turners are held. If the volume of left tuners traffic is less than 150 PCUs per hour, then mainline cyclists could still proceed with left turnings from the left turning pocket on a flashing amber arrow.

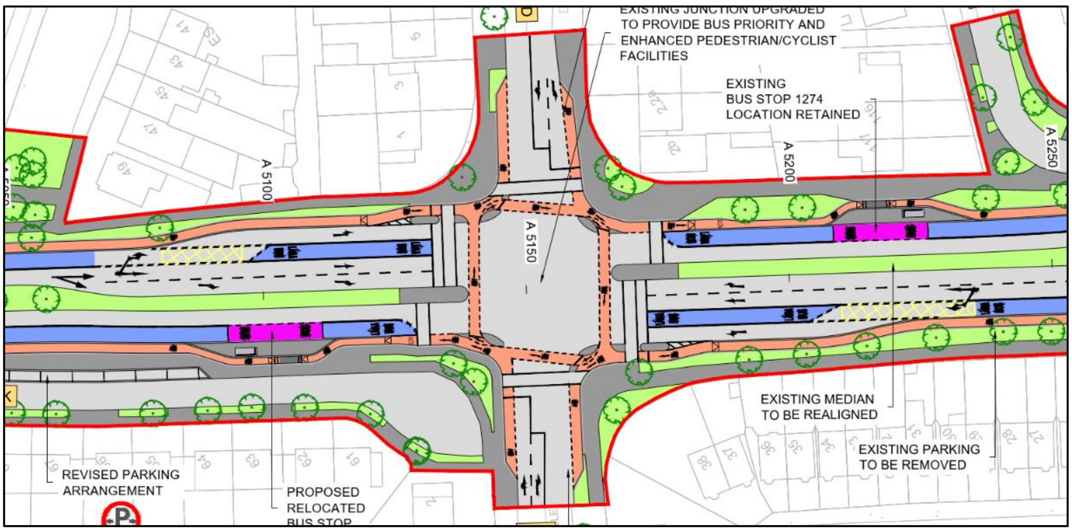

Figure 5-2: Junction Type 2, Proposed Tonlegee Road / Malahide Road junction

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 inbound and outbound 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 turning volumes are less than 150 PCUs per hour. Left turning from the left turn pocket are given a flashing amber.

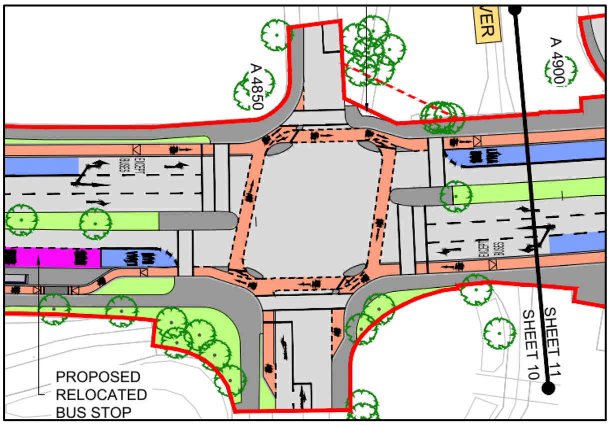

Figure 5-3: Junction Type 3, Proposed Greencastle Road / Malahide Road junction

5.3.3.4 Junction Type 4

Junction Type 4, as described in Section 7.4.4 of BCPDGB, illustrates a signalised junction with an inbound and outbound bus lane, but also positions the pedestrian crossings on the inside of the cycle lanes across the arms of the junction. Pedestrian crossing distances are minimised as a result. Signalised pedestrian crossings are proposed across the cycle tracks to allow pedestrians to cross from the footpath to the pedestrian crossing landing areas, thus avoiding uncontrolled pedestrian – cyclist conflict. The key design features and considerations relating to this junction type are as follows:

- An orbital cycle track is provided, with controlled crossing points to allow pedestrians to cross to large islands within a central signal controlled area
- Left turning cyclists can effectively bypass the junction, while giving way to pedestrians crossing as well as cyclists already on the orbital cycle track
- Pedestrians and cyclists can cross at the same time due to the segregated and nonconflicting crossings; and
- Signal controlled pedestrian crossing distances are reduced when compared to traditional junction layouts, due to the face that pedestrians cross the cycle track in a separate signalised movement. Pedestrian crossings are also close to the pedestrian desire line. However the number of crossings for pedestrians is increased as pedestrians must cross the cycle track to access the central signal controlled area.

Junction Type 4 is chosen for the following reasons:

- High incidence of HGV movements e.g. at industrial estates or where two major regional roads meet; and
- Suburban setting and lower pedestrian volumes.

In this instance, mainline buses and left turning from the mainline proceed together.

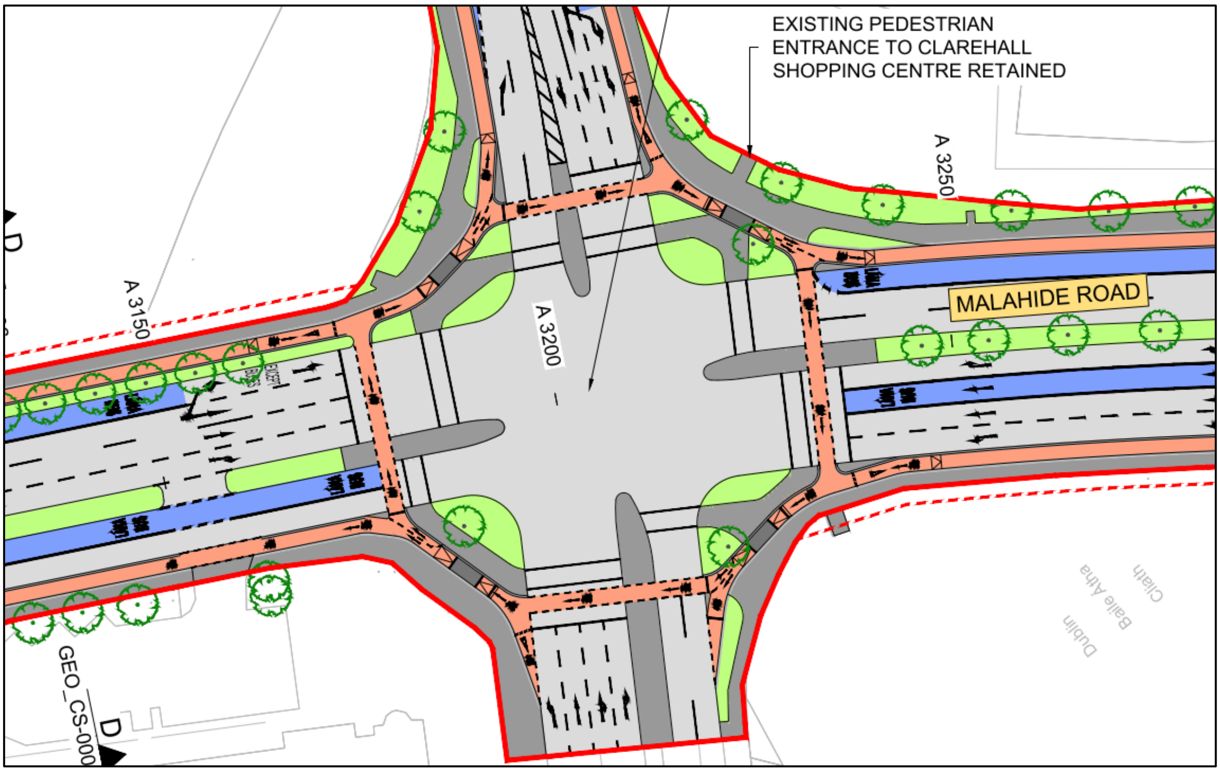

Figure 5-4: Junction Type 4, Proposed Clarehall Avenue / Malahide Road junction

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 seconds early start has been proposed on the main arms of the majority of junctions, with 3 seconds minimum at certain junctions;
- 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 and Table 5-3, 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.	Junction	Key Design Notes
1	Malahide Road / Mayne River Avenue	Junction Type 1 with bus lane upto the stop line. New direct pedestrian crossings
2	R107 Malahide Road / R139 'Northern Cross'	Junction Type 4: Junction layout with dedicated pedestrian and cycle crossings Bus priority inbound and outbound along the CBC proposed. Key interchange location with orbital bus services
3	Malahide Road (R107)-Clarehall Shopping Centre	Junction Type 1 and Junction Type 2: Proposed bus priority, pedestrian and cycle infrastructure at the existing junction. New Toucan crossing facility.
4	Malahide Road -Blunden Drive	Junction Type 4: Removal of existing roundabout junction to facilitate upgrade to a signal control junction that includes pedestrian, cycle and bus infrastructure. Junction Type 4 design applied
5	Malahide Road -Greencastle Road	Junction Type 3: Introduction of pedestrian and cycle crossings on all arms of the junction, with bus priority at the junction.
6	Malahide Road -Tonlegee Road - Brookville Crescent	Junction Type 2: Existing 4 arm junction to be upgraded to provide pedestrian and cycle crossings on all arms. Bus priority proposed upto the junction.
7	Malahide Rd-Ardlea Road	Junction Type 4: Existing roundabout junction proposed to be removed. Introduction of a signal controlled junction with pedestrian and cycle crossings, with bus priority also upto the stop line.
8	Malahide Rd-Kilmore Road	Junction Type 1 and Junction Type 2: Pedestrian and cycle crossings proposed. Bus priority also upto the stop line.
9	Malahide Road - Killester Avenue	Junction Type 1 and Junction Type 3: Cycle and pedestrian crossing faciltiies proposed, with bus priority.
10	Malahide Road - Elm Mount Road	Junction Type 1 and Junction Type 3: Proposed pedestrian and cycle crossings. Bus priority introduced.
11	Malahide Rd-R103 Collins Avenue	Junction Type 2 and Junction Type 3: Proposed pedestrian and cycle infrastructure & crossings on all arms of the junction.
12	Malahide Rd- Casino Park	Junction Type 1 and Junction Type 3: Bus priority inbound upto the junction, proposed pedestrian and cycle crossings. Outbound bus lane proposed.
13	Malahide Rd- Griffith Avenue - Copeland Avenue	Junction Type 2 and Junction Type 3: Proposed pedestrian and cycle crossings. Outbound bus lane proposed.
14	Malahide Rd-Clontarf Road	Junction Type 1: Proposed direct pedestrian crossings, with bus priorirty inbound and outbound directions

Table 5-3 Moderate Junctions

No.	Junction	Key Design Notes
1	Malahide Road – Belcamp Lane	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment)
		No right turn onto Malahide Road.
2	Malahide Road – Grove Park	Uncontrolled pedestrian crossing maintained.
	Malahide Road – Newton Road	Uncontrolled pedestrian crossing maintained.
3	Main Street – Grange Lodge Avenue	No right turn onto Malahide Road.
4	Malahide Road – Retail Centre	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment)
5	Malahide Road – Newton Cottages	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment)
6	Malahide Road – Crown Decorating Centre	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)
7	Main Street – Park Avenue	Proposed right turn ban onto Malahide Road.
8	Malahide Road – Coolock Village	No current pedestrian crossing facilities (raised table side entry treatment proposed)
		Proposed right turn ban onto Malahide Road.
9	Malahide Road – St. Brendan's Drive	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)
10	Malahide Road – Newton Road	Proposed right turn ban onto Malahide Road.
11	Malahide Road – Brookville Park	No current pedestrian crossing facilities (raised table side entry treatment proposed)
12	Malahide Road – Retail Centre	No right turn onto Malahide Road.
13	Malahide Road – Mornington Grove	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)
14	Malahide Road – Danieli Road	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)
		No left turn onto Danieli Road.
15	Malahide Road – St. David's Wood	Cycle and pedestrian crossing faciltiies proposed
16	Malahide Road – Elm Road	Existing raised table crossing retained
17	Malahide Road – Clancarthy Road	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)
18	Malahide Road – Donnycarney Road	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)
19	Malahide Road – Brian Road	Existing raised table crossing retained.
		No right turn onto Brian Road.
20	Malahide Road – Marino Avenue	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)
21	Malahide Road – Charlemont Road	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)
22	Malahide Road – Crescent Place	Uncontrolled pedestrian crossing maintained.
23	Malahide Road – Marino Crescent	Uncontrolled pedestrian crossing maintained. (raised table side entry treatment proposed)

5.3.5.1 Minor and Priority Junctions

There are no minor or priority junctions in the Proposed Scheme that are not already listed above.

5.3.5.2 Roundabouts

No roundabouts are proposed as part of the Proposed Scheme.

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 and resulting adverse traffic impacts.

The traffic modelling steps can be summarised as follows and 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 provided 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 stage green 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.

Figure5-5 illustrates an overview of the traffic modelling process for the proposed scheme.

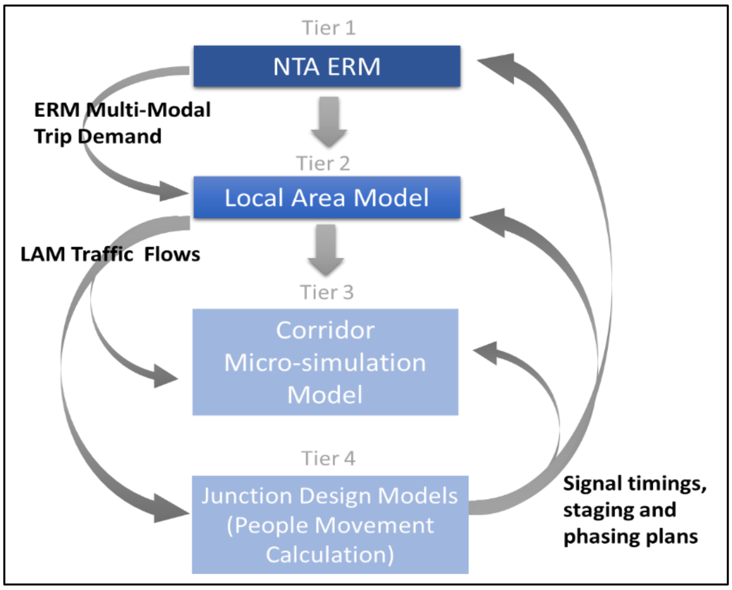

Figure 5-5: Proposed Scheme Traffic Modelling Hierarchy

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 5-6: 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 stage green 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 5-7 illustrates an initial 2028 AM distribution plot, whilst Figure5-8 illustrates a final iterated distribution plot. Figure 5-7 illustrates more significant traffic dispersion onto the surrounding road network, whilst the refined Figure 5-8 demonstrates a more optimised Proposed Scheme, where traffic dispersion has been minimised without compromising the sustainable modes.

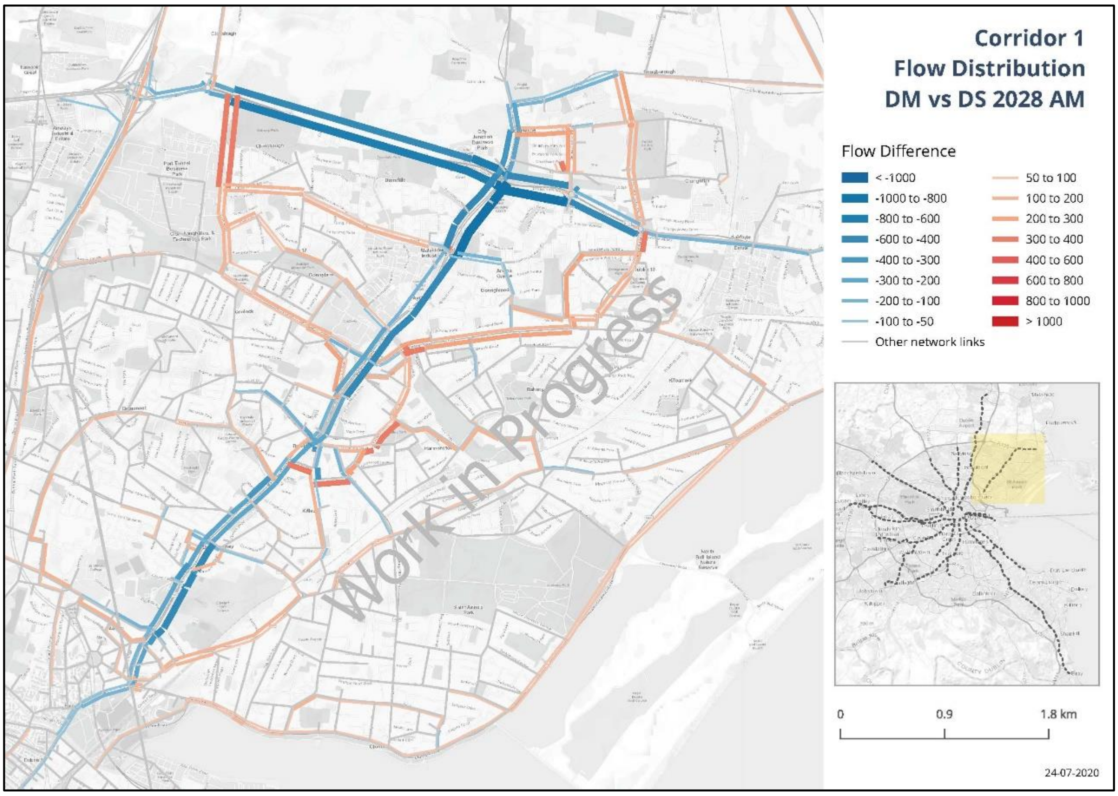

Figure 5-7: An initial 2028 AM Peak DLAM Distribution Plot

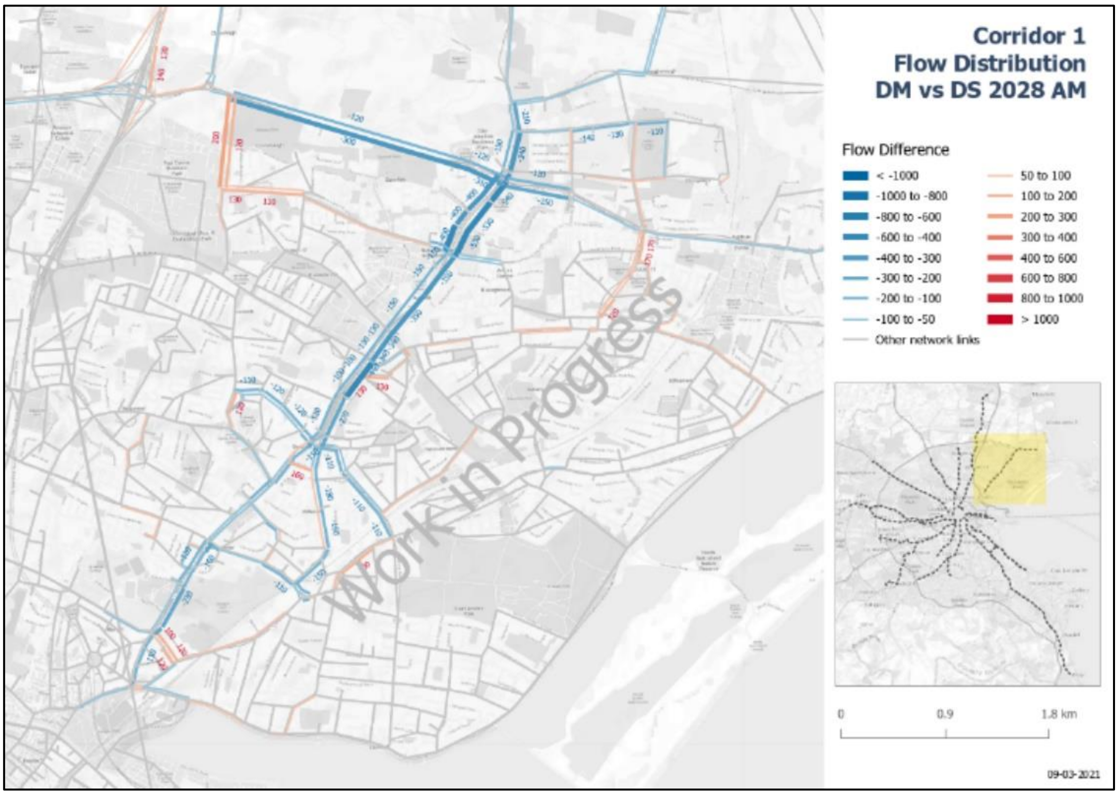

Figure 5-8: Optimised and Iterated 2028 AM Peak DLAM Distribution Plot

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 Satrun 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”.

Each junction along the Proposed Scheme has 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 5-6 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 5-4 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 5-4 Cyclist People Movement Quantification

Junction Name	Cycle Quantification (Number of Cyclists)			
	2028 AM Peak Hour		2028 PM Peak Hour	
	Design Target	Total Modelled	Design Target	Total Modelled
Mayne River Avenue	407	440	358	590
R107 Malahide Road / R139 'Northern Cross'	640	650	735	750
Malahide Road (R107)-Clarehall Shopping Centre	421	495	501	530
Malahide Road -Blunden Drive	484	685	537	575
Malahide Road -Greencastle Road	394	692	440	510
Malahide Road -Tonlegee Rd - Brookville Crescent	519	785	534	550
Malahide Road-Ardlea Road	576	635	570	615
Malahide Road-Kilmore Road	500	610	544	560
Malahide Road - Killester Avenue	503	590	502	550
Malahide Road - Elm Mount Road	483	530	473	490
Malahide Road-R103 Collins Avenue	592	760	547	580
Malahide Road- Casino Park	531	600	515	540
Malahide Road-Griffith Avenue - Copeland Avenue	645	795	570	595
Malahide Road-Clontarf Junction	1,077	1,090	918	1,030

5.4.4.3 LinSig Results

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

Table 5-5 Proposed Scheme Signalised Junctions

No	Junction Name	Cycle Time (Seconds)		Practical Reserve Capacity (%)	
		DM	DS	AM Peak Hour	PM Peak Hour
1	Mayne River Avenue	N/A	120	13%	3%
2	R107 Malahide Road / R139	160	120	-5%	-15%
3	Malahide Road - Clarehall Shopping Centre	120	120	135%	96%
4	Malahide Road - Blunden Drive	Roundabout	120	14%	23%
5	Malahide Road - Greencastle Road	156	120	33%	3%
6	Malahide Road - Tonlegee Road	Roundabout	120	-15%	5%
7	Malahide Rd-Ardlea Road	Roundabout	120	11%	4%
8	Malahide Road - Kilmore Road	162	100	46%	29%
9	Malahide Road - Killester Avenue	164	120	-17%	-19%
10	Malahide Road - Elm Mount Road	124	100	15%	12%
11	Malahide Rd-R103 Collins Avenue	135	120	-12%	1%
12	Malahide Road - Casino Park	115	110	49%	8%
13	Malahide Road - Griffith Avenue	127	120	-11%	-18%
14	Malahide Road - Clontarf Road	127	120	13%	13.8 %

In summary the Proposed Scheme junction designs are generally operating within capacity with the exception of Griffith Avenue, Killester Avenue and the Northern Cross Junction (R107/R139). The Griffith Avenue junction presents a challenging arrangement where inbound cyclists are taken diagonally across the junction to the new two-way cycle facility. As such this creates a challenge from an operational and staging perspective and requires an additional stage in the cycle to facilitate the movement.

The Killester Avenue junction has capacity issues related to the ahead and right turn lane on the northern and southern arms. Spatial constraints cannot permit the introduction of a dedicated right turn lane here in either direction. Consequentially green time has been maximised in the northern and southern arms to facilitate the flow of traffic.

The Northern Cross Junction has a high volume of traffic approaching the junction being a key node with western and eastern arm movements to and from the M50 being the primary capacity constrained arms which do not impact on the bus priority for the main corridor for the AM peak. The situation is very similar in the PM peak with an additional capacity constraints on the core bus corridor arms for the outbound traffic heading towards the M50 (left turn from the southern arm and right turn from the northern arm). The junction design has responded to the analysis for the heavy left turn from the southern arm and the Proposed Scheme provides a dedicated left turn lane from the upstream Clarehall Shopping Centre Junction in response to the demand. Similarly the bus lane has been relocated to lane 3 on the approach to the junction to facilitate the bus priority.

6 Ground Investigation and Ground Condition

6.1 Introduction and Desktop Review

The following sections provide a summary of the desk study and commentary on the findings of ground investigations that have been undertaken for the Proposed Scheme. 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 AECOM/Mott MacDonald document:

- Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated October 2019 which has been located in Appendix E.

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

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

As there are no significant structures on this scheme no specific ground investigation has been undertaken to date. It is anticipated that a ground investigation with locations and spacings generally conforming to guidelines of EC7, will be carried out at later date.

It should be noted that the Proposed Scheme does not have any significant structures (retaining walls over 2 metres or bridge structures) proposed along the route that would require traditional extensive ground investigation works.

6.2 Summary of Ground Investigation Contract

No specific ground investigation has been undertaken to date.

6.3 Ground Investigation

No specific ground investigation has been undertaken to date.

6.4 Soils and Geology

6.4.1 Quaternary Sediments

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.4.2 Bedrock

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.5 Groundwater

6.5.1 Groundwater Monitoring

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.5.2 Contaminated Land

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.6 Overview of Soil Classification, as applicable

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 Road Works (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;
- 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.

6.6.1 Re-use

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

6.6.1.1 Topsoil

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

6.6.1.2 Glacial Till

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

Laboratory California Bearing Ratio (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. Moisture Condition Value (MCV) test data at the site investigation stage can also frequently underestimate the acceptability of Class 2 materials.

In-situ CBR results obtained from Dynamic Cone Penetrometer (DCP)testing in trial pits and measured Standard Penetration Tests (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 c_u value as follows:

$$Cu = f_1 \times N_{60}$$

Guidance on the value of f_1 is provided by Stroud & Butler (1975) who related the parameter to the soil plasticity index. A value of 5.5 - 6 could be used for f_1 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 300mm 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 Hydrogeology, as applicable

6.7.1 Aquifer Classification

According to the GSI Groundwater Resources (Aquifer) map the Lucan and Malahide Formations, which predominantly underly the route, are classified as Locally Important Aquifers (LI). These formations are moderately productive only in local zones.

The Tober Colleen Formation, which crosses the central portion of the route, is classified as a Poor Aquifer (PI) and is described as being generally unproductive except for local zones.

Soil permeability across the route and surrounding area is low; consequently, the groundwater recharge is estimated by the GSI to be between 23mm and 61mm per year.

According to the GSI wells and springs map there is one spring and three boreholes located within 1km of the route. These are summarised in the following Table 6-1:

Table 6-1 Review of GSI Well and Springs

Type	Name (GSI Reference)	Distance from route	Comment
Spring	St Brendan's Well (3223SWW005)	150m	Located on the southern banks of the Santry River.
Borehole	BH1 (2923SEW033)	250m	Monitoring well for industrial use. 16.5m deep. Bedrock not encountered.
Borehole	BH2 (2923SEW032)	250m	Monitoring well for industrial use. 15.0m deep. Bedrock not encountered.
Borehole	N/A (3223SWW001)	450m	Well for industrial use. Described as having a "Good" yield of 196m3/day. Depth of hole 52.7m. Depth to bedrock 10m.

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

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019, see Appendix E.

6.7.2 Groundwater Vulnerability

The GSI National Groundwater Vulnerability map indicates that most of the proposed route lies within an area of "Low" groundwater vulnerability. However, the southern 2.3km of the scheme lies within an area of "Moderate" to "Extreme" groundwater vulnerability. It should be noted that rock is recorded at or near surface to the east of the route at this location. Two localised areas of "Moderate" to "High" groundwater vulnerability are recorded along the route in the Coolock and Clongriffin areas respectively.

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.7.3 Karst Landforms

According to the GSI Groundwater Karst Data map there are no karst features recorded within the route. However, a spring is recorded 1.2km north of the route, located within an area underlain by an inlier of Waulsortian Limestone.

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.8 Preliminary Engineering Assessment

6.8.1 Embankments

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.8.2 Cuttings

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.8.3 Pavement Design

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.9 Geotechnical Input to Structures

6.9.1 Foundations

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

6.9.2 Retaining Structures

Refer to Preliminary Sources Study Report (PSSR): BusConnects Corridor Route 01: Clongriffin to City Centre, dated December 2019.

7 Pavement, Kerbs, Footways and Paved Areas

7.1 Pavement

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.

7.1.1 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. 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 bus and cycle infrastructure. Existing footpaths and existing traffic lanes will also be impacted by the works. In general, all existing footpaths 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 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.

7.1.2 Design Constraints

7.1.2.1 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.

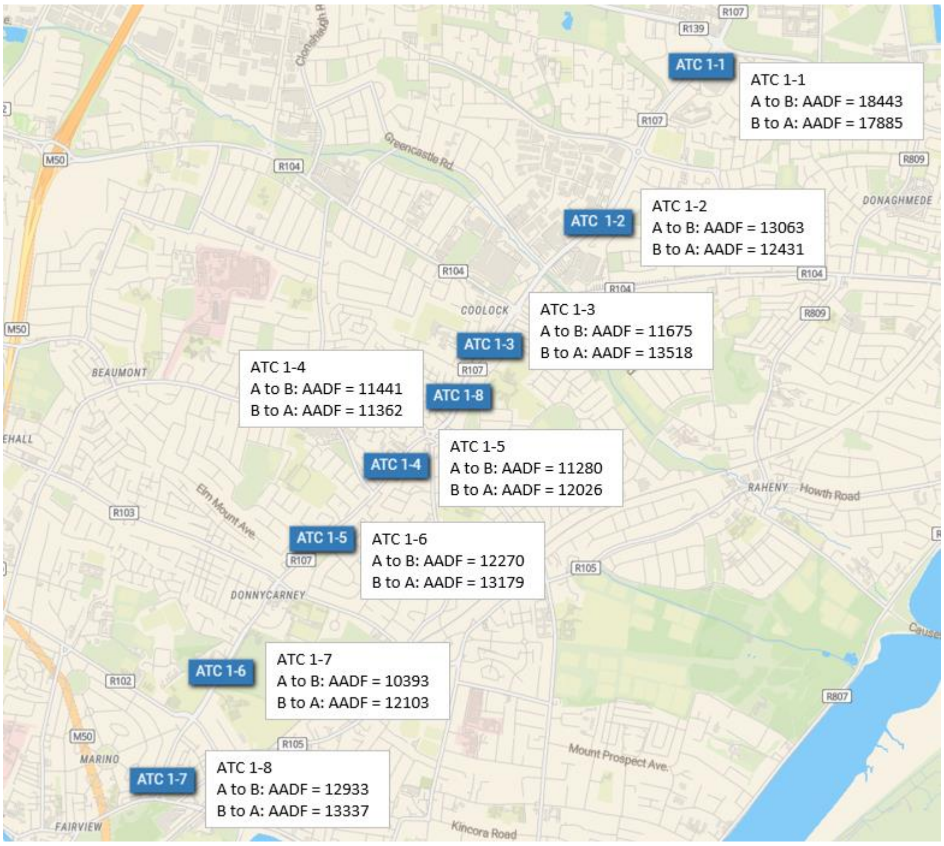

Figure 7-1: 2019-2020 AADF – Proposed Clongriffin to City Centre Scheme

Based on surveyed flows Table 7-3 below gives the estimated design for 20-year (rehabilitation) and 40-year (widening/ new construction) design periods for the Proposed Scheme. Based on the New Dublin Area Bus Network, the forecast bus frequency of 45 busses per hour equates to 30 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 Clongriffin to City Centre Proposed Scheme.

Design Life	
20 Years	40 Years
7 to 11 msa	– 13 to 21 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		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 (CSRSW) in DCC and is presented below in Figure 7-9. The design allows for Hot Rolled Asphalt (HRA) and Stone Mastic Asphalt (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, 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.

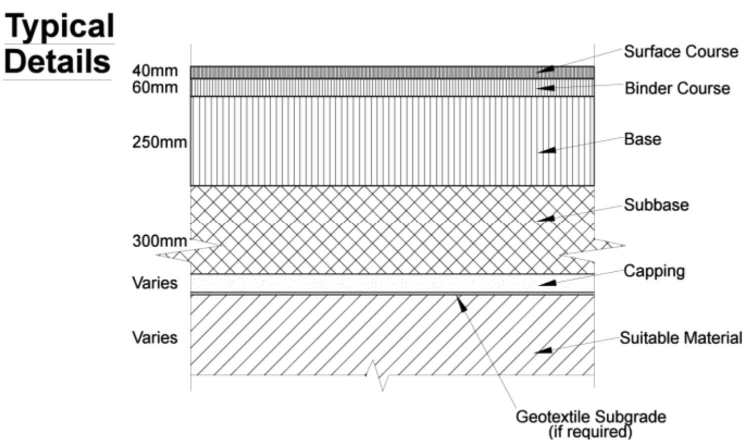

Figure 7-2: DCC Construction Standards for Roads and Street Works – Bus Corridor – Asphalt Road (Indicative 80msa Design)

Where it is considered uneconomical to provide a standard design for particular low traffic scenarios, like non bus routes/ quiet routes, 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 TII's DMRB).

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

- Bus stops (on and off-line);
- Priorswood Road bus turnaround facility;

- Loading / Unloading areas for delivery vehicles;
- Off-line parking areas;
- Driveways; and
- Traffic calming features.

7.1.2.2 Geometry Considerations

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.

7.1.2.2.1 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).

7.1.2.2.2 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 kerblines.

7.1.2.2.3 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.

7.1.2.2.4 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.

7.1.2.2.5 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.

7.1.2.2.6 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.

7.1.2.2.7 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.

7.1.2.3 Existing Pavement Considerations

7.1.2.3.1 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 HRA and 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.

7.1.2.3.2 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.
- **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 & 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 drawing series BCIDA-ACM-PAV_PV-0006_XX_00-DR-CR-9001.

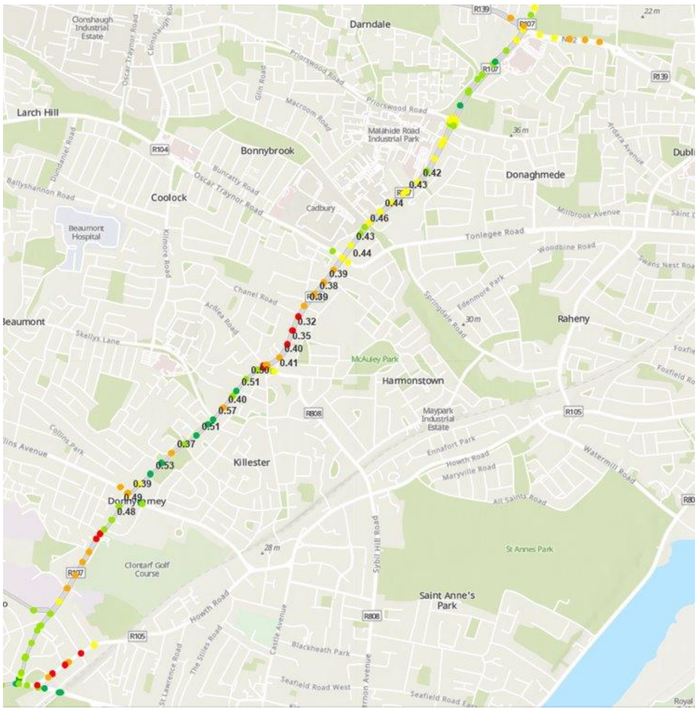

Figure 7-3: Corrected SCRIM Conditions for Proposed Scheme Source: ArcGIS RMO MapRoad (2019 DCC Pavement Surveys) - Esri UK, Esri, HERE, Garmin, METI/NASA, USGS mapping

The SCRIM assessment (Figure 7-3) for the Proposed Scheme indicates that retexturing treatment or replacement of the surface course (40mm Asphalt Surface Course) may be required along Malahide Road from Colin's Avenue to Griffith Avenue and Priorswood Road to Ardlea Road/Gracefield Road, where these sections of the route have been categorised as 'Amber' or 'Red'. 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 & 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

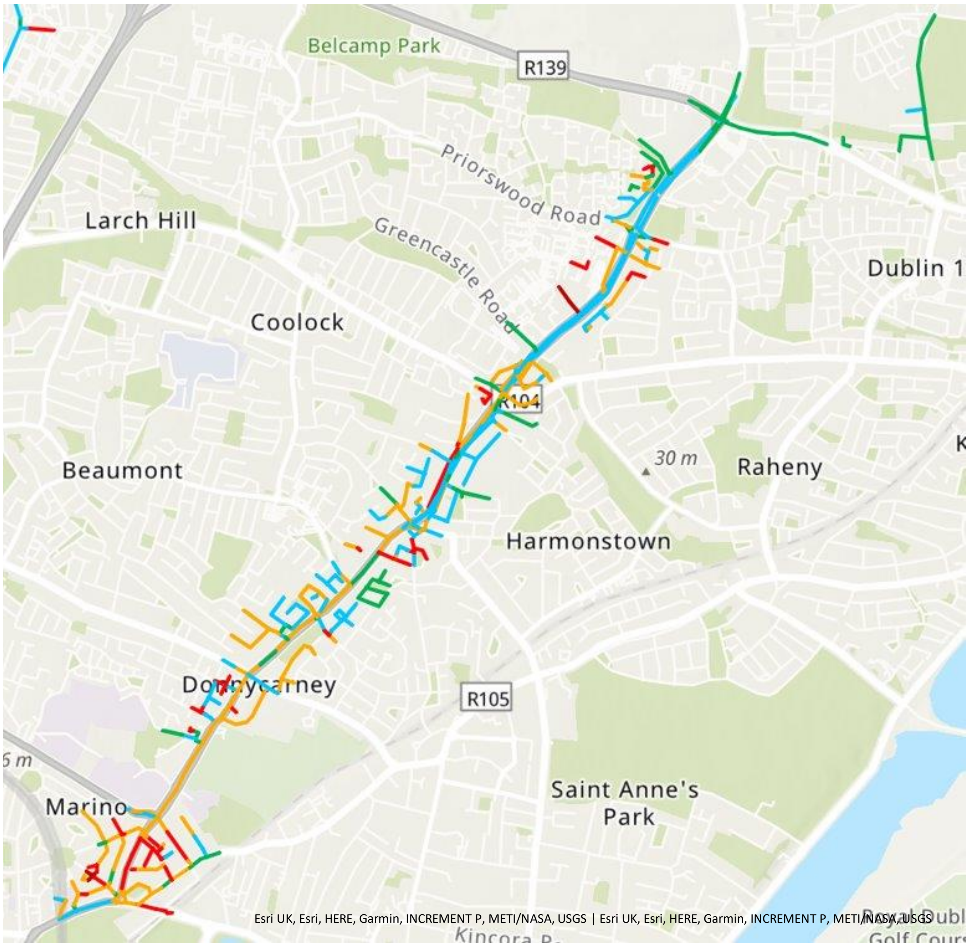

Figure 7-4: PSCI Survey for the Proposed Scheme

The PSCI survey (Figure 7-4) 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 localised areas of the route with moderate defects located on Carleton Road (Marino) and stretches of Malahide Road. There are also areas of the route in poor/distressed condition along Malahide Road (Fairview to Charlemont Road), Haverty Road and St. Aidan's Park Road.

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 showing defects which corroborate with the PSCI data received.

Figure 7-5: Localised Poor Road Pavement Condition on Malahide Road Near Junction with Crescent Place ©2019 Google Maps

Figure 7-6: Localised Poor Road Pavement Condition on Haverty Road (Proposed Quietway) ©2021 Google Maps

Road Condition Index (RCI) Scanner

Where RCI scanner data 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 RCI scanner survey (Figure 7-7) 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 localised areas of poor condition identified at the Malahide Road/Colin's Avenue junction and roundabout connecting Malahide Road/Gracefield Road/ Ardlea Road. Scanner data was not included for Haverty Road in Marino, but it is expected to be in poor condition following multiple longitudinal and transverse utility excavations.

Figure 7-7: 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 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.

Section	Length	Pavement Quality								N/A
	(both sides)	Red		Amber		Yellow		Green		(No Data)
	(m)	Length (m)	%	Length (m)	%	Length (m)	%	Length	%	
Malahide Road										
Malahide Road (Belmayne Avenue - Priorswood Road)	3122	0	0	40	1	1200	38	1882	60	0
Malahide Road (Priorswood Road - Greencastle Road)	1676	42	3	20	1	172	10	1442	86	0
Malahide Road (Greencastle Road - Tonlegee Road)	1178	0	0	6	1	368	31	804	68	0
Malahide Road (Tonlegee Road - Ardlea Road/Gracefield Road)	3500	80	2	60	2	1254	36	2106	60	0
Malahide Road (Ardlea Road/Gracefield Road - Killester Ave)	1540	34	2	60	4	1012	66	434	28	0
Malahide Road (Killester Avenue - Collins Avenue)	990	0	0	0	0	634	64	356	36	0
Malahide Road (Collins Avenue - Griffith Avenue)	3348	38	1	146	4	3164	95	0	0	0
Malahide Road (Griffith Avenue - Marino Mart)	1244	100	8	588	47	556	45	0	0	0
Haverty Road/Carleton Road/Brian Road	1418	0	0	114	8	1088	77	216	15	0

Figure 7-8: Preliminary Overall Pavement Quality Assessment of Pavement Works for Clongriffin to City Centre Scheme (Both Directions)

A summary of the overall assessment in Figure 7-9 indicates just 8% of the pavement on the route needs further intervention than resurfacing.

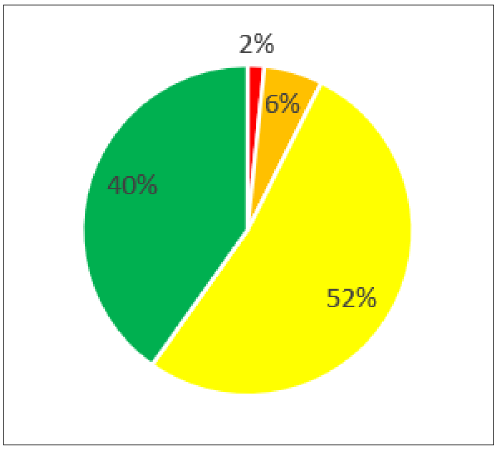

Figure 7-9: Summary of Overall Preliminary Pavement Quality Assessment – Key: Red (Poor), Amber (Moderate / Poor), Yellow (Moderate / Good) and Green (Good)

7.1.2.4 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 Penetrating 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.

7.1.3 Pavement Design

7.1.3.1 Pavement Materials

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. Concrete (rigid) pavements, particularly if proposed at bus stops may prove impractical for these works due to long curing times and the need to remain untrafficked until sufficient strength gain has been achieved. For such reasons, concrete pavements at on-line bus stops are likely to be difficult to accommodate without delaying the construction programme. However, off-line bus stops, and bus interchanges where buses are likely to remain stationary for longer periods of time and thus benefit from rigid construction, could more feasibly be concrete pavements without causing delay to construction. This will need to be reviewed during future detailed design.

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 & 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 7-5 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 7-5 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.

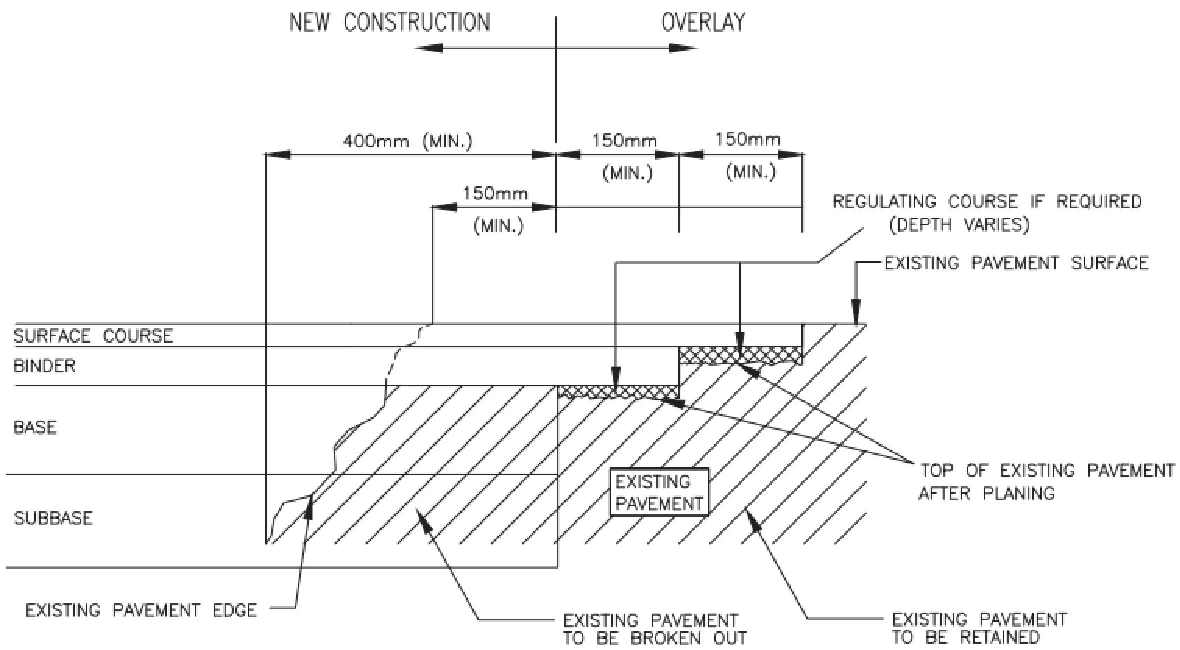

Figure 7-10: TII - Typical Road Section Longitudinal Tie In with Existing Road

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 7-6for a range of design traffic which will cover the variable traffic volumes along the bus lanes.

Table 7-6 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

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

7.1.3.2 Pavement Strategy

7.1.3.2.1 New Pavement and Bus Interchange Strategy

No new sections of carriageway alignment or bus interchanges are proposed on this scheme.

7.1.3.2.2 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 7.1.2.4 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 & 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 drawing series BCIDA-ACM-PAV_PV-0006_XX_00-DR-CR-9001 included 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.

7.1.3.3 Opportunities for Innovation

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

7.1.3.4 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 DCC (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, Natural Stone or Concrete Pavers .

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 cycleway and cycle track design and materials selection. This is in line with DCC CSRSW requirements.

7.2.2 Design Constraints

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 Figure7-11

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.

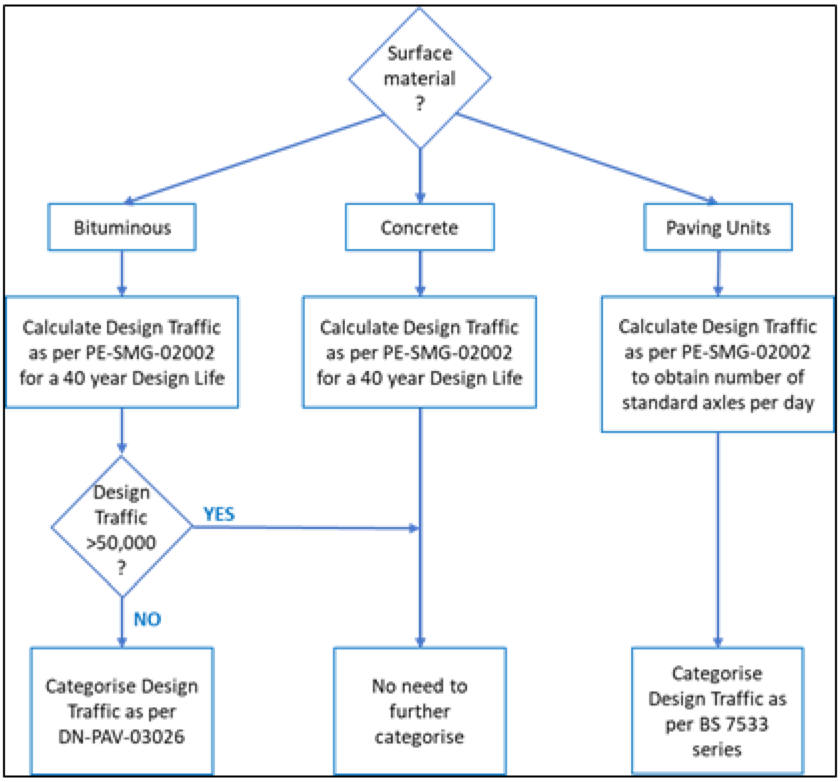

Figure 7-11: Traffic Design and Categorisation for KFPA

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

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 areas.

For bituminous footways and cycle tracks, the bituminous layer(s) should make use of as much recycled material as possible. low energy bound mixtures (LEBM) should be considered as an alternative to the conventional asphalt concrete (AC), HRA and SMA mixtures.

To improve legibility, it is proposed that all cycle tracks and cycle lanes are to have red coloured epoxy type surfacing, or red coloured HRA, or similar in accordance with the National Cycle Manual. The choice of surfacing materials, including the Potential Development Opportunity areas, are discussed further in Section 14.

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

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8 Structures

8.1 Overview of Structures Strategy

Where the route 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. 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 bridge structures are proposed which interface with TII assets 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

Table 8-1 Existing Structures Along the Proposed Scheme

Location	Co-ordinates	Local Authority	Comment
Santry River Crossing, Malahide Road/ Greencastle Road	53°23'28.6"N 6°11'42.6"W	DCC	Structure Not Impacted
Donnycarney Bridge	53°22'33.2"N 6°13'05.1"W	DCC	Structure Not Impacted

8.3 Summary of Principal Structures

No principal bridge structures are proposed on the Proposed Scheme.

8.4 Summary of Minor Structures

Table 8-2 Existing Minor Structures Along the Proposed Scheme

Location	Co-ordinates	Local Authority	Comment
CCTV mast Northern Cross Junction	53°24'10.9"N 6°10'44.9"W	DCC	Minor Structure Not Impacted
CCTV mast Malahide Road/Tonlegee Road Junction	53°23'22.4"N 6°11'52.1"W	DCC	Minor Structure Impacted

8.5 Summary of Retaining Walls

There are no significant retaining walls proposed on the Proposed Scheme.

8.6 Summary of Miscellaneous Structures

Table 8-3 Existing Miscellaneous Structures Along the Proposed Scheme

Location	Co-ordinates	Local Authority	Comment
Retaining wall north of Priorswood Road/ Malahide Road Junction	53°23’53.5"N 6°11’11.0"W	DCC	Small retaining wall approx. height less than 1m
Retaining wall south of Priorswood Road / Malahide Road Junction	53°23’50.5"N 6°11’14.0"W	DCC	Small retaining wall approx. height less than 1m
Retaining wall south of Griffith Avenue/Malahide Road Junction	53°22’06.0"N 6°13’37.0"W	DCC	Small retaining wall approx. height less than 1m

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, silt traps and/or oil/petrol interceptors. The drainage system should ensure that surface water drains from existing and new pavement areas be limited by the capacity of the existing highway drainage network.
- 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 run off 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 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). Stage 1 and Stage 2 Flood Risk Assessments have been completed on the preliminary design and are summarised in Section 9.7. The Proposed Scheme crosses the following watercourses:

Table 9-1 Existing Watercourses and Culverts

Watercourse	Chainage	Crossing Detail
Santry River	A4895	Bridge
Wad River	A7220	Culvert

9.3 Existing Drainage Description

Based on the information received from Irish Water 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 the combined sewer systems are managed by Irish Water. Flows are typically collected in standard gully grates 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 Proposed Scheme can be split into the nine 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-0001_XX_00-DR-CD-1001, BCIDA-ACM-DNG_RD-0001_XX_00-DR-CD-1002 and BCIDA-ACM-DNG_RD-0001_XX_00-DR-CD-1003.

The catchments are summarised below:

Table 9-2 Summary of Existing Catchments

Existing Catchment Reference	Approx. Drainage Catchment Area (km^2)	Existing Network Type	Existing Outfalls
R01-01.1	1.125	Surface Water (Storm)	Network Outfalls to Mayne River
R01-02	0.707	Surface Water (Storm)	Network Outfalls to Mayne River
R01-03	1.030	Surface Water (Storm)	Network Outfalls to North Bull Island
R01-04	2.144	Surface Water (Storm)	Network Outfalls to Santry River
R01-05	1.265	Surface Water (Storm)	Network Outfalls to Naniken River at St Anne's Park
R01-06	2.759	Surface Water (Storm)	Network Outfalls to Tolka Estuary
R01-07	1.410	Surface Water (Storm)	Network Outfalls to Tolka Estuary

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 the discharge rate 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, oil/petrol interceptors, 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.

The proposed surface water drainage works are shown on the drawings BCIDA-ACM-DNG-RD-0001-XX-00-DR-CD-0006 to 0021

Table 9-3 provide 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 9-3Summary 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 (%)
R01-02	A3000 – A3650	24,205	1,817	1,102	715	3
R01-03	A3650 - A4450	57,824	5,320	2,537	2783	5
R01-04	A4450 – A5550	45,145	2,165	3,674	-1509	-3
R01-05	A5550 – A6455	41,161	2,002	1,759	243	1
R01-06	A6455 – A7550	25,813	1521	866	655	3
R01-07	A7550 - End	42,105	20	1854	-1834	-4

9.5 Preliminary Drainage Design

The existing drainage network will be maintained and used as the main discharge point for the new drainage system. The purpose of the design will be to replicate the existing situation. Where new multiple gully connections discharge to a combined sewer are required, a new surface water pipe will be provided where possible and connected to the combined sewer as per Irish Water requirements.

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

- **Sealed Drainage (SD)** comprised of side entry gullies and sealed pipes. They will collect, convey, and discharge runoff. The side entry gullies will be located within the kerb line mostly between the cycle track and bus lane and/or the footpath and the cycle track depending on the highway 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/footpath 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.
- **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 (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

Catchment	Chainage	Drainage Type
Asset owner/Location: Dublin City Council		
R01-02	A3000 – A3650	Existing drainage, new surface water network, sealed drainage, Bio Retention Areas/Rain Gardens (SW/RG) with filter drains.
R01-03	A3650 - A4450	Existing drainage, new surface water network, sealed drainage, Bio Retention Areas/Rain Gardens (SW/RG) with filter drains.
R01-04	A4450 – A5550	Existing drainage, new surface water network, sealed drainage, Bio Retention Areas/Rain Gardens (SW/RG) with filter drains.
R01-05	A5550 – A6455	Existing drainage, new surface water network, sealed drainage, Bio Retention Areas/Rain Gardens (SW/RG) with filter drains.
R01-06	A6455 – A7550	Existing drainage, new surface water network, sealed drainage, Bio Retention Areas/Rain Gardens (SW/RG) with filter drains.
R01-07	A7550 - End	Existing drainage, new surface water network, sealed drainage, Bio Retention Areas/Rain Gardens (SW/RG) with filter drains.

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, a sustainable drainage system 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 practicable and possible.

The attenuation measures for the Proposed Scheme are summarised for each catchment within Table 9-5 below. Attenuation volumes have been estimated using Micro drainage 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 Existing (m^2)	Approx. Impermeable Surface Area Change (m^2)	Permitted Discharge (l/sec)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
A3056 – A3180 Left Hand Side	R01-02	1600	457	2 l/s	Tree pits	Existing gullies to be relocated and connected to surface water network. Further survey required to confirm existing gullies. Proposed area for SuDS 208m². Catchment ultimately outfalls to the Mayne River.
A3770 – A4150 Left Hand Side	R01-03	5000	1214	2 l/s	Bioretention system 79-154 m3	Existing gullies to be relocated and connected to existing DN 225 & DN300 surface water network. Proposed area for SuDS 318m². Further survey required in this area. Filter drain connected to existing drainage network, DN225. Catchment ultimately outfalls to North Bull Island.

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area Existing (m^2)	Change (m^2)	Permitted Discharge (l/sec)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
A3770 – A3920 Right Hand Side	R01-03	1725	382	2 l/s	Bioretention system 33-66 m3	Existing gullies to be relocated and connected to DN 225 surface water network. Further survey required to confirm existing gullies. Catchment ultimately outfalls to North Bull Island.
A4150 – A4520 Left Hand Side	R01-03	3250	841	2 l/s	Bioretention system 20-40 m3	Existing gullies to be relocated and connected to DN 225 surface water network. Further survey required to confirm existing gullies, proposed SuDS discharge location and existing road drainage system. Proposed areas for SuDS 339m² & 229m². Catchment ultimately outfalls to North Bull Island.
A4150 – A4520 Right Hand Side	R01-03	3250	348	2 l/s	Bioretention system 65-128 m3	Existing gullies to be relocated and connected to DN 225 surface water network. Further survey required to confirm existing gullies, proposed SuDS discharge location and existing road drainage system. Proposed areas for SuDS 228m². Catchment ultimately outfalls to North Bull Island.
A6020 – A6210 Left Hand Side	R01-05	2000	403	2 l/s	Bioretention system 21-40 m3	Existing gullies to be relocated and connected to DN 225 surface water network. Further survey required to confirm existing gullies and existing road drainage system. Outlet to existing network DN375, CH 6+210. Proposed areas for SuDS 276m². Catchment ultimately outfalls to Naniken River.
A6060 – A6210 Right Hand Side	R01-05	1200	55	2 l/s	Bioretention system 8.1-17 m3	Proposed new DN 225 surface water network. Discharge to existing surface water network DN1050. Further survey required to confirm existing gullies. Proposed areas for SuDS 159m². Catchment ultimately outfalls to Naniken River.
A6210 – A6390 Right Hand Side	R01-05	1500	8	2 l/s	Bioretention system 30-59 m3	Proposed new DN 225 surface water network. Further survey required to confirm existing gullies and road drainage location. Discharge to existing surface water network DN1050 Catchment ultimately outfalls to Naniken River.

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area Existing (m^2)	Approx. Impermeable Surface Area Change (m^2)	Permitted Discharge (l/sec)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
A6400 – A6670 Left Hand Side	R01-05	2200	NA	10 l/s	Bioretention system 34-68 m3	In case gullies' discharge to combined sewer network, proposed surface water network is necessary DN225. Discharging to existing surface water network DN225 - pipe diameter need to be increased to DN300 Further survey required to confirm existing gullies. Catchment ultimately outfalls to Naniken River.
A6670 – A6800 Left Hand Side	R01-06	800	9	8 l/s	Bioretention system 16-32 m3	Proposed new surface water network DN300. Existing gullies discharged to combined network. Discharge to existing surface water network DN225. Catchment ultimately outfalls to Tolka River.
A6390 – A6520 Right Hand Side	R01-05	1000	236	2 l/s	Bioretention system 1.6-3.9 m3	Proposed new DN 225 surface water network. Discharge to existing surface water network DN1050. Catchment ultimately outfalls to Naniken River.
A6520 – A6770 Right Hand Side	R01-06	2000	785	2 l/s	Bioretention system 80-160 m3	Proposed new surface water network DN225. Proposed area for SuDS location 1072 m^2 - collecting surface water from footpath and carriageway. Filter drain from SuDS connected to existing network DN225. Catchment ultimately outfalls to Tolka River estuary.
A7390 – A7520 Right Hand Side	R01-07	1500	NA	8 l/s	Bioretention system 22-43m3	Existing gullies probably connected to combined sewer network-further survey required.In case gullies' discharge to combined sewer network, proposed surface water network is necessary DN225. Further survey required to confirm existing gullies' discharge location and existing road drainage system. Catchment ultimately outfalls to Tolka River Estuary.
A7520 – A7710 Left Hand Side	R01-07	1700	NA	10 l/s	Bioretention system 47-88 m3	Proposed drainage network discharge to existing DN 225 – DN 300 Catchment ultimately outfalls to Tolka River Estuary.
A7520 – A7600 Right Hand Side	R01-07	750	NA	16 l/s	Bioretention system 23-40 m3	Proposed network to discharge to existing DN 450.Further survey required to confirm existing gullies' discharge location. Catchment ultimately outfalls to Tolka River Estuary.

Chainage	Existing Catchment Reference	Approx. Impermeable Surface Area Existing (m^2)	Approx. Impermeable Surface Area Change (m^2)	Permitted Discharge (l/sec)	Possible SuDS Solution / Attenuation Measure	Catchment Outfall
A7895 – A8270 Left Hand Side	R01-07	3500	NA	60 l/s	Bioretention system 32-92m3	Existing gullies probably connected to combined sewer network – further survey required. In case gullies' discharge to combined sewer network, proposed surface water network is necessary. Further survey required to confirm existing network and existing road drainage system. Proposed network DN 225 – DN 600. Discharge to existing DN 450. Catchment ultimately outfalls to Tolka River Estuary.
A8270 – A8525 Left Hand Side	R01-07	5000	NA	33 l/s	Bioretention system 5-29 m3	Existing gullies to be relocated and connected to proposed surface water network. Proposed network DN 225 – DN 375. Discharge to existing DN 225. Catchment ultimately outfalls to Tolka River Estuary.

9.6 Drainage at New Bridge Structures

There are no new bridge structures in the Proposed Scheme that require special surface water management techniques.

9.7 Flood Risk

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 informs 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 Clongriffin to City Centre)

9.7.1 Flood Risk Assessment

There are a number of historic flood events located along or near to the Proposed Scheme. The Proposed Scheme is largely on existing roads and will result in minimal additional paved areas and will therefore not increase the risk of these events reoccurring compared to the current scenario.

There are two points of the route which are located close to coastal boundaries. At Fairview the route is located approx. 0.5km from the coastal boundary of Dublin Bay, and from Fairview to the end of the route, the Proposed Scheme is near the coastal boundaries of either the Tolka River, the Royal Canal, or the River Liffey. According to the Dublin City Development Plan 2016-2022 Strategic Flood Risk

Assessment Volume 7, there are two areas of the Proposed Scheme, between Fairview and the route end, that are at risk of coastal flooding. These are:

- At Fairview (junction between R105 and R107) – This area is in Flood Zone B; and
- On the R105, between the Tolka River and the Royal Canal – This area is in Flood Zone A

The above areas are well outside of the proposed development, therefore the risk is low.

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

The risk of pluvial flooding along most of the proposed route is high in the current scenario. Where new surface water sewers are being proposed along the development, these networks shall be designed to provide for a return period of up to 30 years where possible. 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 Sustainable (Urban) Drainage Systems (SuDS) such as rain gardens, swales, and tree pits where possible. These SuDS features will provide source control measures and reduce the risk of pluvial flooding.

Donnycarney is located at the junction between regional roads R103 and R107 is at risk of fluvial flooding according to Dublin City Development Plan 2016-2022 Strategic Flood Risk Assessment Vol 7. The area is located within a Flood Zone A, however the proposed BusConnects development is located outside the extents of the area at risk. Run-off from the proposed development corridor will not exacerbate existing flooding conditions, as the permeable (grass area) is being increased locally within the corridor together with the provision of SuDS measures to control run-off.

Finally, proposed development 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 Clongriffin 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 Bord (ESB);
- Eir;
- Virgin Media;
- BT;
- Vodafone;
- Enet; 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 possible 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 (Ref. Appendix B) Table 10-1 provides a summary of the service data received to date.

Table 10-1 Service Data Received Summary

Service Type	Date Received
High Pressure (HP) Gas	15/10/2019
Medium Pressure (MP) Gas	15/10/2019
Low Pressure (LP) Gas	15/10/2019
Telco Duct	15/10/2019
Foul Sewer (FS)	15/10/2019, 26/03/2020
HV Electricity	15/10/2019
MV Electricity	15/10/2019
LV Electricity	15/10/2019
IW Water Network (WN)	15/10/2019, 26/03/2020
IW Abandoned Lines	15/10/2019, 26/03/2020

10.3 Summary of Recommended Diversions

10.3.1 Gas Networks Ireland

There is one location where GNI high pressure gas mains require a diversion. No impacts to medium pressure gas mains have been identified. There are six locations where GNI low pressure gas mains require a diversion. Table 10-2 below outlines potential diversions of Gas Networks Ireland services, and are illustrated on drawing series BCIDC-ACM-UTL-UG-0001_XX_00-DR-CU-9001.

Table 10-2 GNI Asset Diversions

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R01-LP-G13-E-1	GNI	A 5670 - A 5730	LP Underground	Localised diversion c. 80m of LP gas main in verge/footway of Brookville Park south of Chanel Road junction.
R01-LP-G13-E-2	GNI	A 5800 - A 5830	LP Underground	Localised diversion c. 35m of LP gas main in verge/footway of Brookville Park approximately 90m north of Mount Dillon Court.
R01-HP-G13-H1	GNI	A 5980	HP District Regulating Installation	Localised diversion of District Regulating Installation (DRI) north of intersection with Ardlea Road and Gracefield Road.
R01-LP-G15-E	GNI	A 6390 - A 6470	LP Underground	Localised diversion of c. 80m of LP gas main in verge/footway of Malahide Road along Mornington Park.
R01-LP-G17-N	GNI	A 7240 - A 7270	LP Underground	Localised diversion c. 30m of LP gas main in verge/footway of Malahide Road north of intersection with Collins Avenue.
R01-LP-G20-S	GNI	A 8360 - A 8420	LP Underground	Localised diversion c. 55m of LP gas main in verge/footway of Malahide Road south of junction with Charlemont Road.
R01-LP-G20-T	GNI	A 8500 - A 8650	LP Underground	Localised diversion c. 150m of LP gas main in verge/footway of Malahide Road commencing approximately 50m north of Crescent Place junction continuing to approximately 80m north of tie into Clontarf to City Centre Cycle & Bus Priority Project.

10.3.2 ESB

A key plan for the Proposed Scheme with ESB apparatus overlaid is included within Appendix B (BCIDC-ACM-UTL_UE-0001_XX_00-DR-CU-9001).Table 10-3 below outlines several potential diversions for ESB services.

Table 10-3 ESB Asset Diversions/Protections

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R01-UG-MV-E13-M-1 / R01-UG-MV-E14-F	ESB	A 6010 - A 6060	MV Underground	Localised diversion c. 75m of MV cables in the verge/footway of Malahide Road and road crossing of Ardlea Road.
R01-UG-MV-E14-F-1	ESB	A 6060	MV Underground	Localised diversion c. 90m of MV cables in the verge/footway of Ardlea Road and Gracefield at the intersection with Malahide Road.
R01-OH-LV-E14-AP	ESB	A 6380	LV Overhead	Localised relocation of c. 25m of LV overhead lines to underground crossing Malahide Road where retail units/food outlets are located.

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R01-OH-LV-E15-P	ESB	A 6360 - A 6520	LV Overhead	Relocation of c. 160m of LV overhead lines in the verge/footway of Malahide Road north of the Kilmore Road junction.
R01-OH-LV-E15-AA	ESB	A 6500 - A 6520	LV Overhead	Localised relocation of c. 35m of LV overhead lines to underground crossing Malahide Road north of the Kilmore Road Junction.
R01-OH-LV-E15-R-2	ESB	A 6535 - A 6545	LV Overhead	Localised relocation of c. 35m of LV overhead lines to underground crossing Malahide Road at the Kilmore Road Junction.
R01-OH-LV-E15-P	ESB	A 6520 - A 6540	LV Overhead	Localised relocation of c. 27m of LV overhead cables to underground at the Kilmore Road junction.
R01-OH-LV-E15-O	ESB	A 6530 - A 6500	LV Overhead	Localised relocation of c. 25m of LV overhead lines to underground in the verge/footway of Malahide Road at the Kilmore Road junction.
R01-OH-LV-E15-R	ESB	A 6540 - A 6590	LV Overhead	Localised relocation of c. 30m of LV overhead lines in the verge/footway of Malahide Road south of the Kilmore Road junction.
R01-OH-LV-E15-R-1	ESB	A 6590 - A 6600	LV Overhead	Localised relocation of c. 60m of LV overhead lines to underground in the verge/footway of Malahide Road with 1 no. road crossing south of the Kilmore Road junction.
R01-OH-LV-E16-S-1	ESB	A 7090 - A 7120	LV Overhead	Localised relocation of c. 40m of LV overhead lines in the verge/footway of Malahide Road immediately south of Mayfield Park.
R01-OH-LV-E17-U-2	ESB	A 7160 - A 7180	LV Overhead	Localised relocation of c. 25m of LV overhead lines to underground crossing Malahide Road north of service station.

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R01-OH-LV-E17-W	ESB	A 7210	LV Overhead	Localised relocation of c. 20m of LV overhead lines to underground crossing Malahide Road south of service station.

10.3.3 Irish Water

A key plan of the Proposed Scheme with Irish Water foul water apparatus overlaid is included in Appendix B (BCIDC-ACM-UTL_UD-0001_XX_00-DR-CU-9001). No diversion of foul water apparatus is currently envisaged.

A key plan of the CBC with Irish Water potable water apparatus overlaid is included in Appendix B (BCIDC-ACM-UTL_UW-0001_XX_00-DR-CU-9001). Table 10-4 presented below outlines a number of potential diversions for watermain services.

Table 10-4 Irish Water Watermain Asset Diversions/Protections

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R01-W6-A	IW	A 3060 - A 3170	125mm moPVC Main	Localised diversion c. 106m ductile iron of DN 125mm moPVC watermain in verge/footway of Malahide Road across from Hilton Dublin Airport Hotel.
R01-W6-O	IW	A 3370 - A 3400	250mm Ductile Iron Main	Localised diversion c. 30m of DN 250mm DI watermain in verge/footway of Malahide Road at bus stop outside Clarehall Shopping Centre.
R01-W8-A-1	IW	A 3970 - A 4010	304.8mm Asbestos Cement Main	Localised diversion c. 87m ductile iron of DN 304.8mm AC watermain crossing Malahide Road and Priorswood Road at intersection.
R01-W13-B / R01-W14-B	IW	A 5970 - A 6110	452.7mm Cast Iron Main	Localised diversion c. 137m ductile iron of DN 457.2mm CI watermain in verge/footway of Malahide Road and crossing Ardlea Road at intersection.
R01-W13-A	IW	A 5990 - A 6110	160mm HDPE Main	Localised diversion c. 26m ductile iron of DN 457.2mm HDPE watermain in cycle track of Malahide Road north of intersection with Ardlea Road and Gracefield Road.

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R01-W14-B-1	IW	A 6030	452.7mm Cast Iron Main	Localised diversion c. 48m ductile iron of DN 457.2mm CI watermain crossing Malahide Road at intersection with Ardlea Road and Gracefield Road.
R01-W15-B	IW	A 6390 - A 6520	152.4mm Cast Iron Main	Localised diversion c. 127m ductile iron of DN 152.4mm CI watermain in verge/footway of Malahide Road along Mornington Park.
R01-W15-A	IW	A 6580 - A 6740	152.4mm Cast Iron Main	Localised diversion c. 158m ductile iron of DN 152.4mm CI watermain in verge/footway of Malahide Road between Kilmore Road junction and St. David's Wood junction.
R01-W17-A-6	IW	A 7230 - A 7250	101mm Cast Iron Main	Localised diversion c. 20m ductile iron of DN 101mm CI watermain in cycle track of Malahide Road north of intersection with Collins Avenue.
R01-W19-B	IW	A 7900 - A 7980	228.6mm Cast Iron Main	Localised diversion c. 80m ductile iron of DN 228.6mm CI watermain in verge/footway of Malahide Road along Clontarf Golf Club.
R01-W19-B-1	IW	A 8190 - A 8210	228.6mm Cast Iron Main	Localised diversion c. 21m ductile iron of DN 228.6mm CI watermain in verge/footway of Malahide Road north of the intersection with Copeland and Griffith Avenues.

10.3.4 Telecommunications

A key plan of the Proposed Scheme with telecommunications apparatus is overlaid is included in Appendix B (BCIDC-ACM-UTL_UT-0001_XX_00-DR-CU-9001). Table 10-5 below outlines several potential diversions for telecom services.

Table 10-5 Telecommunications Asset Diversions/Protections

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R01-ER6-T	Eir	A 3070 - A 3150	Eir Ducting	Localised diversion c. 80m of 6 no. 100mm ducts including chamber relocations in verge/footway on Malahide Road across from Hilton Dublin Airport Hotel.

Ref. no	Utility Provider	Chainage	Asset Impacted	Description of Works
R01-ER6-U	Eir	A 3230 - A 3330	Eir Ducting	Combined diversion c 190m of 15 no. 100mm ducts (1 bank of 2 ducts, 1 bank of 4 ducts and 1 bank of 9 ducts) including chamber relocations in the footway of Malahide Road south of the intersection with Clarehall Avenue and R139 Regional Road.
R01-VM8-P	Virgin Media	A 4030 - A 4060	Virgin Media Ducting	Localised diversion c. 30m of ducts including chamber relocations in verge/footway on Malahide Road south of roundabout intersection with Priorswood Road and Blunden Drive.
R01-ER11-AU	EIR	A 5090 – A 5920	EIR Ducting	Localised diversion c. 30m of ducts including chamber relocations in verge/footway on north of Brookville Park and Brookville Crescent
R01-ER13-AN /R01-ER13-AO	Eir	A 5660 - A 5900	Eir Ducting	Diversion c. 245m of 2 no. 100mm ducts including chamber relocations in the verge/footway along Brookville Park.
R01-ER14-AW	Eir	A 6090 - A 6110	Eir Ducting	Localised diversion c. 20m of ducts including chamber relocations in verge/footway on Malahide Road south of the intersection with Ardlea Road and Gracefield Road.
R01-ER14-AS, R01-ER15-X & R01-ER15-W	Eir	A 6360 - A 6520	Eir Ducting	Localised diversion c. 160m of 6 no. 100mm ducts including chamber relocations in verge/footway on Malahide Road commencing approximately 70m south of Danieli Road Junction continuing to Kilmore Road junction.
R01-ER15-X / R01-E15-X-1	Eir	A 6540 - A 6730	Eir Ducting	Diversion c. 265m of 16 no. 100mm ducts including chamber relocations in the verge/footway along the verge of Malahide Road commencing at the Kilmore Road junction continuing to approximately 50m north of the junction with St. David's Wood and Killester Avenue.
R01-ER16-T / R01-ER17-AD	Eir	A 7040 - A 7260	Eir Ducting	Localised diversion c. 225m of 10 no. 100mm ducts including chamber relocations in verge/footway on Malahide Road commencing at Mayfield Park continuing to intersection with Collins Avenue.
R01-VM17-X-1	Virgin Media	A 7230 - A 7270	Virgin Media Ducting	Localised diversion c. 45m of ducts including chamber relocations in verge/footway on Malahide Road north of intersection with Collins Avenue.

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 top soil 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 footpath/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 scheme length.
Vegetation (eg 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 scheme
Fencing	Metal	40 kg/m	Nominal assumed average weight per railing over 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 scheme length
	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 scheme length
Lighting poles	Metal	100 kg per 8m pole	Nominal assumed average scenario over scheme length
ESB/EIR poles	Timber/wood	250 kg per 9m pole	Nominal assumed average scenario over scheme length
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 scheme length
Safety barrier	Metal	20 kg/m	Nominal assumed average scenario over scheme length

Item	Material	Assumed Nominal Weight	Notes
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)
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)

Item	Material	Assumed Nominal Weight	Notes
Bike railings/hand rails	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)
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/m3)	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)

Asset type	Assumed nominal average trench width (m)	Assumed material spec. (TII)	Assumed nominal average trench depth under pavement layer (m)	Notes
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)
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)

Asset type	Assumed nominal average trench width (m)	Assumed material spec. (TII)	Assumed nominal average trench depth under pavement layer (m)	Notes
Electric/power bedding excavation assessment (assumed at 0.75m cover under footpath i.e obvert at 0.55m under subbase layer of footpath/cycletrack)	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 footpath i.e obvert at 0.55m subbase layer of footpath)	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 footpath i.e obvert at 0.4m subbase layer of footpath)	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)

Asset type	Assumed nominal average trench width (m)	Assumed material spec. (TII)	Assumed nominal average trench depth under pavement layer (m)	Notes
Gas Excavation Assessment (assumed at 0.6m cover i.e obvert at 0.4m under subbase layer of footpath)	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 Footpath and Road Widening Excavation Assumptions

Layer	Assumed Layer thickness (m)	Assumed material spec. (TII)
Footpath 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.
Footpath sub-layer excavation due to FDC widening (material under footpath)	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 footpath 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 & 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

Layer	Assumed Layer thickness (m)	Assumed material spec. (TII)
	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 75,000 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 footpath) 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 top soil 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 footpath/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 19,500 tonnes of recycled/reused aggregates to improve the overall sustainability of the Proposed Scheme.

It is estimated that an order of magnitude of 1,620 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&D Sources	Approximate Waste and Material Quantity (Tonnes)
Concrete, bricks, tiles and similar	6,000
Bituminous mixtures	22,000
Soil and stone	47,000
TOTAL	**75,000**

12 Traffic Signs, Lighting and Communications

12.1 Traffic Signs and Road Marking

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 contained within Appendix B for Traffic Signs and Road Markings Drawings and Lighting Drawings.

12.2 Traffic Sign Strategy

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.

A set of Route Strategy Plans were created which display the following information relating to the five sections above; 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.

12.3 Traffic Signage and Road Marking

12.3.1 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.

12.3.2 Gantry Signage

No gantry signage exists along the route, and the original concept design and its development through preliminary design did not identify the requirement for any new gantry signage.

12.3.3 Road Marking

A preliminary design of road markings has been undertaken in accordance with TSM Chapter 7. Refer to the preliminary design 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.

12.4 Public Lighting

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 design drawings within Appendix B.

12.4.1 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 footpath 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 12.4.2.

12.4.2 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 & 1400;
- Volume 4 - NRA Road Construction Details, Series 1300 & 1400;
- IS EN 40 – Lighting Columns; and
- Institution of Lighting Professionals "GN01 Guidance Notes for Reduction of Obtrusive Light"

All new lighting shall aim to minimise the affects 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).

12.4.3 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).

12.5 Traffic Signal Control

See Chapter 5 of this report for design details relating to traffic signal control equipment and any associated structures, ducting and cabling.

12.6 Traffic Monitoring Cameras

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.

12.6.1 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 Tonlegee Junction will 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.

12.6.2 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 prioritize the access for pedestrians and cyclists in the area and the aesthetics of the street urban landscape

12.6.3 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.

12.6.4 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.

For the purpose of this design it has been assumed that that a new private optical fibre network will be installed along the length of the Proposed Scheme which will pass through each site where a camera is to be located, where practicable existing ducting will be utilised. 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.

12.6.5 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 possible 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.

12.7 Real Time Passenger Information

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.

Figure 12-1: Flag Type Display

12.7.1 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.

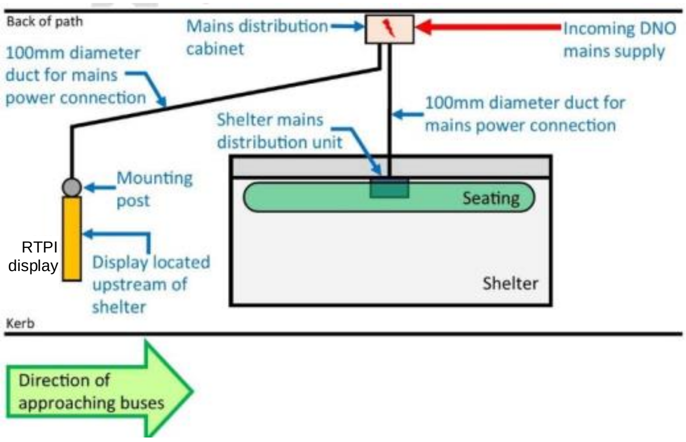

Figure 12-2: Typical Layout for Bus Stop with RTPI Display

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.

12.7.2 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 Figure12-2 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 Figure12-2**.**

12.7.3 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.

12.8 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.

12.9 Maintenance

Maintenance of signs, lighting and communication infrastructure has been considered and allowed for as part of the design process.

12.10 Traffic Signals

12.10.1 Above Ground Infrastructure

12.10.1.1 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.

12.10.1.2 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.

12.10.1.3 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 footpaths, to minimise the impact on the effective width of the footpath. 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.

12.10.2 Under Ground Infrastructure

12.10.2.1 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.

12.10.2.2 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 be not be shared between users.

12.10.2.3 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.

12.10.3 Traffic Signal Priority

12.10.3.1 Overview

Further to the information discussed in Section 4.12 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 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 Chapter 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.

12.10.3.2 Infrastructure

Public Transport Priority will be provided through a number of passive and active means. The means of passive priority are discussed in Section 4.12 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.

12.10.4 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 each of these networks will be extended along the length of 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, shall be provided along the length of the Proposed Scheme with access chambers at 180m centres; and
- Fibre breakout cabinets will be provided at each traffic signal controller, or CCTV camera.

Microwave wireless point-to-point links - Where it is not possible 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.

Cellular subscriber networks (3G/4G/5G) - Cellular communications will be provided to low bandwidth devices such as RTPI and VMS.

12.11 Safety and Security

12.11.1.1 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.

12.11.1.2 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

12.12 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 and Land Acquisition Requirements

As part of the proposed works, land is to be acquired at key locations along the proposed route. A list of land to be acquired is shown in Table 13-1.

The land use along the Proposed Scheme comprises a mix of 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 Protected Road Order Deposit Maps. The total area that lies within the proposed road development boundary is approximately 25ha. including the existing roads and footpaths.

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 practiable, 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);
- WMA 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.

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. In total approximately 4.0ha. of land will be required to be permanently acquired, of which approximately 3.3ha is currently in DCC ownership, to construct the Proposed Scheme. There will also be an additional 0.24Ha of temporary land required to allow for construction of boundary treatment and surface tie in work. This includes approximately 0.2ha currently in DCC ownership.

13.3 Summary of Effected Landowners/ 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 landowners/properties that are affected by the Proposed Scheme are summarised below.

Table 13-1 List of Landowners

Reference	Address	Area of Land Take Permanent (m2)	Area of Land Take Temporary (m2)	Proposed Works
001	Dublin City Council - Opposite Clarehall SC	185.2	162.3	Realignment of boundary
002	Ground in front of Hilton Dublin Airport Hotel and Burnell Square,	1337.9	0	Realignment of cycle track and footpath
003	Development site at Junction of Malahide Road and R139 (Northern Cross),	346.5	236.4	Realignment of boundary wall
004	Dublin City Council - Opposite Clarehall SC	23.6	36.3	Realignment of boundary
005	Dublin City Council - Opposite Clarehall SC	35.4	147.5	Realignment of boundary
006	Dublin City Council - Buttercup Park/Priorswood Rd	167.2	4812.9	Realignment of cycle track and footpath
007	Dublin City Council - Green area Priorswood Road to Newton road	1727.6	0	Realignment of cycle track and footpath
008	Dublin City Council - Green area Newton North of Service Station	1075.2	0	Realignment of cycle track and footpath
009	Open Space between 45 & 47 Ayrefield Drive,	1244.9	0	Green Space and New footpath and cycle track
010	Dublin City Council - Green area Newton South of Service Station	1977.6	0	Realignment of cycle track and footpath
011	Dublin City Council - Santry River	15	76.2	Realignment of boundary
012	Dublin City Council - Buttercup Park	686.3	7700.3	Realignment of boundary
013	44A Malahide Rd	11.8	19.5	Realignment of bollards
014	44 Malahide Rd	6.8	13.3	Realignment of boundary wall and access gate
015	Villa Maria, Mornington Park	4.4	19.7	Realignment of boundary wall
016	Arva, Mornington Park	26.6	30.9	Realignment of boundary wall and access gate
017	Sunview, Mornington Park	43.8	30.8	Realignment of boundary wall and access gate
018	Helenville, Mornington Park	42.2	23.5	Realignment of boundary wall and access gate

Reference	Address	Area of Land Take Permanent (m2)	Area of Land Take Temporary (m2)	Proposed Works
019	Upmeads, Mornington Park	48.9	23.5	Realignment of boundary wall and access gate
020	Saint Gerards, Mornington Park	50.6	23.6	Realignment of boundary wall and access gate
021	Iona, Mornington Park	55.3	24.7	Realignment of boundary wall and access gate
022	Maria Philomena, Mornington Park	62.3	28.4	Realignment of boundary wall and access gate
023	12 Artane Cottages Upper, Malahide Rd	1.7	12.8	Realignment of boundary
024	Little Rea, 11 Artane Cottages Upper, Malahide Rd	6.2	15.5	Realignment of boundary wall and access gate
025	10 Artane Cottages Upper, Malahide Rd	6.8	13.9	Realignment of boundary wall and access gate
026	9 Artane Cottages Upper, Malahide Rd	6.2	15.4	Realignment of boundary wall and access gate
027	8 Artane Cottages Upper, Malahide Rd	5.1	14.9	Realignment of boundary wall and access gate
028	7 Artane Cottages Upper, Malahide Rd	6.7	19.6	Realignment of boundary wall and access gate
029	6 Artane Cottages Upper, Malahide Rd	7.4	20	Realignment of boundary wall and access gate
030	5 Artane Cottages Upper, Malahide Rd	6.5	15.8	Realignment of boundary wall and access gate
031	4 Artane Cottages Upper, Malahide Rd	6.7	14.2	Realignment of boundary wall and access gate
032	3 Artane Cottages Upper, Malahide Rd	7.4	14.7	Realignment of boundary
033	2 Artane Cottages Upper, Malahide Rd	5.7	14.5	Realignment of boundary wall and access gate
034	1 Artane Cottages Upper, Malahide Rd	4.9	16	Realignment of boundary
035	Laneway between 1 Upper Artane Cottages and 12 Cottages Lower	0.1	1.8	Realignment of boundary wall and access gate
036	Green space adjoining Pinebrook Estate,	1654.5	0	Realignment of cycle track and footpath

Reference	Address	Area of Land Take Permanent (m2)	Area of Land Take Temporary (m2)	Proposed Works
037	Green space adjoining St. David's Estate,	773.1	127.8	Realignment of cycle track and footpath
038	Landing at Mornington Park,	297.5	0	Realignment of cycle track and footpath
039	Entrance to The Goblet Car Park,	75.1	0	Realignment of cycle track and footpath
040	Green space adjoining St. David's Estate,	266.2	117.3	Realignment of cycle track and footpath
041	DUBLIN CITY COUNCIL - MAYPARK	5831.9	0	Realignment of cycle track and footpath
042	226 Malahide Rd	12.4	20.8	Realignment of boundary wall and access gate
043	224 Malahide Rd	6	10.4	Realignment of boundary wall and access gate
044	222 Malahide Rd	6.7	10	Realignment of boundary wall and access gate
045	220 Malahide Rd	7.8	10.2	Realignment of boundary wall and access gate
046	218 Malahide Rd	8.3	10.1	Realignment of boundary wall and access gate
047	216 Malahide Rd	17	20.2	Realignment of boundary wall and access gate
048	212 Malahide Rd	17.3	20	Realignment of boundary wall and access gate
049	210 Malahide Rd	8.9	10.3	Realignment of boundary wall and access gate
050	208 Malahide Rd	8.4	10.1	Realignment of boundary wall and access gate
051	206 Malahide Rd	7.8	10.3	Realignment of boundary wall and access gate
052	204 Malahide Rd	6.7	9.7	Realignment of boundary wall and access gate
053	202 Malahide Rd	10.6	15.9	Realignment of boundary wall and access gate
054	200 Malahide Rd	30.4	37.8	Realignment of boundary wall and access gate

Reference	Address	Area of Land Take Permanent (m2)	Area of Land Take Temporary (m2)	Proposed Works
055	198 Malahide Rd	2	10.5	Realignment of boundary wall and access gate
056	1-6 Winston Ville, Charlemont Rd	17.3	39.8	Realignment of boundary wall and access gate
057	Winston Ville, 64 Malahide Rd	5.9	22.2	Realignment of boundary wall and access gate
058	62 Malahide Rd	7.5	25.7	Realignment of boundary wall and access gate
059	60 Malahide Rd	3.2	10.8	Realignment of boundary wall and access gate
060	58 Malahide Rd	2.6	10.3	Realignment of boundary wall and access gate
061	56 Malahide Rd	2.4	11.6	Realignment of boundary wall and access gate
062	54 Malahide Rd	2.3	11.1	Realignment of boundary wall and access gate
063	52 Malahide Rd	2	11	Realignment of boundary wall and access gate
064	50 Malahide Rd	1.5	10.3	Realignment of boundary wall and access gate
065	48 Malahide Rd	1.3	11.1	Realignment of boundary wall and access gate
066	38 Malahide Rd	1.7	15.4	Realignment of boundary wall and access gate
067	36 Malahide Rd	2.2	12.7	Realignment of boundary wall and access gate
068	DUBLIN CITY COUNCIL - Griffith Avenue	1372.4	0	Realignment of cycle track and footpath
069	Presbytery, 1 Maypark, Malahide Rd	18.7	21.4	Realignment of boundary wall and access gate
070	2 Maypark, Malahide Rd	18.4	21.3	Realignment of boundary wall and access gate
071	3 Maypark, Malahide Rd	16.8	18.4	Realignment of boundary wall and access gate
072	4 Maypark, Malahide Rd	17	18.3	Realignment of boundary wall and access gate

Reference	Address	Area of Land Take Permanent (m2)	Area of Land Take Temporary (m2)	Proposed Works
073	5 Maypark, Malahide Rd	16.9	18.1	Realignment of boundary wall and access gate
074	6 Maypark, Malahide Rd	20.6	23	Realignment of boundary wall and access gate
075	6A Maypark, Malahide Rd	29.7	26.1	Realignment of boundary wall and access gate
076	7 Maypark, Malahide Rd	15.9	18.1	Realignment of boundary wall and access gate
077	8 Maypark, Malahide Rd	18.9	18.3	Realignment of boundary wall and access gate
078	9 Maypark, Malahide Rd	17.9	17.9	Realignment of boundary wall and access gate
079	10 Maypark, Malahide Rd	17.1	18.4	Realignment of boundary wall and access gate
080	11 Maypark & 238 Malahide Rd. Vacant Site, Malahide Road, Dublin 5	60.8	58.5	Realignment of boundary wall and access gate
081	236 Malahide Rd	20.2	13.8	Realignment of boundary wall and access gate
082	234 Malahide Rd	81.6	42.8	Realignment of boundary wall and access gate
083	232 Malahide Rd	8.7	18.1	Realignment of boundary wall and access gate
084	34 Malahide Rd	2.3	12.4	Realignment of boundary wall and access gate
085	32 Malahide Rd	2.8	12.5	Realignment of boundary wall and access gate
086	30 Malahide Rd	3.4	13.5	Realignment of boundary wall and access gate
087	28 Malahide Rd	3.1	10.9	Realignment of boundary wall and access gate
088	26 Malahide Rd	4	12.1	Realignment of boundary wall and access gate
089	24 Malahide Rd	4.5	12.8	Realignment of boundary wall and access gate
090	22 Malahide Rd	6.4	18.2	Realignment of boundary wall and access gate

Reference	Address	Area of Land Take Permanent (m2)	Area of Land Take Temporary (m2)	Proposed Works
091	20 Malahide Rd	6.8	28.8	Realignment of boundary wall and access gate
092	19 Malahide Rd	4.7	21.1	Realignment of boundary wall and access gate
093	17 Malahide Rd	7	22.9	Realignment of boundary wall and access gate
094	15 Malahide Rd	7.4	21.7	Realignment of boundary wall and access gate
095	13 Malahide Rd	5.6	21.2	Realignment of boundary wall and access gate
096	11 Malahide Rd	5.7	21.9	Realignment of boundary wall and access gate
097	9 Malahide Rd	6.4	21.4	Realignment of boundary wall and access gate
098	7 Malahide Rd	7.2	21.2	Realignment of boundary wall and access gate
099	5 Malahide Rd	8.4	21.4	Realignment of boundary wall and access gate
100	3 Malahide Rd	9.5	21.7	Realignment of boundary wall and access gate
101	1 Malahide Rd	3.9	22.5	Realignment of boundary wall and access gate

13.4 Demolition, if any

There are no buildings proposed to be demolished as part of this Proposed Scheme.

Boundary walls and railings will be removed and replaced as part of the works as listed in Table 13-1 above.

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 - Typically 2m working room offset for temporary land take;
- Fences - Typically 2m offset for temporary land take;

- Significant retaining walls –There are no significant retaining walls within this scheme; and
- Specific structures (bridges etc) –There are no specific structures within this scheme that require temporary land take.

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.

Modifications to driveways and entrances will be in line with DCC’s *Parking Cars in Front Gardens Advisory Booklet.* The basic dimensions to accommodate the footprint of a car in the front garden are 3m x 5m and a vehicular opening would typically be between 2.5m and 3.6m in width though this may need to be widened to allow for sightlines and manoeuvrability.

Existing gates will be reused where possible however considerations will be required for the use of bifold/roller gates to mitigate impacts on parking in driveways.

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.

Dublin City Development Plan 2016-2022

Section 9, Sustainable Environmental Infrastructure states in policy SI18 a requirement to use SuDS in all new developments where appropriate, as set out in the GDRCoP.

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 footpaths 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 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 following document BusConnects Dublin - Urban Realm Concept Designs, https://busconnects.ie/media/2089/busconnects-urban-realm-concept-designs.pdf, was also used as guidance in developing the proposals. For each section of the route, a broad overview of typical dwelling age and style, extents of vegetation and tree cover was undertaken. 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 Proposed Scheme may alter this. The outcome of the analysis allowed the urban realm design to consider appropriate enhancement opportunities along the route. The enhancement opportunities include key nodal 'Potential Development Opportunities 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 possible, a SuDS approach will be taken to assist with drainage along the route. SuDS principles will be used as much as possible to deal with run-off at, or close to, the surface where rainfall lands.

14.4 Arboricultural Survey

14.4.1 Scope of Assessment

An Arboricultural Impact Assessment Report identified the likely direct and indirect impacts of 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 are to 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 prepared by John Morris Arboricultural Consultancy (JMAC) (ref: 20-092-03), based on the requirements of BS5837:2012 Trees in relation to design demolition and construction – Recommendations (BS5837).

The Arboricultural Impact Assessment set out the likely principal direct and indirect impacts of the Proposed Development 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 considerd 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 development; 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, in particular, 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.

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 footpaths. Concrete pavements can be laid without a kerb, can have neatly trowelled edges and textured surface for a clean, durable, slip resistant surface;
- **Asphalt footpath.** - Widely used on existing footpaths 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 relaid in the same location, 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, at locations where there is potential development opportunities there is the prospect to provide additional street furniture where it would most enhance the communal spaces.

14.6 Softscape

14.6.1 Tree Protection and Mitigation

The first priority of the landscape strategy is to protect existing trees along the route. 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. The impact of roadworks will be minimised near existing trees by utilising no-dig construction as described in Appendix D. 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 were identified as potential conflicts and the road layout was reconfigured to preserve the trees.

- **Malahide Road Chainage A3900- A4050**
  Tree loss will be inevitable at the Priorswood Road junction however the locations of the pedestrian footpaths and cycle tracks will be routed to avoid further loss, and to cater for substantial tree planting as future mitigation.
- **Malahide Road Chainage A5950- A6100**
  Trees will be protected during upgrades to the Ardlea Road junction by protective fencing and by careful routing of the pedestrian footpaths and cycle tracks, in addition substantial tree planting as future mitigation will be undertaken to enhance the quality of the area.
- **Malahide Road Chainage A6600- A7100**
  Road widening will be undertaken to the eastern side of Malahide Road only, this will result in the loss of some young trees to the perimeter of Donnycarney Park, but importantly, but ensure retention of the healthy mature trees along St. David's Wood.
- **Malahide Road Chainage A7550- A8000**
  In order to preserve the tree lined boundaries along the Clontarf Golf Club and the boundary trees to Nazareth House care home on the opposite side of the Malahide Road it is proposed to narrow the central median. This will result in the loss of some median trees of lower quality. Mitigation planting is proposed to the median following the road widening by planting into reinforced tree pits which will sustain root growth in a built up environment.

14.6.2 Tree Loss and Mitigation

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 it is estimated that there will be 221 trees lost, refer to Table 14-1 below. This loss has been addressed through mitigation and replanting efforts as outlined in the planting strategy (Section 14.6.3) below resulting in a substantial tree planting plan with a net increase of 324 additional semi-mature tress along the Proposed Scheme.

Table 14-1 Summary of Trees Retained, Removed and Proposed as part of the Bus Connects Route.

Retained Trees	Removed Trees	Proposed Trees	Total Trees in Development
Total retained in development	Total identified tree numbers lost	Street trees planted	Proposed Scheme
779	**-221**	**545**	**1324**

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.

- 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 the Drainage, Hydrology and Flood Risk section 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 14.7.11.14.7.11.

- **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 14-1: Tillia Cordata (Semi Mature Tree)

Figure 14-2 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 14-3: Malahide Road 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 14-4: Replacement of Boundaries (for example Opposite the Hilton on the Malahide Road)

- **Native Planting / Tree Planting (Woodland Copses) -** Opportunity for small clusters of planting exist in spaces not readily accessible at junctions or wider verges. Promote native trees with understorey planting, long grass and swathes of bulbs.

Figure 14-5: Woodland Copses

- **Ornamental or Formal Planting -** Small landscape interventions at local community spaces opportunity for combination of street trees, raised beds, seating and more formal planting arrangements exist at certain intervals and are often picked up as potential development opportunities.

Figure 14-6: Example of Potential Development Opportunity at Donnycarney

- **Residential Boundary Planting -** Residential boundaries vary greatly along the Proposed Scheme, and mitigation will largely replace like with like, but an opportunity exists to consider introduction of new green infrastructure in hedgerows and boundary trees. With greater opportunity for ornamental planting thus increasing the opportunity for greater biodiversity and support of pollinators.

Figure 14-7: Residential Boundaries Replaced with Like For Like Hedgerows

- **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

The proposed landscaping and urban realm designs are 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 Opportunity (PDO) areas (placemaking, enhancement opportunities).

The Proposed Scheme is routed via Malahide Road to the junction with Marino Mart / Fairview. Much of the route along the Malahide Road 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.

From Marino Mart the Proposed Scheme ties into a separate project, Clontarf to City Centre Cycle & Bus Priority Project currently proposed by DCC. Primarily opportunities for betterment occur at the junctions as described below.

14.7.1 Junction of Malahide Road with the R139 Clarehall Avenue

Existing Character: This stretch of Malahide Road services a largely commercial area of Dublin with large commercial complexes and fenced parking lots. The general character is functionary with emphasis on secure fencing, wide asphalt roads and poured concrete pavements. Tree planting along the road boundaries and the central median provides much needed greenery. The exception is the Hilton Hotel which has a prominent street frontage and well maintained planted boundaries with block paving to pedestrian and vehicle surfaces.

Proposed Design: The pavement and planting along the front of the Hilton Hotel will be retained, road widening on the opposite side of the street will require removal of trees and their replacement with semi-mature trees. The Clarehall junction will be improved with hedge lined boundaries, wildflower grassland and mature tree planting, there is opportunity to uplift the overall appearance of the area by replacing a length of palisade fencing with new railings and hedge row.

14.7.2 Malahide Road/Entrance to Clarehall Shopping Centre

The removal of the slip lane for vehicles at the entrance provides a much enhanced pedestrian access set back from the road. A stand of semi-mature Hornbeam trees is proposed to mark the entrance to the shopping centre.

14.7.3 Clarehall Avenue to Blunden Drive / Priorswood Road

Existing Character: Currently this section of Malahide Road is quite open, with security fencing and open featureless grassland at Buttercup Crescent housing estate.

Proposed Design: The proposed location for the construction compound at Buttercup Park provides opportunity for betterment of the area, with creation of community greenspace enclosed with hedge planting to provide enclosure and separation from the road with extensive tree planting to create a series of new woodland walkways.

14.7.4 Blunden Drive Junction

Existing Character: Blunden Drive Roundabout is situated in a largely commercial area; the Malahide Road is a duel carriageway with tree planting along the median and to both verges. The roundabout has dense vegetation to the center. Although the planting is not manicured and the commercial properties generally sit behind high security fences the existing trees provide good screening,

Proposed Design: The Malahide Road junction with Blunden Drive, was highlighted as a PDO. With a revised road layout providing opportunity for greater public open space, improved pedestrian and cycling facilities and increased tree planting. The trees are proposed as semi mature native species, interspersed with wildflower / seasonal bulb underplanting which will greatly add to the biodiversity of this area.

14.7.5 Malahide Road Blunden Drive to Tonglegee Road / Brookville Crescent

Existing Character: This section of the Malahide Road is a combination of residential properties and commercial estates; the road is tree lined with grass verges. The residential properties are mostly set back behind a wall and the commercial properties are set well back with wide grass verges and car parks. The road corridor and the trees are the defining character, and although the road has a wide footprint the central median successfully breaks down the scale of the road to improve the visual appearance of the area for residents, pedestrians and motorists.

Proposed Design: The proposed urban realm will act to enhance the existing character, reinforcing the tree cover and providing additional median planting. Enhanced planting at Brookville Park / Bothar Mhullach Ide will provide a small community pocket park. New tree and hedge planting with newly paved surfaces will improve the appearance of the junction with Brookville Crescent.

Figure 14-9: Sketch Scheme for Design Intent - Malahide Road Cycle track and footpath Improvements at Ayrfied Drive Crossing.

14.7.6 Malahide Road to junction with Ardlea Road / Gracefield Road.

Existing Character: The tree lined character of the Malahide Road continues to the junction with Gracefield Road.

Proposed Design: The replacement of the roundabout with a junction again allows more opportunity for improved cycle and footpath network which is carefully laid out to retain the existing tree cover. The proposed design will supplement existing trees with informal clusters of semi mature native trees. The increased tree planting, wildflower meadow and seasonal bulb underplanting will greatly add to the biodiversity of this area.

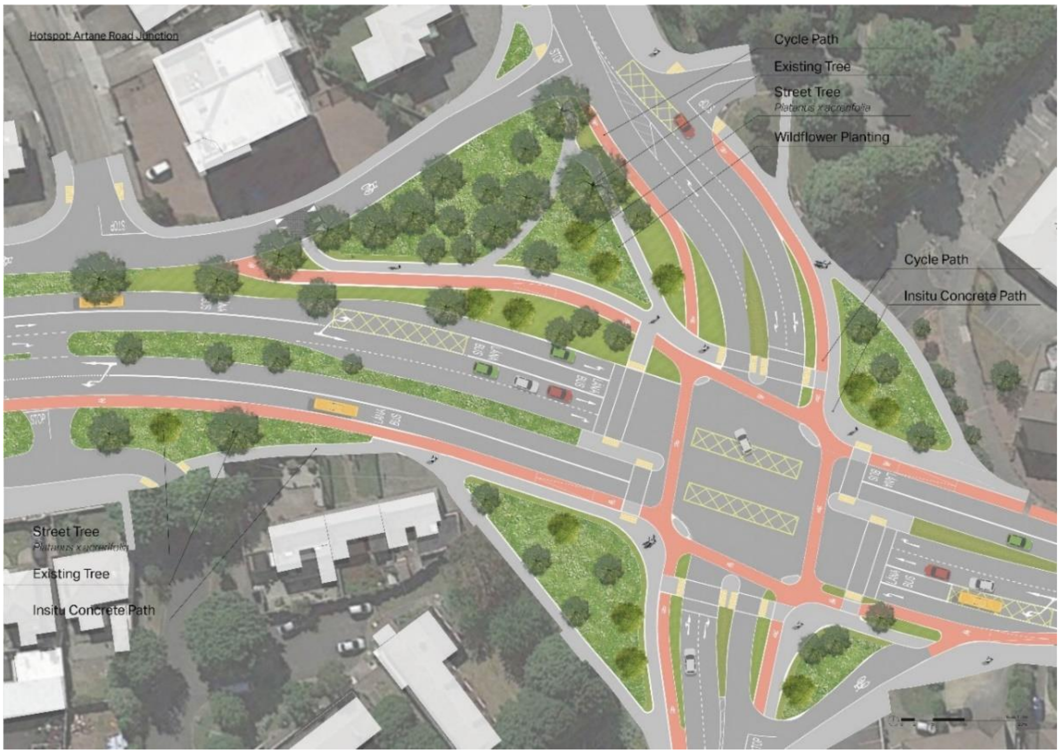

Figure 14-10: Artane Road Potential Development Opportunity

14.7.7 Malahide Road from Gracefield Road to Clontarf Road

Existing Character: This southern section of the Proposed Scheme has notably different landscape character. The road narrows to a single carriageway with intermittent bus lanes for large portions passing through residential areas. Mayfield park, St David's Wood and Clontarf Golf Club provide mature tree lined boundaries,

Proposed Design: Between Gracefield Road and Clontarf Road junctions, it is proposed to upgrade the junctions on the Malahide Road, establish new tree planting and median planting with a diverse planting mix. On this section, limited areas of land take are required from private properties, so boundaries will be reinstated 'like for like'.

Figure 14-11: Sketch Scheme for Design Intent - St David's Wood, Boundary Retained

14.7.8 Malahide Road/Collins Avenue Junction

Existing Character: The junction at Collins Avenue is notable for the stepped entrance to Donnycarney Church. Set within relatively dense residential area, this is a notable public open space and local landmark.

Proposed Design: This has been designated a PDO and the urban realm design includes stone paving to the front of the church with mature trees. The access road for residential properties off Elm Road receive a similar treatment that embraces the clock column on the corner to provide a strong local identity.

Figure 14-12: Donnycarney Potential Development Opportunity

Figure 14-13: Sketch Scheme for Design Intent - Donnycarney Church Public Realm Improvement

Figure 14-14: Sketch Scheme for Design Intent - Donnycarney Junction Urban Realm Improvement

14.7.9 Malahide Road/Copeland Avenue/Griffith Avenue Junction

Existing Character: This stretch of the Malahide Road from Clontarf Golf Club to Griffith Avenue has mature trees along a central median and is flanked by open space at the Golf Club and at Ardscoil Ris Secondary School. The junction at Griffith Avenue is notable for an open green space containing a very fine mature stand of trees.

Proposed Design: The existing junction has wide signalised pedestrian crossings and a large paved surface area, contrasting with the leafy suburban character of surrounding streets. The proposed layout while including the cycle lanes reduces the width of the pedestrian crossings and provides central refuges for pedestrians. The existing mature trees are retained, and central median planting enhanced to reduce the apparent scale of the road surface and improve the pedestrian and cyclist experience.

14.7.10 Malahide Road/Clontarf Road Junction.

Existing Character: There is a major road junction between Clontarf Road and Malahide Road, however the landscape character of the leafy suburbs is retained due to mature trees to the south in Fairfield Park, and to the east in Marino Crescent Park. Pedestrian islands and street tree planting also breaks up the extents of the road surface.

Proposed Design: It should be noted the Clontarf Road junction will have an improved urban realm undertaken prior to the Proposed Scheme being implemented therefore the design proposals are closely integrated with the Clontarf to City Centre Cycle & Bus Priority Project. Open paved areas and planting beds will provide an upgraded public space, the use of high-quality materials will be in keeping with the heritage of the surrounding area.

14.7.11 Tables of Plant Species.

Table 14-2: List of Trees Not Suitable for Urban Realm Environment

Latin Name	Common Name	Notes
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 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	Tree that attracts 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.

Latin name	Common name	Benefit
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.
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 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.

Latin name	Common name	Benefit
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.
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 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 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.

Latin name	Common name	Benefit
Armeria maritima	Thrift, Sea Pink	Attractive to pollinators.
Aster novi-belgii	Michaelmas Daisy	Attractive to a range of bees, butterflies, moths and birds.
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, 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, 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.

Latin name	Common name	Benefit
Silene vulgaris	Bladder Campion	Attractive to pollinators.
Thalictrum flavum	Meadow Rue	Attractive to pollinators.
Viola riviniana	Dog Violet	Flowers from April to June and is attractive to bees and other insects.

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.

Currently, bus priority is characterised by discontinuity. Bus priority is only provided along certain sections and a number of pinch-points cause significant delays which result in a negative impact on the performance of the bus service as a whole. Within the extents of the Proposed Scheme route, bus lanes are currently provided on only approximately 68% and 79% of route outbound and inbound respectively of which significant portions of the route are shared with cyclists and or parking lanes.

Issues related to frequency, reliability and a complex network have persisted for many years and will continue to do so without further intervention. As well as the existing services on the Proposed Scheme there are a number of planned high frequency public bus services along the route which are anticipated to be in operation prior to the Proposed Scheme being implemented, including the D1, D2, D3, D4, D5 and 20,21 bus routes, as well as multiple orbital routes including N2, N4, N6, N8. 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 all these services more reliable, particularly in peak times, thus providing a more attractive and sustainable alternative mode of transport. The introduction of segregated cycle and parking facilities will facilitate 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 junctions.

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 cycle tracks are currently provided on only approximately 4% 4% of the route both outbound and inbound, while advisory cycle lanes are provided on only approximately 73% and 61% of the route outbound and inbound 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 along the corridor in both directions 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 footpaths 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 footpath 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 the NTA, 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.

Appendices

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Project Ireland 2040
Building Ireland's Future