Wicklow County Council

N11 / M11 Bus Priority Interim Scheme

Engineering Feasibility Report

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Issue 3 | 25 June 2021

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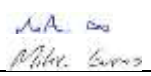
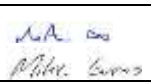
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1 Introduction

1.1 Overview

In July 2020, Arup was commissioned by the National Transport Authority (NTA) and Wicklow County Council (WCC) to develop proposals for the provision of bus priority measures on the N11/M11 national road. For the purposes of the brief, the project is referred to as the *Bus Priority Interim Scheme*. The terms of reference for the study targets bus priority measures delivered via the provision of a dedicated lane that can be used by buses and coaches during peak periods to avoid congested traffic lanes.

The assessment is being undertaken concurrently with the *N11/M11 Junction 4 to Junction 14 Improvement Scheme*, which is being progressed separately by Transport Infrastructure Ireland (TII) and WCC. This project, currently at Phase 2 (Option Selection) of the TII Project Management Guidelines (PMG), aims to identify an overall transportation solution along the wider N11/M11 corridor from the M11/M50 interchange near Shankill as far south as Junction 14 at Coyne's Cross. The *Bus Priority Interim Scheme* is supportive of the broader aims of the N11/M11 Scheme, vis-à-vis supporting a balance of alternative transport modes and providing a more sustainable transport solution along the corridor, but aims to identify a short to medium term interim solution which could be implemented in advance of the larger, more comprehensive N11/M11 Scheme.

1.2 Background to the Study

The NTA's *Transport Strategy for the Greater Dublin Area 2016 – 2035* (hereafter, the *GDA Strategy*) identifies six regional bus corridors forming part of a Core Bus Network for the overall region. This core network is intended to serve significant origins and destinations within the Greater Dublin Area (GDA), particularly those that are not directly served by heavy rail and light rail. The core bus network will also provide greater opportunity for reliable and convenient interchange with other transport modes. As outlined in the *GDA Strategy*, in order to develop an efficient, reliable and effective bus system, the core bus network should be developed to achieve;

- Continuous priority for bus movement on the portions of the Core Bus Network;
- Enhanced bus lane provision on these corridors; and
- Removal of current delays on the bus network, enabling the bus to provide a faster alternative to car traffic along these routes.

A more efficient core bus system with faster bus journeys means that more people can be moved with the same level of vehicle and driver resources.

In this regard the *Bus Priority Interim Scheme* aims to deliver enhanced accessibility via a more transit friendly N11/M11 route, prioritising person throughput over vehicle throughput, with multi-agency institutional coordination that is not merely highways led.

The N11/M11 route has been identified within the *GDA Strategy* as one of the core radial bus corridors, as presented in **Figure 1** below.

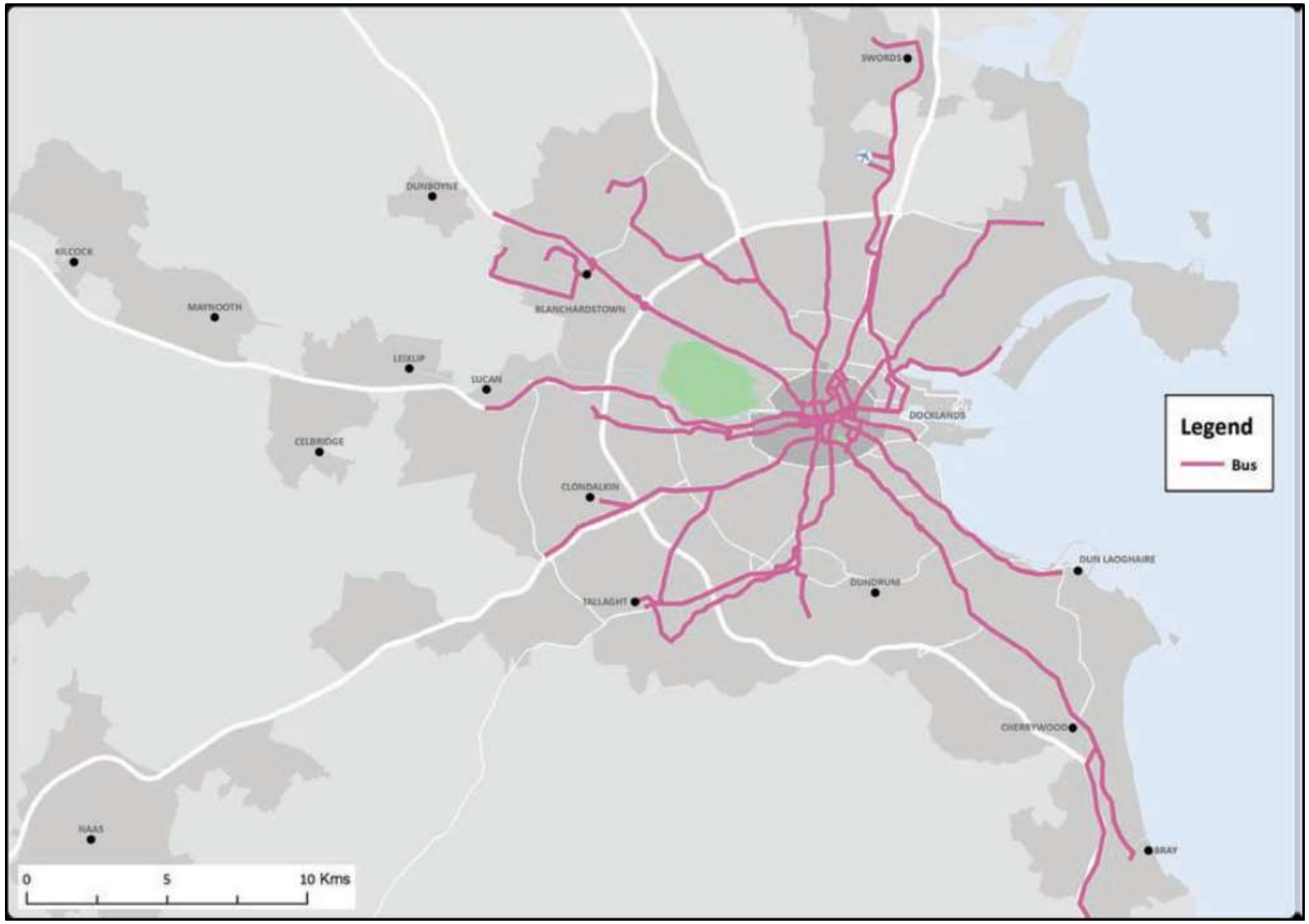


Figure 1: 2035 Core Bus Network - Radial Corridors (extracted from NTA *GDA Strategy*)

The N11/M11 has additionally been identified within the *GDA Strategy* as one of the six regional bus corridors forming part of the Core Bus Network, serving longer distance buses from Wexford and regional services from Arklow, Wicklow and the N11/M11 corridor.

1.3 Extent of the Scheme

As per the terms of reference for the study, the extent of the *Bus Priority Interim Scheme* shall extend from Kilmacanoge village in the south to Loughlinstown Roundabout in the north – refer to **Figure 2** below for an illustration of the study area.



Figure 2: Proposed study area for N11/M11 *Bus Priority Interim Scheme*

The study will focus specifically on the existing N11/M11 route as a basis for assessing bus priority feasibility. Engineering assessments will examine the viability of providing a bus lane either within the existing road cross section or on a widened N11/M11 road cross section in both the northbound and southbound directions.

1.4 Objectives of the Study

As noted above, the *Bus Priority Interim Scheme* will align with and support the objectives of the wider *N11/M11 Junction 4 to Junction 14 Improvement Scheme*. These objectives have been framed within the context of the six criteria outlined in the Common Appraisal Framework (CAF), namely; Economy, Safety, Environment, Accessibility and Social Inclusion, Integration and Physical Activity.

It should be noted however, that for the purposes of the initial Engineering Feasibility Study, it is not proposed to appraise potential bus priority solutions against these agreed set of objectives. To do so would require detailed assessments of, inter alia, an environmental and economic nature, which does not fall within the scope of this initial study. For the purposes of the initial Engineering Feasibility Study, a more concise set of overriding principles or objectives have been agreed following discussions with NTA and WCC, as follows;

The N11/M11 *Bus Priority Interim Scheme* shall aim to:

- Develop a solution which provides continuous priority (where possible) for bus movement along the N11/M11, thereby enabling the bus to provide a faster alternative to private car;
- Increase the people carrying capacity (as opposed to vehicle carrying capacity) of the N11/M11;
- Encourage modal shift to more sustainable transport modes by increasing the speed and reliability of public transport; and
- Deliver a practicable interim retrofit solution for short/medium term benefits.

The final objective listed above is particularly pertinent, as it frames, to a certain extent, the nature and type of solutions which may be considered within the context of an interim bus priority scheme. As discussed in more detail in Chapter 2, the existing N11/M11 exhibits many physical and operational deficiencies which instigate the current congestion issues and inhibit the attractiveness of those existing public transport services which serve the corridor. It is not considered to be within the scope of the bus priority scheme to resolve the myriad of issues which contribute to the problems on the N11/M11 – it is understood that these will be addressed within the broader corridor scheme separately in progress.

To represent a viable, interim solution, capable of realising early benefits in advance of the main project, the bus priority scheme will attempt to identify a practicable and safe means of implementing priority for bus movement within the existing road constraints to the largest extent possible. Consequently, it is acknowledged that the interim solutions proposed may not uniformly adhere to current design standards and are likely to involve compromises such as geometric departures or localised discontinuity of the bus lane.

Ultimately, the Engineering Feasibility Report will attempt to ascertain whether feasible options exist and define, at a high level, the complexity and extent of works required to deliver the option(s). Further refinement of these options will be required during the Option Selection phase, along with road safety audit and agreement of geometric proposals with TII before a preferred arrangement can be determined.

1.5 Scope of the Engineering Feasibility Study

The following specific activities were included in the scope of items to be addressed in the Engineering Feasibility Report;

- Assess engineering feasibility of providing a dedicated bus lane along the N11/M11;
- Identify areas where road widening is necessary;
- Outline options for bus priority at locations where road widening is not feasible or requires significant engineering works;
- Outline options for dealing with bus priority at junctions; and
- Advise on bus stop locations[1].

In order to advise on the items above, a large focus of the study will be on the geometric design of the bus lane and an assessment of impacts on existing structures. Implications for the design of ancillary items such as pavement, drainage and traffic signs will also be considered.

1.6 Structure of the report

This report comprises of 8 chapters as follows:

- Chapter 1 – *Introduction*;
- Chapter 2 – *Existing Conditions on the National Road*, describes the existing geometric and operational deficiencies on the N11/M11 and discuss existing bus usage on the corridor;

[1] Following further discussions with NTA, it is now understood that the bus priority facility is intended to cater for longer distance point to point services, primarily coaches, rather than catering for local multi-stop services. As such, the Engineering Feasibility Report has not examined potential bus stop locations along the N11/M11.

- Chapter 3 – *Inputs to Feasibility Study*, discussed what technical standards have been consulted to inform the engineering feasibility assessment and outlines what survey/as-built data has been made available;
- Chapter 4 – *Key Design Assumptions*, outlines the type of bus facility to be provided, cross section details, junction and structure treatment and design speed assumptions;
- Chapter 5 – *Principal Engineering Constraints*; discusses how the major engineering constraints have been identified and categorised;
- Chapter 6 – *Engineering Feasibility Assessment*; details the feasibility assessment of providing a dedicated bus lane along the existing N11/M11;
- Chapter 7 – *Further Considerations*; discusses a number of additional, largely non-engineering related, issues which may impact on the viability of the proposals. This includes, inter alia, legislation, constructability and operational viability concerns; and
- Chapter 8 – *Conclusions and Recommendations.*

2 Existing conditions

2.1 Existing Road Network

The N11/M11 national road is the primary artery connecting Dublin to the south east of the country. In addition, the N11/M11 forms part of the Comprehensive Trans-European Transport Network (TEN-T), providing access to international markets for freight and tourist traffic through Rosslare Europort as well as serving a high commuting demand within the Dublin metropolitan region.

2.2 Mainline Cross Section

The existing N11/M11 cross section varies slightly over the length of the section under consideration for the bus lane. As a motorway / dual carriageway, the cross section should, as a minimum, comply with the requirement of TII detail CC-SCD-00007 as presented in **Figure 3** below.

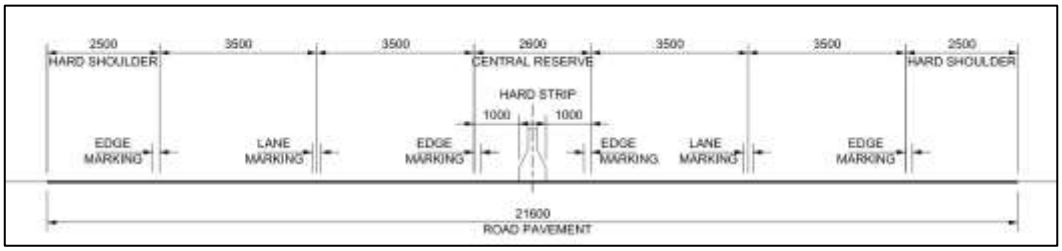


Figure 3: Standard Motorway / Type 1 Dual Carriageway Cross Section

However, owing to the piecemeal construction of the present route over several decades and the varying standards to which it was designed, the lane, hard shoulder and central reserve widths vary somewhat depending on the section of the route considered. The dimensions of the various cross section components are presented in Table 1 below.

Table 1: Existing N11/M11 cross section details

Route Section	Hard Shoulder (m)	Carriageway (m) / No. of Lanes	Median (m)	Hard Shoulder (m)	Carriageway (m) / No. of Lanes
Loughlinstown Roundabout – J4	3.0	7.0 (2 x 3.65)	Up to 9.2 (Narrows towards roundabout)	3.0	7.0 (2 x 3.65)
J4 – J5	3.0	10.95 (3 x 3.65)	9.0	2.5 – 3.0	10.95 (3 x 3.65)
J5 – J6	3.0	7.3 (2 x 3.65)	9.0	3.0	7.3 (2 x 3.65)
J6 – J7	3.0	7.3 (2 x 3.65)	Varies (9.0 – 4.6)	2.7 – 3.0	7.3 (2 x 3.65)
J7 – J8	3.0	7.3	Varies	3.0	7.3

Route Section	Hard Shoulder (m)	Carriageway (m) / No. of Lanes	Median (m)	Hard Shoulder (m)	Carriageway (m) / No. of Lanes
		(2 x 3.65)	(9.0 – 4.1)[2]		(2 x 3.65)

2.3 Existing Junctions and Accesses

The frequency, layout and consistency of junctions and accesses varies considerably on the section of the N11/M11 under consideration for the bus priority feasibility study. Commencing at the northern end of the scheme at Loughlinstown Roundabout, the route is of motorway designation with access restricted to fully grade separated junctions only. Further south, the motorway status ends and the number of accesses increases significantly, with a multitude of intermediate access points serving local roads, businesses and residential properties in between the major junctions.

The number, type and location of each existing access point on the N11/M11 northbound and southbound carriageways between Loughlinstown Roundabout and Kilmacanoge is presented in Tables 2 and 3 below.

Table 2: Existing N11/M11 northbound accesses (major junctions in bold)

No.	Junction / Access Description	Junction / Access Form
1	**Loughlinstown Roundabout**	At grade roundabout
2	**Junction 4 M11/M50 (City Centre/Dún Laoghaire)**	Freeflow Interchange
3	**Junction 5 R761 (Bray North)**	Grade Separated Junction
4	**Junction 6 R918 (Bray/Fassaroe)**	Grade Separated Junction
5	Junction 6a (Enniskerry)	Left-in / Left-out Junction
6	Private Access (Dublin Oak Academy)	Direct Access
7	**Junction 7 (Bray South)**	Grade Separated Junction
8	Private Access (Woodlands Academy	Direct Access
9	Glencormack / Avoca	Parallel Service Road with Merge / Diverge
10	**Junction 8 (Kilmacanoge / Roundwood)**	Grade Separated Junction

Table 3: Existing N11/M11 southbound accesses (major junctions in bold)

No.	Junction / Access Description	Junction / Access Form
1	**Loughlinstown Roundabout**	At grade roundabout
2	**Junction 4 M11/M50 (Wexford/Bray)**	Freeflow Interchange
3	**Junction 5 R761 (Bray North)**	Grade Separated Junction
4	**Junction 6 R918 (Bray/Fassaroe)**	Grade Separated Junction

[2] The width of the central median between Junction 7 (Bray South) and Junction 8 (Kilmacanoge) is to be further altered by the provision of the Kilmacanoge Parallel Service Road, which is currently under construction.

No.	Junction / Access Description	Junction / Access Form
5	Access to Silverbridge Halting Site	Left-in / Left-out Junction
6	Dargle Lane L152	Left-in / Left-out Junction
7	Herbert Road L1956	Left-in / Left-out Junction
8	Kilcroney Church	Direct Access
9	Private Access (Residential)	Direct Access
10	**Junction 7 R767 (Bray South/Greystones/Enniskerry)**	Grade Separated Junction
11[3]	Pedestrian access - Brennanstown	Pedestrian Access
12[3]	Gated Field Access	Direct Access
13[3]	Gated Field Access	Direct Access
14[3]	Gated Field Access	Direct Access
15[3]	Garden of Ireland	Direct Access
16[3]	Single Residential Access	Direct Access
17[3]	Single Residential Access	Direct Access
18[3]	Commercial / Residential / Wastewater Treatment Plant Access	Direct Access
19[3]	Commercial Access (Kelly Recovery / Oxygen Care)	Direct Access
20[3]	Commercial Access (Glen fuels / Circle K)	Direct Access
21[3]	Residential Access	Direct Access
22[3]	Gated pedestrian access	Pedestrian Access
23	**Junction 8 R755 (Roundwood/Kilmacanoge**	Grade Separated Junction

Travelling from north to south, the first major junction is located approximately 800m south of Loughlinstown Roundabout and consists of a 3-way – 2 level interchange linking the M11 and M50 motorways, to the east of Shankill. A schematic of the interchange is presented in **Figure 4** and an aerial view in **Figure 5** below. At this interchange, the M11 from Loughlinstown Roundabout merges with the M50, with the M50 terminating at this point and the route continuing as the M11 southbound.

The interchange caters for high volume traffic movements between the motorways via interchange links with a ghost island merge in the southbound direction and a 2-lane diverge in the northbound direction. As a 3-way interchange, not all movements are catered for and the interchange works in connection with other junctions.

[3] It should be noted that direct access to the mainline from accesses 11-22 shall be removed by the provision of the Kilmacanoge Parallel Service Road which is under construction at the time of preparing this report.

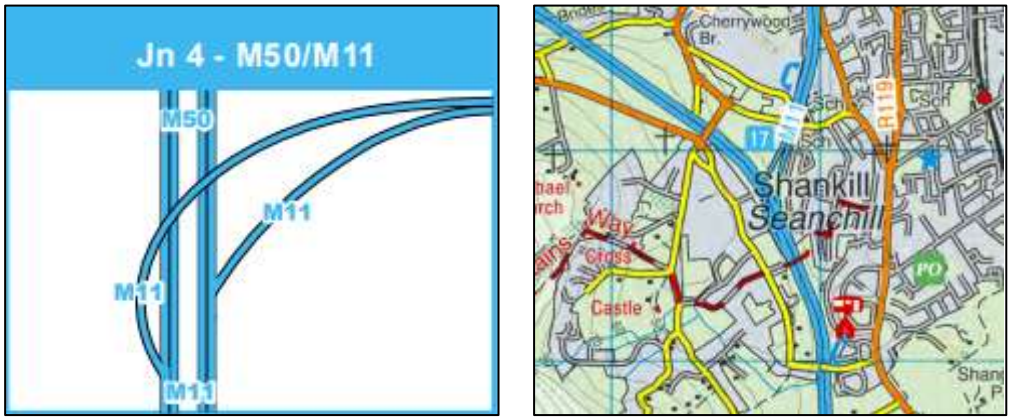


Figure 4: Junction 4 (N11/M50) schematic view



Figure 5: Junction 4 (M11/M50) aerial view

Junction 5 is located approximately 1.4km to the south of Junction 4 and serves Bray north. A schematic of the interchange is presented in **Figure 6** and an aerial view in **Figure 7** below. The junction was originally constructed as part of the Bray-Shankill Bypass opened in 1991 and resembles a 3-way – 2 level trumpet layout, connecting the M11 to the R119 and R761 at the Wilford Roundabout near Woodbrook. A northbound diverge is included slightly remote from the main junction to the south, connecting the M11 to Old Connaught Avenue.

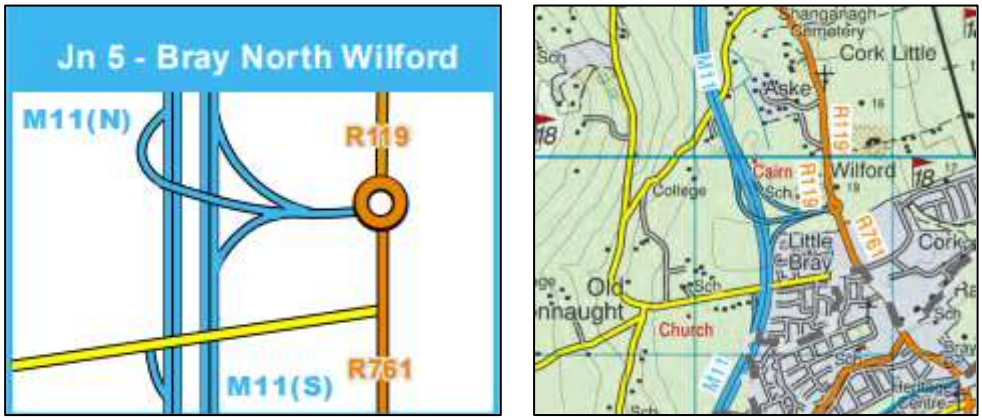


Figure 6: Junction 5 (Bray North) schematic view



Figure 7: Junction 5 (Bray North) aerial view

Junction 6 is located a further 1.8km to the south of Junction 5 and serves Bray (north and central) via the R918, and Fassaroe to the west of the N11/M11. A schematic of the interchange is presented in **Figure 8** and an aerial view in **Figure 9** below. The junction was added to the old N11 dual carriageway in 1993 and resembles a dumbbell layout. Elements of the junction layout are non-compliant with TII geometric standards, notably the slip roads in the southbound direction, which are more similar to on/off loops in layout and exhibit poor visibility and reduced capacity.

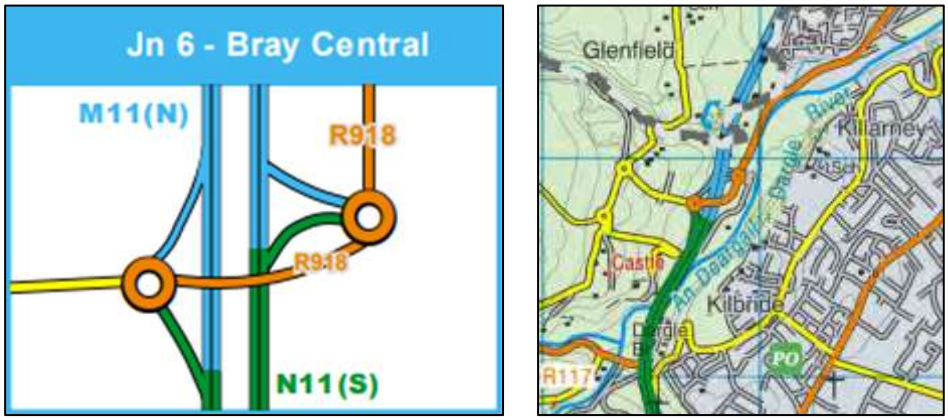


Figure 8: Junction 6 (Bray/Fassaroe) schematic view



Figure 9: Junction 6 (Bray/Fassaroe) aerial view

Junction 7 serves the southern side of Bray town and is located approximately 1.6km south of Junction 6. A schematic of the junction is presented in **Figure 10** and an aerial view in **Figure 11** below. The junction was added to the original Kilcroney dual carriageway in 1995. The layout of the junction was dictated by the surrounding topography and land-use and as such, contains a number of unorthodox elements which impact on its present capacity and operation. Most notably, the southbound diverge consists of a sharp loop arrangement leading to a busy roundabout connecting to the R768.

Conflicting movements at this roundabout are a significant contributor to congestion in the area, which impacts the operation of the junction and can result in queuing on the N11 mainline. Junction 7 is the one of the busiest junctions on the scheme and a major source of delay on the network. Accordingly, the navigation of the bus lane efficiently through this junction may be critical to the overall success of the bus priority facility.

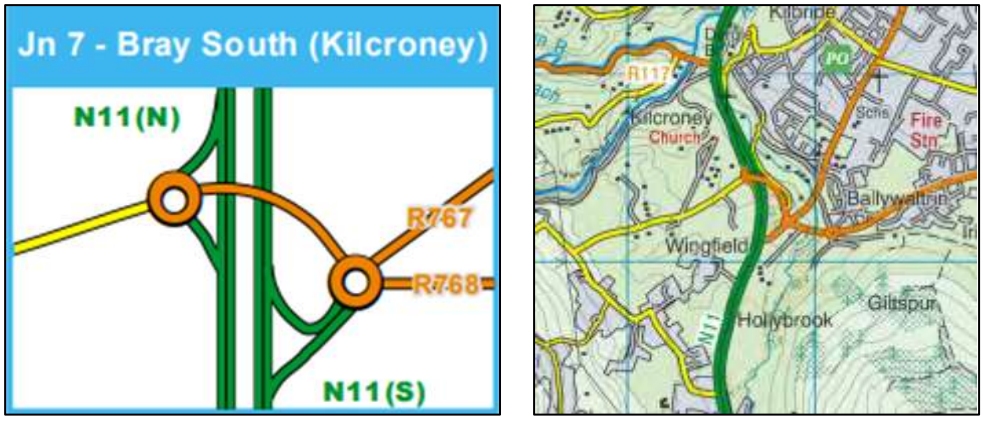


Figure 10: Junction 7 (Bray North) schematic view



Figure 11: Junction 7 (Bray North) aerial view

Junction 8 is located 1.5km to the south of Junction 7 and serves Kilmacanoge and Roundwood via the R755 and was originally constructed as part of the Kilmacanoge to Glen of the Downs widening scheme opened in 2003. A schematic of the junction is presented in **Figure 12** and an aerial view in **Figure 13** below. The junction is of standard form in the southbound direction with slip roads connecting to the R755 roundabout to the east of the N11. However, the junction contains numerous sub-standard elements in the northbound direction, including a diverge comprising of a mainline auxiliary lane which leads almost directly to a mini roundabout, without provision of a connector/slip road to current TII standards.

Merging traffic from the west must negotiate the same mini roundabout before passing along a two-way road which also serves as access to a service station, before merging onto the mainline N11, sometimes at an inappropriately low speed. The presence of a bus stop immediately upstream of the merge can make this manoeuvre particularly hazardous.

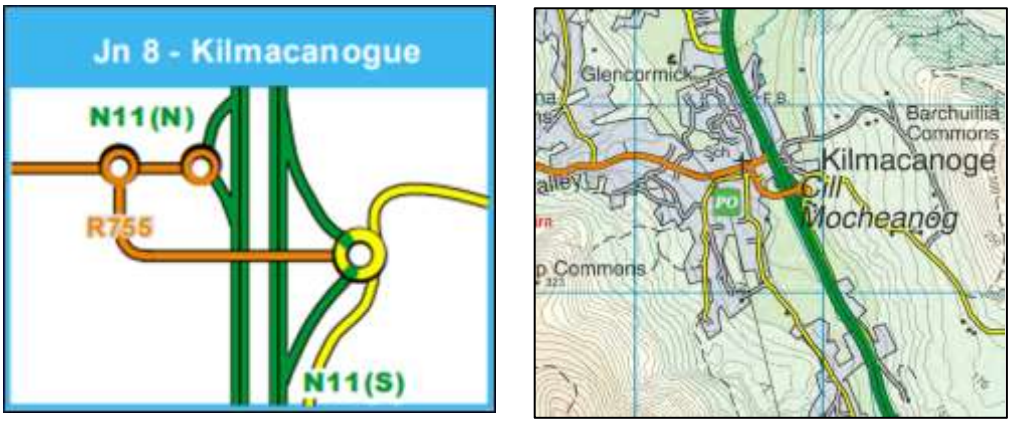


Figure 12: Junction 8 (Kilmacanoge) schematic view



Figure 13: Junction 8 (Kilmacanoge) aerial view

2.4 Existing Structures

There are a number of existing structures located within the N11/M11 corridor between Loughlinstown Roundabout and Kilmacanoge, comprising footbridges, road overbridges, underpasses, culverts and retaining walls. These structures are listed in Table 4 below.

Table 4: Existing N11/M11 structures within study area

LIST OF EXISTING STRUCTURES				
Bridge Number	**Bridge Name**	**Type of Structure**	**Year of Constr.**	**Condition Rating**
Dun Laoghaire – Rathdown County Council:				

LIST OF EXISTING STRUCTURES				
Bridge Number	**Bridge Name**	**Type of Structure**	**Year of Constr.**	**Condition Rating**
TBC	Stonebridge Road Overbridge	Overbridge	1991	1 (2015)
DR-M11-004.40	M11/M50 Overbridge	Overbridge	2005	1 (2017)
DR-M11-004.00	Ballybride Road Road Footbridge (Newvale Footbridge over Bray Shankill Bypass)	Pedestrian	1991	1 (2015)
DR-M11-003.00	Crinken Lane Bridge	Overbridge	1991	2 (2017)
DR-M11-002.00	Cois Carn M11 On-Ramp (Junction 5 Overbridge)	Overbridge	1991	2 (2015)
DR-M11-001.00	Old Connaught Avenue Bridge	Overbridge	1991	1 (2015)
Wicklow County Council:				
WW-N11-063.00	Dargle Road Interchange Bridge / Junction 6 Overbridge	Overbridge	unknown	1 (2015)
-	Retaining Wall	Retaining Wall	unknown	-
WW-N11-062.00	Saint Valery Bridge (Valerie Bridge)	Underbridge	1971	1 (2017)
WW-N11-061.70	Enniskerry Footbridge	Pedestrian	2008	1 (2015)
WW-N11-061.50	Kilbride Culvert	Culvert	unknown	1 (2017)
WW-N11-061.00	Wingfield Interchange Bridge (Junction 7 Overbridge)	Overbridge	2002	1 (2012)
WW-N11-060.00	Kilmacanoge Footbridge	Pedestrian	2002	0 (2015)
WW-N11-059.00	Culvert No. 1	Culvert	2002	0 (2012)
WW-N11-058.00	Kilmacanoge Overbridge / Junction 8 Overbridge	Overbridge	2004	1 (2017)

2.5 Existing Bus Usage on N11/M11

The N11/M11 corridor already serves a number of bus services from the surrounding population centres and wider south eastern region. This includes services operated by Dublin Bus, Bus Éireann and private operators such as Wexford Bus and Go-Ahead Ireland. In the absence of a dedicated bus facility, these services must navigate the same congestion and are subjected to the same delay and journey time uncertainty.

An analysis of TII traffic counter data has been undertaken to estimate the number of buses using the N11/M11 route. For the purposes of quantifying the number of buses, data was extracted from the TII counter located between Junction 4 (M11/M50) and Junction 5 (Bray North). Table 5 presents average weekday bus volumes for the third week in February 2020 and compares this to bus volumes on other radial routes within the GDA.

Table 5: Average weekday bus volumes on GDA radial routes

Route	Total Vehicles	Total Buses	Buses as Percentage of Total Traffic	Existing Infrastructure
N11/M11	**80,988**	**438**	**0.54%**	**No bus lanes**
M1	143,212	2,068	1.44%	No bus lanes
N2/M2	48,666	420	0.86%	No bus lanes
N3/M3	84,893	976	1.15%	Partial inbound bus lane
N4/M4	111,489	1,360	1.22%	Bus lanes
N7	112,333	753	0.67%	Inbound bus lane

It should be noted that the figures above represent 24-hour totals. Many of the services above operate during off-peak hours when the bus lane may not be in operation. During the same time period (February 2020), the average number of bus services using the N11/M11 in the peak hours only were as follows:

- AM peak (06:00 – 09:00) – 95 buses (northbound and southbound combined)
- PM peak (16:00 – 19:00) – 92 buses (northbound and southbound combined)

2.6 Future Network Improvement Schemes

A number of schemes are currently in progress and/or in planning which will impact directly on the N11/M11 route within the study area for the *Bus Priority Interim Scheme*.

2.6.1 N11 Parallel Service Road at Kilmacanoge

The *Kilmacanoge Parallel Service Road Scheme* is currently under construction and involves the provision of a segregated parallel service road in the southbound direction over a distance of approximately 600m upstream of the Junction 8 (Kilmacanoge) diverge. The service road will incorporate the exit for Junction 8 as well as re-directing all minor accesses along the southbound carriageway off the N11 mainline. Construction of the parallel service road will require widening into the central median of the N11 and thereby acts as constraint to the provision of a dedicated bus facility along this section.

2.6.2 N11/M11 Junction 4 to Junction 14 Improvement Scheme

As noted in **Section 1.1**, the *N11/M11 Junction 4 to Junction 14 Improvement Scheme* is being progressed separately by Transport Infrastructure Ireland (TII) and WCC. This project, currently at Phase 2 (Option Selection) of the TII Project Management Guidelines (PMG), aims to identify an overall transportation solution along the wider N11/M11 corridor from the M11/M50 interchange near Shankill as far south as Junction 14 at Coyne's Cross.

3 Inputs to Feasibility Assessment

3.1 Design Standards

TII maintains a broad suite of standards and technical publications which govern the design requirements for national roads in Ireland. At present, there is no technical standard or guidance documentation related to the implementation of hard shoulder bus lanes on motorways or dual carriageways. However, in March 2020, Arup was appointed by TII to commence development of a technical design standard for the inclusion of bus lanes on national roads, specifically motorways and dual carriageways. This commission remains ongoing and at the time of writing, a draft literature review with preliminary design recommendations has been issued to TII for review, which has comprehensively examined international best practice approaches. The engineering feasibility assessment of bus priority on the N11/M11 route has taken cognisance of the draft recommendations of this document – specific elements which have been adopted are discussed in more detail in Chapters 4 and 6.

On other aspects of the geometric design, the following design standards have been consulted;

- DN-GEO-03031 – Rural Road Link Design;
- DN-GEO-03060 – Geometric Design of Junctions (priority junctions, direct accesses, roundabouts, grade separated and compact grade separated junctions);
- DN-GEO-03036 – Cross Sections and Headroom;
- DN-GEO-03034 – The Design of Road Restraint Systems (Vehicle and Pedestrian) for Roads and Bridges.

3.2 Topographical Survey

A detailed topographical survey along the existing N11/M11 route was procured by WCC as part of the *N11/M11 Junction 4 to Junction 14 Improvement Scheme*. This survey has been made available for use on the *Bus Priority Interim Scheme* to undertake the engineering feasibility assessments.

It should be noted however that survey data between Loughlinstown roundabout and Junction 4 was not available during the development of the feasibility assessment. This survey was subsequently undertaken, and the completed survey information provided to Arup in June 2021. It is not anticipated that the survey will have an impact on the conclusions of the feasibility assessment. As such, the survey data will be incorporated into the Phase 2 options / design development.

3.3 Structures

Information on existing structures along the scheme was sourced from as-built data provided by WCC and TII. The condition of structures was extracted from the latest Eirspan Inspection Reports available.

3.4 Pavement

No information on the composition or condition of the existing pavement has been available to input into the feasibility study. Notwithstanding, **Section 6.6** of this report discusses general pavement considerations in respect of the provision of a dedicated bus lane.

3.5 Drainage

As built data of the existing drainage network has not been available for the purposes of undertaking the bus lane feasibility study. Notwithstanding, **Section 6.7** of this report discusses general drainage considerations in respect of the provision of a dedicated bus lane.

3.6 Utilities

Information on existing utility infrastructure along the N11/M11 corridor has been sourced from consultations with Dún Laoghaire-Rathdown County Council, Wicklow County Council and the following utility providers;

- ESB / ESBI;
- Gas Networks Ireland (Bord Gáis);
- Irish Water;
- Virgin Media;
- BT Ireland;
- Eircom / EIR;
- Vodafone;
- Three;
- E-Net; and
- SSE Ireland.

4 Key Design Assumptions

4.1 Type of Bus Facility

As outlined in **Section 1.1**, the terms of reference for the N11/M11 Bus Priority Interim Scheme targets bus priority measures delivered via the provision of a *dedicated lane* that can be used by buses and coaches *during peak periods* to avoid congested traffic lanes. A corollary of this approach is that the bus lane shall be a temporary facility rather than a permanent one. Temporary bus lanes tend to have two distinct operational regimes as follows;

- **Peak period temporary bus lane** – this is when the bus lane is open during pre-specified peak times only. For example, the lane may operate during the morning and evening peak to avoid congestion, but otherwise operates as a hard shoulder outside these times.
- **Peak demand temporary bus lane** – this is when a certain threshold, either mainline speed or congestion level, triggers the opening of the bus lane. This option does typically require Intelligent Transport Systems (ITS) infrastructure to safety implement.

A further implication of a temporary facility is that the bus lane will not be physically segregated from the all-purpose mainline carriageway. While this allows the hard shoulder to be retained for emergency use, it has the disadvantage of creating a speed differential safety risk, whereby the bus can achieve greater speed that the adjacent traffic lane which could be moving slowly (or stationary) during congested periods.

For the purposes of the initial engineering feasibility study, confirmation on the desired type of facility is particularly important given the following;

- The type of facility will dictate the desired cross section of the road and therefore the space requirement;
- The type of facility will influence the treatment of the bus lane at junctions (this is discussed in more detail in **Section 4.4**);
- The type of facility will dictate the operational regime of the bus lane, e.g. speeds achievable, ITS requirements etc.; and
- The type of facility will influence the type of bus journeys (i.e. the bus service pattern) which can be accommodated.

Following discussions with NTA, it has been agreed that the N11/M11 Bus Priority Interim Scheme will aim to provide a non-physically segregated temporary bus lane operating as a peak demand facility. Furthermore, it is envisaged that the bus lane will accommodate long-distance point-to-point services, primarily coaches, rather than catering for local multi-stop services, commensurate with the delivery of a core bus corridor as envisaged within the *GDA Strategy*. It is also envisaged that the bus lane will remain as a hard shoulder at all times and is accessible to any vehicle which becomes disabled or requires to leave the mainline in an emergency.

4.2 Cross Section

The desirable cross section for the scheme has been developed based on reference to the below documentation and is illustrated in **Figure 14** below.

- Managed Routes Programme in Northern Ireland – Feasibility Study into the use of Motorway Hard Shoulders. This is an implemented hard shoulder bus priority scheme on the M1 and M2 in Belfast which has been used for reference.
- TII Standards Commission – Bus Lanes on Dual Carriageways and Motorways. As noted already, this literature and scheme review is still in development and is subject to agreement with TII.

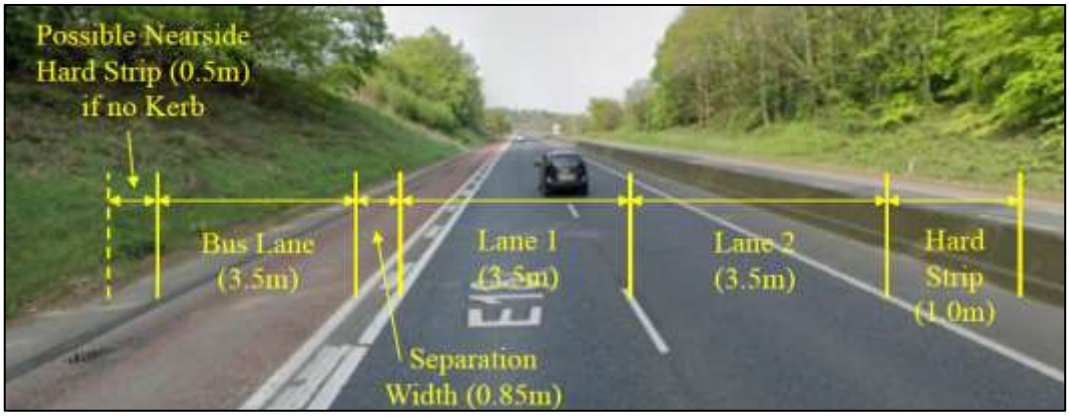


Figure 14: Proposed cross section - traffic lane, bus lane, separation width, hard strip

It should be noted that there are slight differences between the cross section assumed for this feasibility study and that emerging from the ongoing TII standards commission (owing to the N11/M11 Bus Priority Interim Scheme commencing in advance of the issue of initial recommendations under the TII commission). The TII study is currently recommending some slightly reduced parameters for the cross section, including the omission of the nearside hard strip and the provision of a narrower separation width of 0.5m, as illustrated in **Figure 15**.

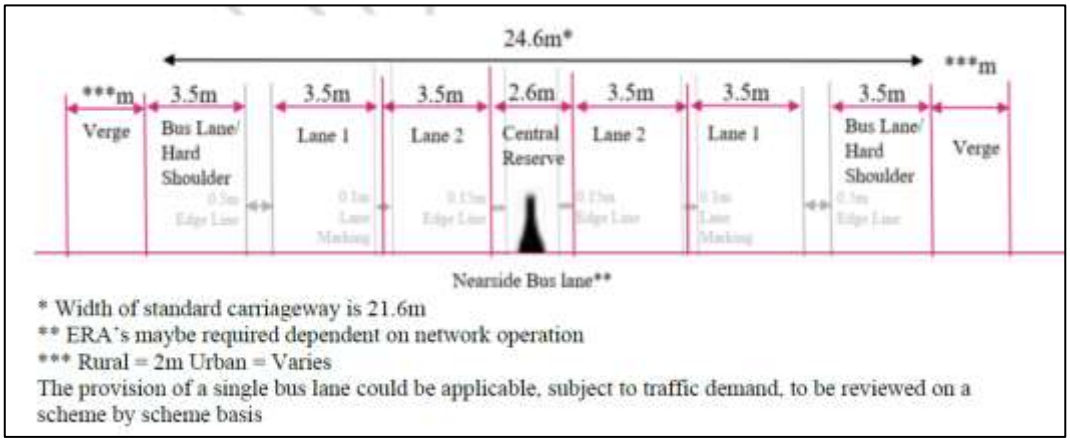


Figure 15: Proposed cross section –TII Standards Literature and Scheme Review

Pending completion of the TII standard, the cross section remains subject to change. However, it is considered that the cross section adopted for the N11/M11 feasibility study takes a conservative approach, given that the TII Standards Literature and Scheme Review recommends some slightly reduced parameters.

For the purpose of this feasibility assessment, it is assumed that any areas where the cross section illustrated in **Figure 14** cannot be achieved, a departure would be required in future design stages.

4.3 Alignment

As discussed in Chapter 2, the existing horizontal and vertical alignment of the N11/M11 route between Loughlinstown Roundabout and Kilmacanoge is not uniformly compliant with TII Standards for the operational speed of the road. In the interests of delivering a practicable interim scheme, the resolution of pre-existing major geometric deficiencies (e.g. sub-standard horizontal/vertical curvature) is not deemed to be within the scope of the interim scheme. Accordingly, the following design assumptions have been made with respect to incorporating a bus lane within the existing route geometry. These principles have been presented and broadly agreed with the NTA, TII and WCC during the development of the feasibility assessment.

- It is proposed that the existing hard shoulder on the nearside of the N11 / M11 is converted to facilitate the bus lane as an interim measure in advance of the main project upgrade. The existing N11 / M11 horizontal and vertical geometry would be largely retained, with widening occurring as an extension of crossfall.
- In addition, the existing access and route provision would also be largely retained.
- Any widening required to accommodate the bus lane is generally provided as follows:
    - Widening is preferred into the median where possible, with the design to match the existing nearside pavement edge. This is due to the generally wide existing median, and fairly constrained corridor on the nearside of the existing N11 / M11. It also has the potential to minimise the extent of works at junctions / accesses.
    - Median widening is not always achievable and there are instances where widening beyond the nearside pavement edge is required due to visibility requirements or other localised constraints
    - Widening on both sides of the existing carriageway. This generally occurs at highly constrained locations or areas where widening is transitioning to / from being on the median side to / from the nearside.
- The bus lane will operate in the AM and PM peak periods only. During the non-peak periods, the hard shoulder would operate as existing.

4.4 Junction Treatment

When determining the most suitable arrangement for the bus lane at junctions, careful consideration of the operational regime and fundamental objectives of the project is essential. As outlined in **Section 1.4**, the NTA has confirmed that continuous bus priority is to be provided on as much of the N11/M11 corridor as is practically feasible to cater for an envisaged long-distance point-to-point coach service. Accordingly, there is no requirement for the provision of bus stops at junctions along the corridor.

Considering the above, the most appropriate form of junction arrangement for the *Bus Priority Interim Scheme* is what is known as Through Junction Running (TJR). This approach involves transitioning the hard-shoulder bus lane into the merge / diverge running lane and extending the lane 'through' the junctions. TJR avoids the need for the bus to exit and re-enter the mainline at the junction and eliminates potentially hazardous weaving manoeuvres should the bus wish to leave the bus lane to stay on the mainline.

The alternative of a Non-TJR treatment, which involves diverging the bus lane off the mainline and then re-merging onto the mainline following the junction, is not consistent with the objectives of the project and type of facility envisaged. The alternatives are illustrated in **Figure 16** and **Figure 17**.



Figure 16: TJR Junction Treatments

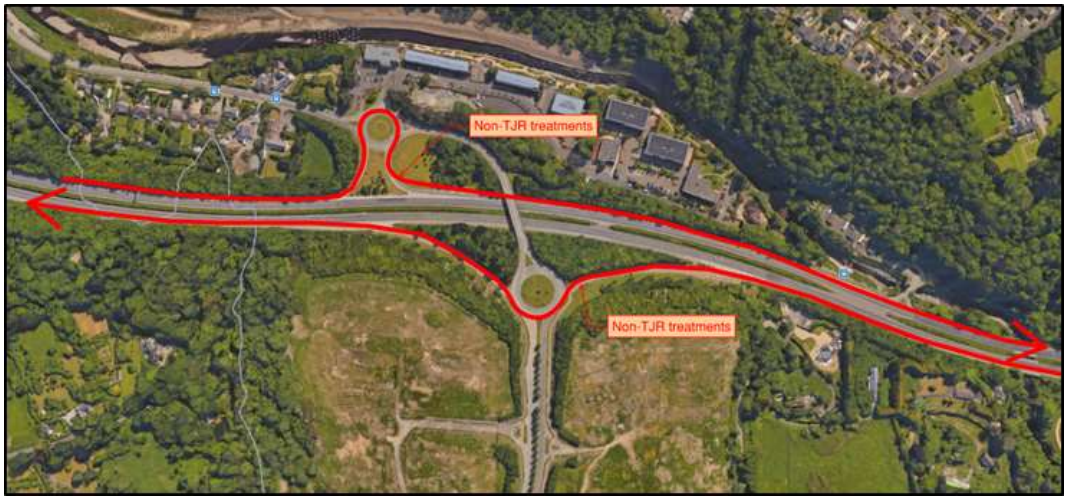


Figure 17: Non-TJR Junction Treatments

The preferred treatments for the junction merge and diverge areas are listed below and discussed further in **Sections 4.4.1** and **4.4.2**. These treatments have taken cognisance of the emerging recommendations within the TII standards commission literature review, which has comprehensively examined international best practice approaches. It should be noted however that the exact merge and diverge treatment remains under development and subject to agreement from TII.

- Diverges – TJR Fork Diverge Treatment;
- Merges;
    1. TJR Parallel Merge Treatment – where space constraints allow; or
    2. TJR Taper Merge Treatment – where space constraints prohibit TJR Parallel Merge Treatment.

4.4.1 Diverges – TJR Fork Diverge Treatment

The fork diverge treatment involves the bus lane interacting with the diverge lane traffic and then merging back onto the hard shoulder via a fork manoeuvre upstream of the existing nose. The proposed treatment is illustrated schematically in **Figure 18** below.

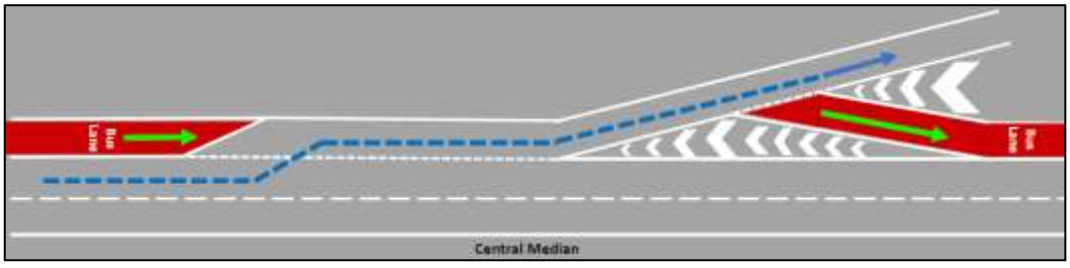


Figure 18: Proposed TJR fork diverge treatment

Under this arrangement, general vehicular traffic undertake the diverge manoeuvre as per normal, while the bus is required to undertake a less conventional movement. This is considered appropriate and a safer approach given the bus drivers will be trained professionals.

There is also a reduced risk of general vehicular traffic incorrectly entering the bus lane under this arrangement. The proposed arrangement has been implemented on the M1 motorway hard shoulder bus lanes in Northern Ireland and on the M90 Queensferry Crossing near Edinburgh, as illustrated in **Figure 19** and **Figure 20**.



Figure 19: TJR Fork Diverge Treatment (Queensferry, UK)



Figure 20: TJR Fork Diverge Treatment (Belfast, UK)

4.4.2 Merges – TJR Extended Merge Treatments

The continuation of the bus lane using the TJR layout requires that traffic joining from the slip road must first merge with the bus lane traffic before subsequently merging with mainline traffic. Depending on the specific site constraints, two options for the merge treatment are proposed:

1. **TJR Parallel Merge Treatment** – The preferable arrangement comprises of a parallel auxiliary merging lane to assist traffic merging from the slip road on to the bus lane, and subsequently an extended shared bus

lane/merging lane to assist traffic to merge onto the nearside mainline lane. This arrangement is illustrated in **Figure 21**.

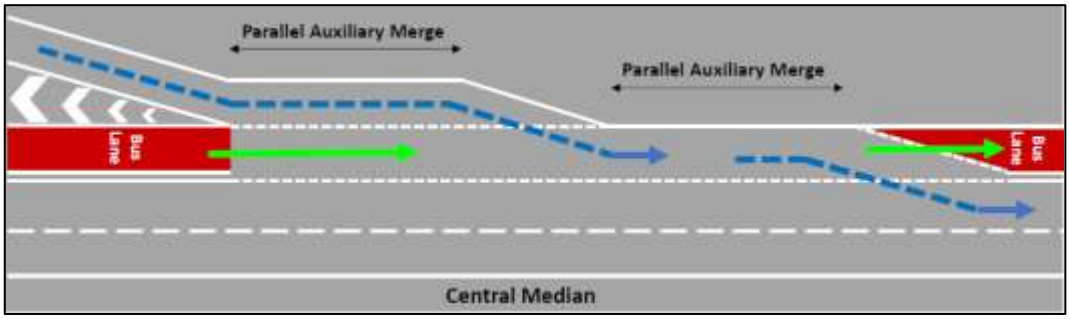


Figure 21: TJR parallel merge treatment

This arrangement is the preferred treatment as it provides increased separation between the slip road merge traffic and the bus lane. The provision of a parallel auxiliary lane for all merging movements is also consistent with the permissible merge treatments within TII Publication DN-GEO-03036. It should be noted however that this treatment requires additional widening relative to the TJR Taper Merge Treatment.

2. **TJR Taper Merge Treatment** – Arrangement comprises of a direct taper merge for traffic merging from the slip road on to the bus lane, and subsequently an extended shared bus lane / merging lane to assist traffic to merge onto the nearside mainline lane. This arrangement is illustrated schematically in **Figure 22**.

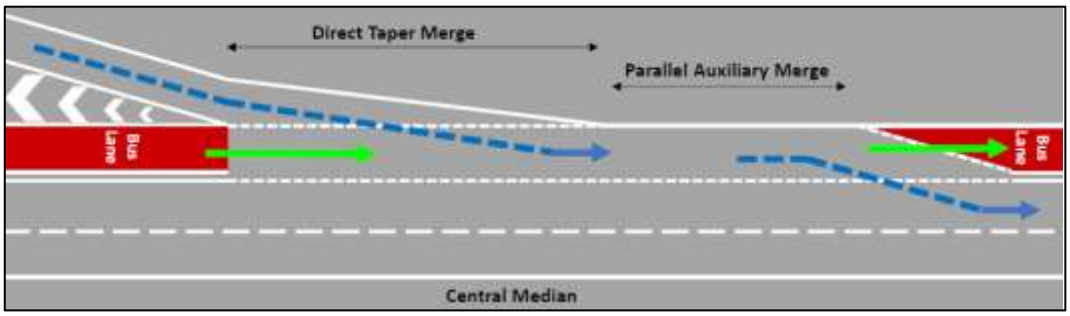


Figure 22: TJR taper merge treatment

This arrangement is considered less preferable to the parallel merge treatment as the inclusion of the direct taper merge is currently prohibited within TII standards. Parallel auxiliary merges are preferred to tapers as the conditions and opportunities for orderly merging are improved, particularly when merging and/or mainline volumes are high. However, it may be acceptable to apply direct tapers for the initial merging movement from slip road to bus lane, on the basis that the bus lane occupancy will be lower (operating during peak periods only), speeds restricted and the bus driver will be trained to understand the particular site conditions. Notwithstanding, the TJR Taper Merge treatment is proposed only at locations where a parallel merge treatment is not feasible due to site specific constraints and would need to be agreed with TII.

4.4.3 Lane Gain Merges

Lane gain merges present a particular challenge to the implementation of the preferred TJR proposals.

This is because the lane gain generates weaving manoeuvres for both the merging traffic and the bus lane traffic, as the two streams essentially 'swap' lanes in order for the bus lane to revert across to the hard shoulder downstream of the junction. This creates a potential conflict point in the weaving area, as illustrated schematically in **Figure 23** below.

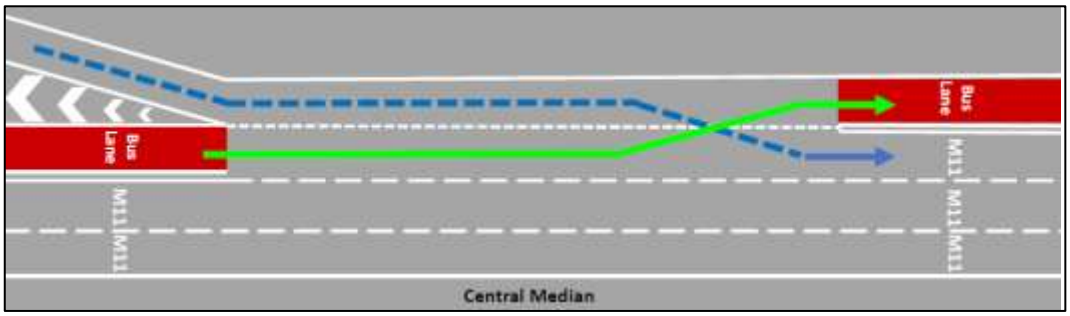


Figure 23: Lane gain merge with resultant conflict point between bus lane/merging traffic

There are a number of occurrences of lane gains along the N11/M11 route under consideration for the feasibility study. Details of proposed merging arrangements are discussed in Chapter 6.

4.5 Ramp Metering

The TII Commission *Literature and Scheme Review Note* examining the implementation of bus lanes on motorways and dual carriageways is currently recommending the use of ramp metering to minimise the risks associated with the weaving of the merge traffic with the bus lane traffic and mainline traffic.

Ramp metering is a traffic control measure which uses signals to regulate the flow of traffic joining a motorway at junctions in order to reduce congestion caused by over utilisation during peak periods. The motorway entry slip-road is used to store traffic waiting to join the motorway and must have sufficient storage capacity to be successful.

Ramp metering would eliminate merging conflicts with the bus lane traffic and also ensure that the bus is not impeded by high merging volumes crossing its path to access the mainline.

For the purposes of the engineering feasibility report, the implementation of ramp metering has not been assumed, on the basis that not all merging sites are conducive to its successful implementation and that it would add significantly to the scope and cost of an interim scheme. Notwithstanding, ramp metering may need to be considered during the option selection stage under the following circumstances;

- If it is deemed that the particular site conditions at a given merge dictate that the TJR arrangement cannot be safely implemented without ramp metering; or

- If the congestion within the merge areas impedes progress of the bus to an unacceptable degree, thereby diminishing the attractiveness of bus services using the facility.

4.6 Design Speed and Stopping Sight Distance

Motorways and type 1 dual carriageways are typically designed with gradients not exceeding 3% in relatively flat terrain and with generous curvature affording good levels of visibility commensurate with the high operational speeds. In accordance with TII Publication DN-GEO-03031 (Rural Road Link Design), the required stopping sight distances (SSD) for the road design speeds in question are as outlined in Table 6 below.

Table 6: Stopping sight distance parameters

Design Speed (km/h)	**Motorway**	**Dual Carriageway**	**Interchange Link / Bus Lane**	**Slip Road**
	120	**100**	**85**	**70**
Desirable Minimum Stopping Sight Distance (m)	295	215	160	120
One Step Below Desirable Minimum (m)	215	160	120	90
Two Steps Below Desirable Minimum (m)	160	120	90	70

For the purposes of undertaking the feasibility study, it has been assumed that the same design speeds as listed in Table 6 above shall apply to the N11/M11 route following the addition of the bus lane. The implication of this is that SSD provision along the route should strive to match the desirable minimum values listed above for the 120km/h (in the case of the M11 motorway) and 100km/h (in the case of the N11 dual carriageway) where possible. It should be noted however that this shall apply only to the general (i.e. all-purpose) traffic lanes and not the new bus lane. The design speed and corresponding SSD provision applied to the geometric design of the bus lane is discussed in **Section 4.6.1** below.

Notwithstanding the above, the geometric deficiencies present on the existing N11/M11 route means that the required SSD for the design speeds listed in Table 6 is not always achieved in the present scenario. At constrained locations, such as underbridges / overbridges, or tight horizontal curves, the existing arrangement achieves a reduced standard of visibility which would represent a relaxation or departure from current standards.

Where additional widening to cater for the bus lane is necessary, there is the potential for existing sight distance deficiencies to be exacerbated. This may occur in cases where a shift in running lanes closer to a localised obstruction such as a bridge pier or concrete barrier occurs. At the outset of the engineering feasibility assessment, the following design philosophy was adopted;

- Where existing SSD departures/relaxations are present on the route, the feasibility design of the bus lane scheme does not set out to resolve these issues;
- At constrained locations such as existing underbridges / overbridges, the feasibility design of the bus lane will endeavor to match the existing SSD provision, i.e. not worsen existing visibility (which may still be a departure from standards);
- If the above is not possible, the design has been optimised to maximise the available SSD without impacting on the structures. As outlined in **Section 4.7**, the demolition of structures would likely render the scheme unfeasible as a practicable interim solution.

It should be noted that the above represent working principles only for the purposes of the feasibility study. Any SSD departures inherent in the proposals, either pre-existing or resulting from the inclusion of the bus lane, will require formal submissions of departures for review by TII on a case by case basis. Departure applications are not within the scope of the feasibility study and will be completed, as required, in future design stages. Further details on SSD achieved at the constrained locations is provided in Chapter 6.

4.6.1 Bus Lane Design Speed / SSD

The terms of reference for the *Bus Priority Interim Scheme* stipulate that the maximum speed limit on the hard shoulder bus lane shall be 60km/h. This maximum speed limit essentially dictates the visibility requirements for the bus lane and achieving appropriate levels of SSD on the bus lane remains a key requirement for the safe operation of the facility.

In the case of the general traffic lanes, visibility around horizontal curves can be maintained over the width of the adjacent hard shoulder, which is acceptable practice under the design standards. However, the bus lane would be operating without the additional width of the hard shoulder, meaning visibility would be restricted if the bus lane operating speed reflected that of the mainline, hence it is appropriate that the operating speed and visibility provision for the bus lane is lower than the all-purpose lanes on the N11/M11. Furthermore, as the bus lane will occupy the (widened) hard shoulder, the bus drivers eye position will be closer to fixed obstructions to forward visibility, such as bridge piers/abutments, cut slopes, traffic signs and boundary features.

Another important consideration in setting the visibility requirement for the bus lane is the potential usage of the facility during off-peak hours, when operating speeds will be closer to the speed limit. At junction merges and diverges, the bus lane will double-up as an auxiliary lane for general traffic. During off peak hours, vehicles may therefore use these lanes at higher speeds which could create a safety hazard if visibility is unduly restricted.

For the purposes of assessing the bus priority feasibility, it has been agreed that a design speed of 85km/h shall apply to the bus lane. This design speed will set the SSD requirements to be achieved (as per Table 6 above).

In most instances, the visibility achieved from the bus lane will exceed the standard required for 85km/h, as the bus lane geometry will align with that of the mainline.

It should be noted that both the assumed design speed (85km/h) and the assumed operating speed (60km/h) will require more specific analysis in later stages of design to ensure appropriateness.

4.7 Structures

A key working assumption inherent within the engineering feasibility study is that existing structures should be retained insofar as possible.

Major structure demolition works on the N11/M11 would likely render the scheme unfeasible as a practicable interim solution in the short term, hence, a key focus of the geometric design is to ascertain if the desired bus lane cross section and visibility can be achieved under and on existing structures. Where this cannot be achieved, it is assumed that departures from standards will be necessary. However, in certain cases, limited structure modifications are proposed.

4.8 Road Restraint Systems

Based on a desktop review, many of the road restraint systems (safety barriers and bridge parapets) in-situ on the existing N11/M11 would appear not to be compliant with current TII standards. In some cases, safety barriers are affixed to bridge piers in such a manner that barrier working width may be compromised. In the central median, the use of wire rope is prevalent along the route, which is no longer permitted. Examples of existing deficiencies are presented in **Figure 24** and **Figure 25** below.



Figure 24: Road restraint system affixed to bridge piers (Crinken Lane Overbridge)



Figure 25: Wire rope median barrier in front of bridge pier (Crinken Lane Overbridge)

Furthermore, design standards governing the specification of bridge parapets have changed over the past few decades, with a minimum parapet containment level of H2 now mandated. Originally constructed in 1971, the current parapet arrangement on St. Valery's Bridge on the N11 mainline between Junction 6 (Bray/Fassaroe) and Junction 7 (Bray South) does not comply with this requirement.



Figure 26: Existing sub-standard parapet arrangement on St. Valery's Bridge

For the purposes of undertaking the engineering feasibility assessments, it is considered necessary to account for the need to upgrade/replace non-compliant restraint systems for the following reasons;

- Although the barrier setback (as defined in DN-REQ-03034) does not include the shoulder width, the existing hard shoulder does provide some lateral width for errant vehicles to regain control under normal operating conditions. However, this will be removed if the hard shoulder is converted into a bus lane and existing non-compliant systems will potentially pose a greater hazard than before;
- When assessing available widths under structures for the bus lane cross section, it is important to consider the additional space required for compliant barrier systems, working width and setback; and

- Compliant barrier systems and parapets may impinge on SSD to a greater degree than the existing systems, which should be assessed.

Consequently, it has been assumed for the purposes of the engineering feasibility study that existing sub-standard safety barriers and parapets will be replaced as part of the *Bus Priority Interim Scheme*.

4.9 Junctions and Accesses

As outlined in **Section 2.3**, there are a multitude of different access arrangements along the existing N11/M11 ranging from major interchanges and grade separated junctions, to direct accesses, field gates and commercial/residential entrances. Many of these accesses are sub-standard from a geometric perspective and create a hazard for all road users.

Notwithstanding, the *Bus Priority Interim Scheme* will seek to examine options which retain existing accesses insofar as possible. This is in keeping with the overall objective of developing an interim scheme capable of realising early benefits in advance of the broader improvement scheme.

It should be noted that the main N11 / M11 scheme is investigating larger scale amendments to major and minor junction arrangements, for example involving closing some of these accesses, providing parallel service roads and junction relocation. It is understood, through collaboration with the client, that such large-scale amendments would be cost prohibitive to the interim bus lane project, and therefore considered outside the scope.

4.10 Pedestrians and Cyclists

The engineering feasibility study has also assessed the impacts of the proposed bus priority measures on pedestrian and cyclist using sections of the route.

As a designated motorway, pedestrians and cyclists are prohibited from accessing the section of existing M11 from its commencement at Loughlinstown Roundabout in the north, to its termination at Junction 6 (Bray/Fassaroe). To the south of this however, the existing N11 dual carriageway is an all-purpose route and, as such, must consider the need to accommodate vulnerable road users in a safe manner.

Under current TII standard DN-GEO-03036 (Cross Sections and Headroom), there is no specific requirement to provide pedestrian and cyclist facilities on type 1 dual carriageways, with cyclists and pedestrians encouraged by signage to seek alternative routes. Dedicated pedestrian/cyclist facilities are prescribed only as part of rural type 2 or type 3 dual carriageways. Provision for vulnerable road users may vary in form, comprising of either adjacent cycleways running directly along the verge of the road, to offline facilities remote from the carriageway, potentially utilising disused railway lines, forest trails or greenways. Alternatively, pedestrians and cyclists may need to be accommodated on an alternative route, where an appropriate alternative facility exists.

In the case of high-speed dual carriageways such as the existing N11, it is usually preferable for cyclists and pedestrians to be accommodated away from the road carriageway, using alternative facilities to limit interaction with high volumes of motorised traffic and to ensure a more comfortable and spacious environment for vulnerable users. However, the development of the present N11 along much of the original trunk road has resulted in a marked absence of alternative routes to satisfactorily cater for pedestrians and cyclists. Along certain sections of the route, cyclists and pedestrians are effectively forced to use the existing N11, compounding an already hazardous environment in view of the geometric and operational deficiencies already discussed. In the absence of any dedicated lanes, cyclists currently use the hard shoulder, mixing closely with high speed traffic and are especially vulnerable at junction exits and entries, where there are no appropriate crossing points to navigate safely amongst weaving vehicles.

Moreover, on many sections of the route the hard shoulder temporarily reduces in width or abruptly disappears altogether where the hard shoulder doubles up as a merge or diverge auxiliary lane, leaving no defined position on the road for cyclists and pedestrians. This problem will be exacerbated should the hard shoulder be converted into a bus lane, even on a temporary basis and the issue will require further study at the option selection and detailed design stages.

The provision of cyclist facilities within this area presents a number of challenges due to the existing deficiencies in the design. Specifics on the provision / consideration of pedestrian and cyclist facilities along the route are discussed in further detail in Chapter 6.

5 Principal Engineering Constraints

The purpose of this chapter is to identify the principal engineering constraints to the provision of a dedicated bus lane on the N11/M11 and to explain how these constraints have been categorised in order to pinpoint specific problem areas.

5.1 Constraint Levels (Red, Amber, Green)

A consistent approach has been developed to determine the problem areas along the corridor. The key parameters affecting engineering feasibility have been defined, and each of these has been assigned a constraint level based on the degree of impact on the parameter.

For illustration purposes, the constraint levels have also been assigned a colour based on the degree of impact. This allows for a categorisation of the constraints along the corridor in a consistent and logical manner.

Table 7: Definition of Constraint Levels (Red, Amber, Green)

Constraint Level **Parameter**	**Level 1 (Green)**	**Level 2 (Amber)**	**Level 3 (Red)**
Existing Road Cross Section / Road Widening	Central median widening generally	Mixture of median widening and widening beyond nearside pavement edge	Extensive widening, beyond pavement edge on nearside and / or offside
Geometric Design Departures	No departures required	Departures required (e.g. SSD no worse than existing can be achieved)	Departures required (e.g. SSD less than existing achieved)
Impacts to structures	No impact / minimal impact	Minor impact (remedial works)	New structures may be required Bridge strengthening may be required
Safety / Operational Issues	None / minimal	Some	Major issues anticipated
Continuous Bus Priority	Achieved	Possible localised obstructions	Significant / extensive obstructions to continuous bus priority
Pedestrians & Cyclists	Enhanced provision for Pedestrians & Cyclists	No improvement on existing situation	Bus lane likely to worsen existing conditions
Additional works	None / minimal	Major re-alignments to junction slip roads Potential utility relocations	Major reconfigurations likely – junction closures / parallel roads Potential utility relocations

It should be noted that the constraint levels have been developed from an engineering and implementation feasibility perspective. While cost feeds some part of this process, (e.g. the project would not be considered feasible if multiple structures required demolition) the objective of this report is not to make a determination on the cost of the scheme.

For example, while the 'Level 1' (green) areas may be considered to be more straightforward relative to the 'Level 2' (amber) and 'Level 3' (red) areas from an engineering feasibility perspective, there may still be substantial cost involved with widening into the median in a relatively straight section of the N11 / M11. Similarly, the 'Level 3' (red) areas are not intended to denote the absence of a feasible solution, but rather that site specific constraints may necessitate more substantial civil works, or result in localised compromises in the design standard, continuity of bus lane or operational efficiency.

5.2 Categorisation of Constraints

The key constraints along the corridor have been defined and categorised as a Constraint Level 1 / 2 / 3 based on the qualitative criteria outlined in Table 7. The constraints have been grouped geographically and a summary of the constraint levels is provided at the end of each section of the feasibility assessment.

An illustration of the constraint levels along the existing route is presented in **Appendix A**.

6 Feasibility Assessment

This chapter provides a summary of the analysis undertaken for determining the engineering feasibility of a dedicated hard shoulder bus lane on the N11/M11.

In order to answer the specific questions of the project brief, the analysis has principally focussed on the geometric design of the bus facility. A preliminary geometric design model has been developed in *Bentley OpenRoads Designer*. This model has been used to assess the constrained cross sections, identify the requirement for carriageway widening, develop merge/diverge treatments and undertake verification checks to understand problem areas, identify potential solutions and ultimately inform the engineering feasibility of the proposal.

A complete set of drawings illustrating the bus lane proposals along the N11/M11 are included in **Appendix B**.

For the purposes of presenting the feasibility analysis in a succinct and logical manner, the scheme has been sub-divided into the sections listed below.

- **Section 1** – Loughlinstown Roundabout to Junction 4 (M11/M50);
- **Section 2** – Junction 4 (M11/M50) to Junction 5 (Bray North);
- **Section 3** – Junction 5 (Bray North) to Junction 6 (Bray/Fassaroe);
- **Section 4** – Junction 6 (Bray/Fassaroe) to Junction 7 (Bray South); and
- **Section 5** – Junction 7 (Bray South) to Junction 8 (Kilmacanoge).

The feasibility study analysis is discussed in detail in **Sections 6.1** to **6.5** below. For each of the five sections making up the scheme, an initial overview is presented highlighting the main findings of the assessment. The principal constraints are then listed and categorised as Level 1 (green) / Level 2 (amber) / Level 3 (red). Potential solutions to overcome each major constraint are discussed in detail and finally, a summary of the constraint levels and feasibility analysis is provided at the end of each section.

6.1 Section 1 – Loughlinstown Roundabout to Junction 4 (M11/M50)

6.1.1 Overview

As noted in **Section 3.2**, detailed topographical survey was not available along this section of the scheme at the time of compiling this report. This survey was subsequently undertaken, and the completed survey information provided to Arup in June 2021. It is not anticipated that the survey will have an impact on the conclusions of the feasibility assessment. As such, the survey data will be incorporated into the Phase 2 options / design development.

From an initial desktop review, the following key constraints have been identified within this section:

- Existing road cross section;

- Stonebridge Road Overbridge; and
- Loughlinstown Roundabout geometry;

During Phase 2 – Option Selection, the topographical data will be used to accurately assess these and the carriageway from Loughlinstown Roundabout to Junction 4 (M11/M50) in general to identify the most beneficial solution to meet the scheme objectives.

6.2 Section 2 – Junction 4 (M11/M50) to Junction 5 (Bray North)

6.2.1 Overview / Key Findings

- Widening of the existing M11 carriageway is required along the entire section to accommodate the bus lane;
- In the southbound direction, continuous bus priority is achieved through Junction 4 (M11/M50), but terminates upstream of Junction 5 (Bray North) as the bus is required to merge into the mainline auxiliary lane to safely enter the diverge;
- In the northbound direction, the bus lane is not continuous at the Junction 5 (Bray North) merge as the facility is shared with merging traffic. The bus lane is continuous through Junction 4 (M11/M50);
- Reconstruction works are required on the M11/M50 overbridge; and
- Visibility departures are required.

6.2.2 Key Constraints

From Junction 4 (M11/M50) to Junction 5 (Bray North), the M11 mainline consists of a two-lane motorway with a continuous auxiliary lane between the two junctions in both the northbound and southbound directions.

The following key constraints have been identified within this section:

- Existing M11 cross section;
- M11/M50 overbridge;
- Ballybride Road Footbridge;
- Crinken Lane Bridge;
- Junction 4 southbound merge / Junction 5 southbound diverge;
- Junction 5 northbound merge / Junction 4 northbound diverge; and
- Junction 5 overbridge.

The impact of each of these constraints on the engineering feasibility of the bus lane is discussed in turn below.

6.2.3 Existing M11 Cross Section

Between Junction 4 (N11/M50) and Junction 5 (Bray North), widening of the mainline carriageway will be required along the full length to incorporate the bus lane cross section as outlined in **Section 4.2**.

This widening will be split between widening into the existing central median only and widening beyond the nearside edge approximately as follows:

- In the northbound direction, widening will be confined to the central median along approximately 80% of the section (~2.26km);
- In the northbound direction, widening beyond the nearside edge of pavement will be required along approximately 20% of the section (~0.57km);
- In the southbound direction, widening will be confined to the central median along approximately 49% of the section (~1.22km); and
- In the southbound direction, widening beyond the nearside edge of pavement will be required along approximately 51% of the section (~1.28km);

The approximate extent of areas requiring widening in both the central median and nearside verge are illustrated on the drawings included in **Appendix C**. Exact extents of widening will be subject to detailed design.

While the design has sought to limit widening into the central reserve as much as possible, widening beyond the nearside edge of pavement is required at merge and diverge locations to provide the required auxiliary lanes, tapers, nosing arrangements and fork diverge treatment. Widening outside the nearside edge of pavement is also required where central median widening would exacerbate visibility problems.

A typical cross section of the proposed M11 motorway with bus lane within section 2 of the scheme is presented in **Figure 27** below.



Figure 27: Typical M11 cross section with bus lane between Junction 4 – Junction 5.

6.2.4 M11/M50 Overbridge

Road Geometry and Cross Section

The existing M11/M50 overbridge carries the M11 motorway northbound interchange link over the M50 motorway as part of the free-flow junction between the two routes. The existing bridge deck caters for two 3.5m lanes, a 2.0m nearside shoulder and a 0.5m offside shoulder. A wide concrete verge of approximately 3.6m is present on the offside, which improves the provision of SSD in front of the bridge parapet on the inside of the bend. The existing cross section of the bridge deck is presented in **Figure 28** below.



Figure 28: Existing N11/M50 overbridge

In order to fit the desired cross section for the bus lane as outlined in **Section 4.2**, widening of the carriageway is required.

This could be accommodated within the existing deck width by widening on the offside and cutting down the existing raised concrete verge. However, it was deemed preferable to compromise locally on the cross section in order to limit the extent to which the existing verge has to be cut back. This means that the 0.5m separation width is removed over the extent of the overbridge. The proposed cross section ties into the existing nearside pavement edge on the bridge deck, with adjustment of the line-marking required on the bridge deck for the new lane configuration. The proposed works and proposed cross section are illustrated in **Figure 29** and **Figure 30** respectively.



Figure 29: M11 / M50 Overbridge - proposed works (bus lane on left side)

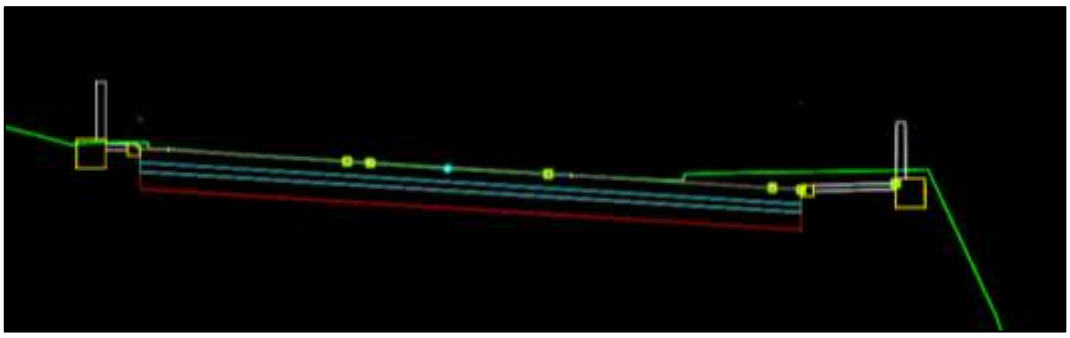


Figure 30: M11 / M50 Overbridge - proposed cross section

As the proposed cross section cuts into the nearside raised verge, there is a resultant shift of the driver's eye and target positions for SSD closer to the obstruction of the bridge parapet. This results in a reduction in the available sight distance in the offside lane relative to the existing scenario. As an interchange link connecting two motorways, the road carried on this overbridge should achieve the geometric standards consistent with a design speed of 85km/h, which equates to a desirable minimum SSD of 160m.

With the bus lane added however, the offside lane SSD is reduced to approximately 104m for the high object and low object over the full length of the bridge parapet – a length of approximately 200m.

This is a further reduction from the existing non-compliant SSD of 130m in the offside lane and equates to two steps below desirable minimum. Desirable minimum SSD is achieved from both the nearside lane and the bus lane.

Considering the above, if the existing posted speed limit of 80 km/h is retained, a design departure would need to be sought and approved in future design stages for the non-compliant SSD of 104m in the offside lane.

Alternatively, a speed reduction on the M11/M50 overbridge to 60 km/h may be considered. A reduction to 60 km/h would ensure a compliant SSD is achieved in the offside lane.

The impacts of the speed reduction upstream and downstream of the ramp would need to be investigated in future stages. It should be noted that the existing posted speed on the N11 north of Loughlinstown Roundabout is 80km/h.

Structure Assessment

The existing M11/M50 Overbridge is a 4-span structure (34.5m / 48.5m / 39.0m / 28.0m) with a total overall length of 150m. The superstructure consists of a post-tensioned concrete twin cell box, continuous over its supports. The deck is supported on bearings. The substructure comprises single column piers at intermediate supports and concrete walled abutments at its ends.

As noted above, the adjustment to the carriageway proposes an encroachment into the offside verge – refer to **Figure 31**. The verges on this bridge comprise mass concrete placed above the structural deck. This verge concrete is non-structural and hence the removal of the concrete in this region does not have a negative impact on the structural cross section of the deck at this location.

Since the deck slab follows the crossfall of the road beneath the verge concrete, the widening of the trafficable surface in this location does not have an impact on the structural cross section.

A number of service ducts are identified on the existing bridge drawings within the verge. These service ducts (and any associated services) would need to be re-positioned within the newly formed verge.

A review of the traffic loading was undertaken to assess whether any additional load would be placed on the structure due to the increased trafficable width. The width between kerbs is proposed to be increased from 9.3m to 11.5m, resulting in a 2.2m widening of the carriageway. While this is a significant widening of the carriageway and introduces an additional marked traffic lane, it does not result in any additional traffic loading being applied to the structure as the bridge would have already been designed for 3 lanes according to EN1991-2 requirements (Traffic Loads on Bridges). Furthermore, the removal of the verge concrete results in a reduction in deadload on the structure. Hence it was assessed that there will be no significant additional design loads applied to the structure due to the widening of the carriageway on this bridge.

The widening of the carriageway towards the offside verge will result in a repositioning of the design traffic lanes towards the deck cantilever on this side.

However, the position of the carriageway on this side of the deck will not be any more onerous than the current arrangement on the opposite side. Hence it has been assessed that there will be no significant local impact on the deck due to this configuration.

The adjustment to the offside verge results in a lowering of the verge surface adjacent to the parapet edge beam. The height of the concrete upstand would increase from approx. 75mm to 350mm. The suitability of the parapet in this scenario would need to be assessed further. Some modifications to the parapet may be required.

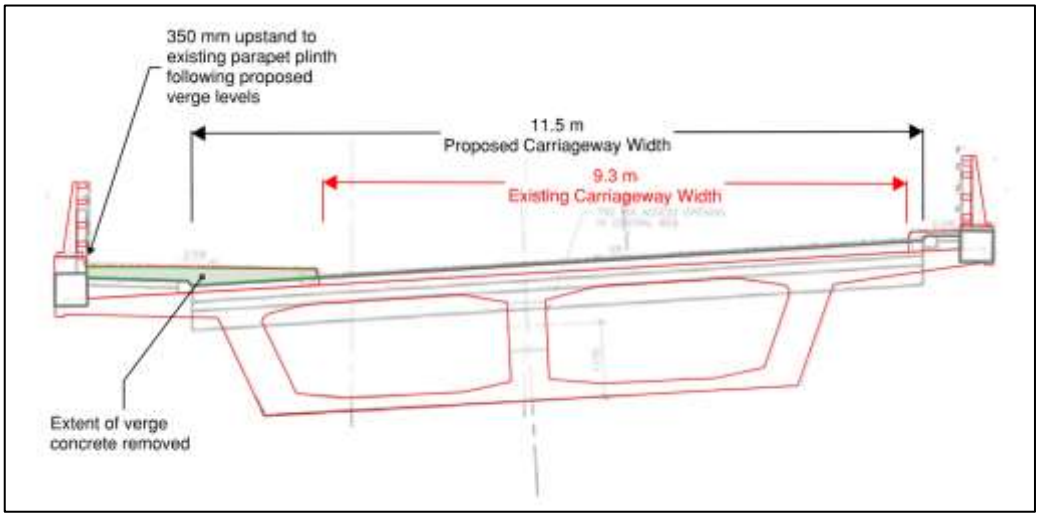


Figure 31: Cross section showing proposed carriageway configuration (black) overlaid onto the existing configuration (red)

6.2.5 Ballybride Road Footbridge

Road Geometry and Cross Section

The Ballybride Road footbridge crosses the N11/M11 in the nose area at the northbound diverge for the M11/M50 overbridge. In the existing scenario, the diverge for the M11/M50 overbridge caters for two 3.7m lanes and a 1.5m nearside shoulder. A concrete barrier is provided adjacent to the nearside shoulder which provides protection from the existing Ballybride Road Footbridge pier located to the west of the diverge, as illustrated in **Figure 32** below.



Figure 32: Existing Ballybride Road Footbridge at M11/M50 diverge

In order to minimise the impact on the mainline and minimise re-configuration works for the nose, widening is proposed to the nearside of the existing carriageway to accommodate the bus lane in the hard shoulder.

Initially, a fully compliant cross section as outlined in **Section 4.2** was investigated. This resulted in widening of the new carriageway extending closer to the existing pier. A potential clash with the pier was identified based on a review of the as-built information for the bridge.

Considering the above, the following adjustments have been made to the desirable cross section, and the proposed cross section is illustrated in **Figure 33** and **Figure 34**.

- Bus lane Separation width reduced from 0.85m to 0.5m. While this is a reduction from the desirable width, it is consistent with the width proposed in the *TII Standards Literature and Scheme Review*.
- Hardstrip at the edge of shoulder / bus lane locally reduced to 0.0m. This would be non-conforming with the desirable cross section proposed in **Section 4.2** and potentially require a departure from standard in future stages.

It should be noted that this revised cross section does result in a localised reduction in northbound SSD for the bus lane. The high object visibility achieved in front of the nearside pier/barrier is 142m – one step below the desirable minimum for the 85km/h bus lane design speed and requiring a departure from standards.

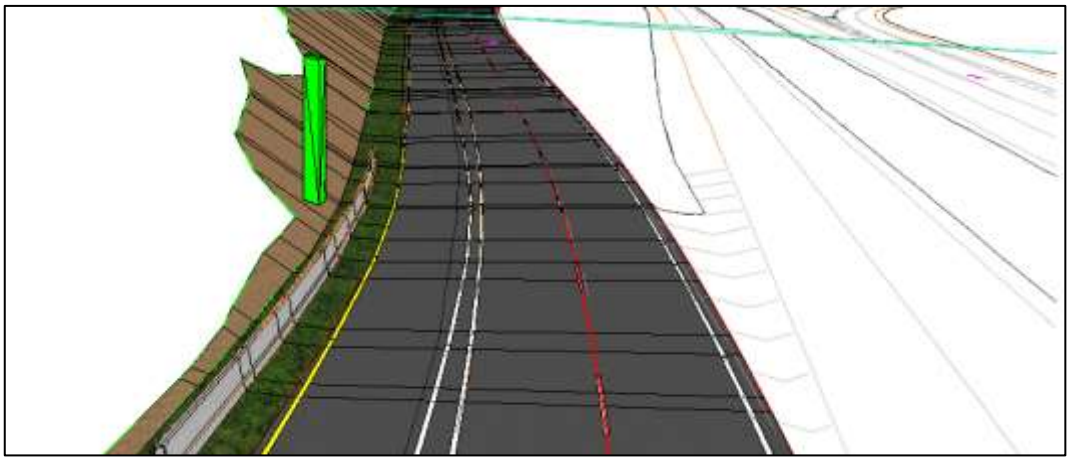


Figure 33: Ballybride Road Footbridge - proposed works

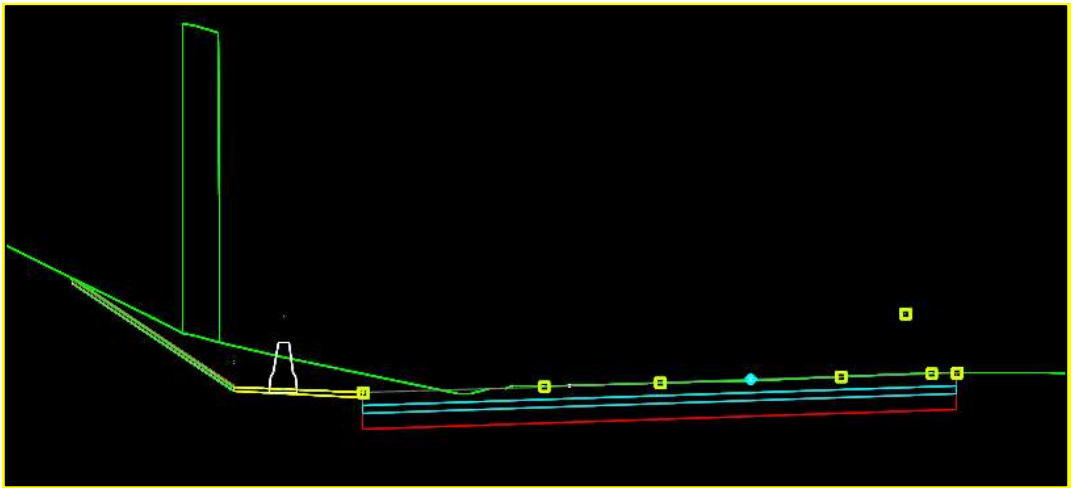


Figure 34: Ballybride Road Footbridge - proposed cross section

Structure Assessment

Ballybride Road Footbridge is a 5-span bridge with a precast prestressed concrete closed box girder deck. The total length of the bridge is 111.3m, with individual spans of 15.5m, 30.1m, 25.1m, 25.1m and 15.5m. The deck is supported on reinforced concrete abutment walls at its ends and 3 reinforced concrete intermediate piers. Elastomeric bearings at all supports allow each span to act as simply supported. Individual spans are connected by half-joints at support locations.

The proposed reconfiguration of the mainline requires the existing concrete (New Jersey) vehicle restraint system to be set back to accommodate the widening of the carriageway. As noted above, the initial proposed alignment caused a clash between the barrier in its new position and the existing pile cap of the intermediate pier in the western verge, refer to **Figure 35**. The solution therefore involves a reconfiguration of the slip road with localised cross section reductions to avoid impacting the pier foundation. No vertical clearance issues are expected to arise as a result of the road reconfiguration.

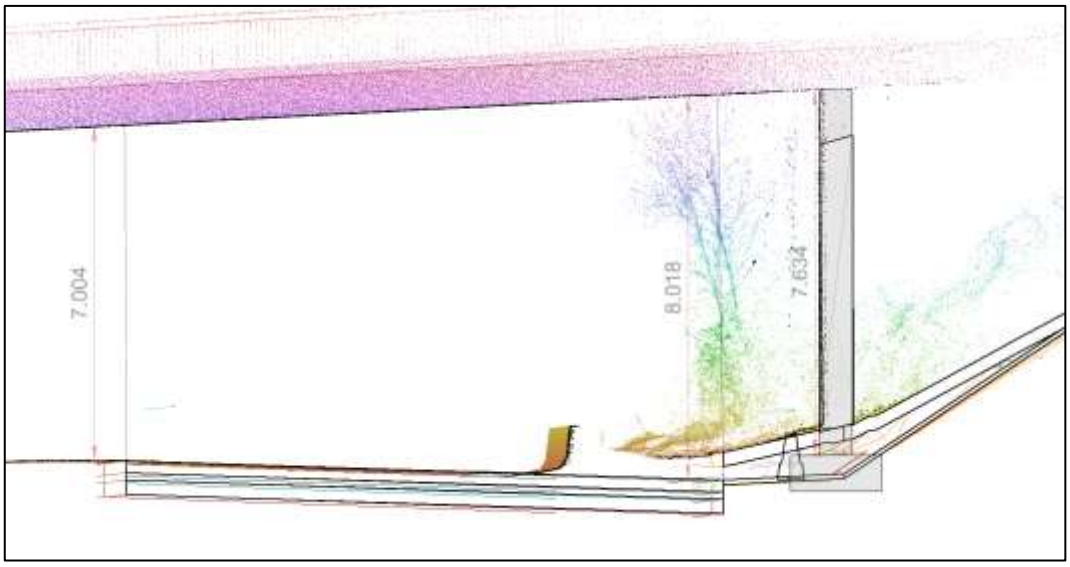


Figure 35: Northbound lane cross section showing initial potential clash identified between VRS and pile cap. Current proposal adjusted to avoid this clash.

6.2.6 Crinken Lane Bridge

Road Geometry and Cross Section

The Crinken Lane bridge crosses the M11 in the 3-lane section of the mainline between Junction 4 (M11/M50) and Junction 5 (Bray North). In the existing scenario, the carriageway caters for:

- 3 x 3.65m lanes, a 3.0m nearside shoulder in the southbound carriageway
- 3 x 3.65m lanes, a 2.7m nearside shoulder in the northbound carriageway

Since widening is required to cater for the bus lane, it is proposed that the existing steel barriers on the nearside and wire rope safety barriers (WRSB) on the offside of the existing carriageway are replaced with compliant concrete barriers underneath Crinken Lane Bridge.

In the southbound direction of travel, the geometry departs a right-hand curve on the approach to the underbridge. This creates a constraint for SSD in the southbound offside lane. Additionally, the new concrete barrier creates a higher obstruction for visibility in the offside lane.

As a result, the required SSD of 295m for a design speed of 120 km/h is not achieved. The design achieves SSD of 275m for the high object and 270m for the low object. This equates to a one step relaxation as outlined in Table 2.1 of DN-GEO-03031.

It should be noted that there is an existing signage gantry located approximately 150m upstream of the underbridge. In order to retain the gantry in its current location, the concrete barrier would need to be flared out around the column in the median. This would create an additional intermittent restriction to SSD on the southbound approach to Crinken Lane bridge.

The SSD reduction to cater for the signage gantry has not been assessed at this stage and needs to be investigated further in future design stages.

This intermittent restriction to SSD may require another relaxation similar to the concrete barrier restriction at the underbridge. Notwithstanding, this is not expected to significantly impact the feasibility of the interim bus lane.

Structure Assessment

Crinken Lane Bridge is a 4-span bridge with spans of 13m, 21m, 20.85m and 13.15m, totalling 68m. Spans consist of precast, prestressed concrete girders supported by reinforced concrete abutments and intermediate piers and cast in situ reinforced concrete deck slab. The two main spans consist of 8 prestressed girders while the end spans consist of 5 girders. Elastomeric and sliding steel bearings at supports allow the deck to move freely under normal service loading. The bridge passes over the M11 mainline at a skew angle of 10°.

The proposed reconfiguration of the carriageway under this bridge is not expected to the pose any headroom clearance issues. The existing vehicle restraint system under the carriageway is fixed to the base of the intermediate piers in both the eastern and western verges as illustrated in **Figure 36**. Any widening of the carriageway at this location may require the VRS system to be set back accordingly, however this will not be possible to do while retaining adequate working width. As outlined above, code-compliant concrete barriers shall be used instead to maximise trafficable space under the bridge.

A review of the foundations adjacent to the proposed carriageway was undertaken. These were found to be below the proposed carriageway works with no clash anticipated.



Figure 36: Vehicle Restraint System Fixed to Bridge Piers

6.2.7 Junction 4 SB merge / Junction 5 SB diverge

The existing Junction 4 (M11/M50) southbound merge consists of a two-lane ghost island with lane gain in accordance with layout option C (Option 2 Alternative) as per TII standard DN-GEO-03036 – refer to **Figure 37** below.

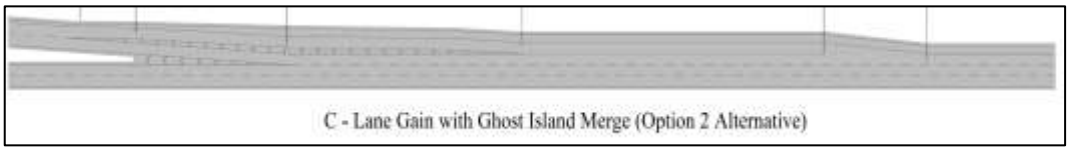


Figure 37: Two-lane ghost island with lane gain - layout option C

This 3-lane section of the M11 then extends southbound to the Junction 5 (Bray North) southbound diverge where the nearside lane exits onto the slip road as part of a lane drop arrangement. Between the two junctions, an effective weaving length of approximately 1.4km is provided; less than the 2km desirable weaving length as per TII standards.

The following modifications are proposed for the addition of the bus lane along this section:

- The bus lane is proposed to continue from Loughlinstown Roundabout within the nearside shoulder of the Junction 4 southbound merge, extending alongside the ghost island which will not be altered. A parallel / taper merge treatment is not required at this location because it is an additional lane scenario on the mainline.
- The bus lane will continue along the hard shoulder of the M11 mainline in the section between Junction 4 and Junction 5.
- In order to provide a TJR layout at the Junction 5 southbound diverge, it is considered necessary to terminate the bus lane approximately 440m in advance of the new fork diverge downstream, with buses required to merge into the nearside traffic lane.
- The bus is expected to travel in the nearside diverge lane, with a fork diverge treatment developing downstream to provide connectivity to the hard shoulder of the mainline and preserve the TJR proposal.

The proposed arrangement is illustrated in **Figure 38** below.

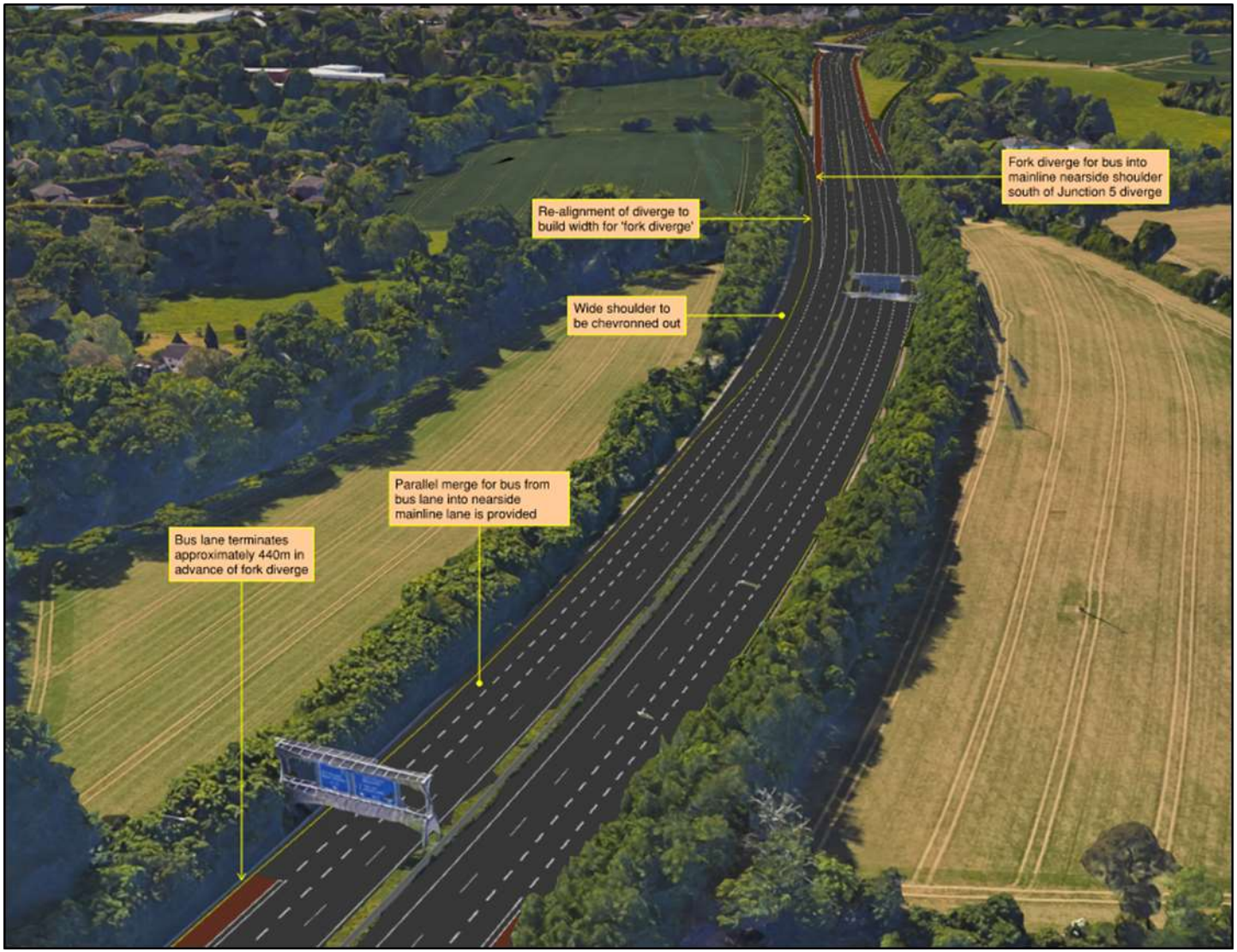


Figure 38: Junction 4 southbound merge / Junction 5 southbound diverge - proposed works

6.2.8 Junction 5 NB merge – Junction 4 NB diverge

The existing Junction 5 (Bray North) northbound merge comprises of a lane gain scenario which creates a 3-lane section of the M11 between Junction 5 and Junction 4. At a point approximately 300m upstream of the Junction 4 diverge, a further auxiliary lane is added, effectively creating a short 4-lane section of the M11 until the diverge, at which point there is double lane drop arrangement with the two mainline lanes transitioning into the M50 motorway. The entire section forms part of a busy weaving area between the two motorways. An effective weaving length of approximately 1.4km is provided; again, considerably short of the required 2km. The present merge/diverge treatment is illustrated schematically in **Figure 39** below.

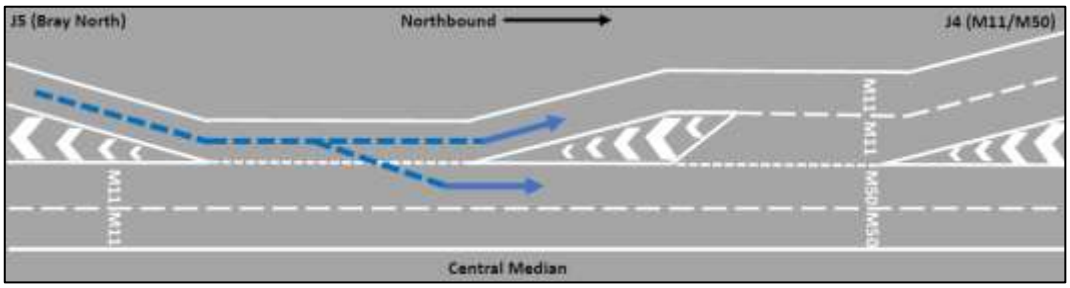


Figure 39: Junction 5 NB merge – Junction 4 SB diverge schematic

The presence of the lane gain in the existing scenario creates an added complexity when seeking to apply the preferred merge treatment. The following modifications are initially suggested for the addition of the bus lane along this section:

- The bus lane is transitioned to the west to allow for a third nearside general traffic lane to develop on the offside of the bus lane.
- A parallel merge is proposed from the Junction 5 northbound merge into the bus lane, creating a short 5-lane section of the mainline. General traffic can then enter the nearside mainline lane via a parallel merge from the bus lane.
- The bus lane continues along the hard shoulder and accesses the Junction 4 northbound diverge slip road. There is no requirement to provide a fork diverge treatment at this location as the bus lane continues north along the M11/M50 overbridge and onto the northern section of the N11.

The layout of this option is illustrated schematically in **Figure 40** below.

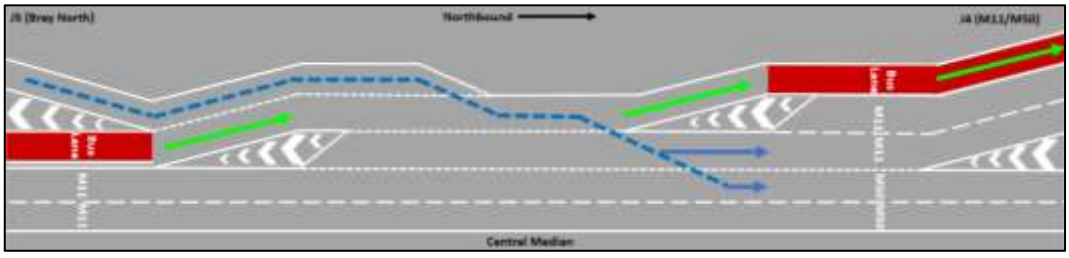


Figure 40: Possible bus lane layout between junction 5 and junction 4 northbound

While this layout seeks to apply the preferred parallel merges whilst also preserving the existing lane gains, the layout is complex and likely to be unintuitive for road users. Under this arrangement, traffic merging from the Junction 5 slip road and wishing to continue along the M50 northbound must manoeuvre across 3 lanes, which is undesirable given the already sub-standard weaving length between the junctions. Furthermore, this option requires widening of the M11 mainline beyond the existing pavement edge to provide the parallel merge.

This approach has been investigated as it is conservative in terms of widening and assesses the largest footprint due to the parallel merge from the northbound diverge into the bus lane. The details of the option are presented in **Figure 41** below.

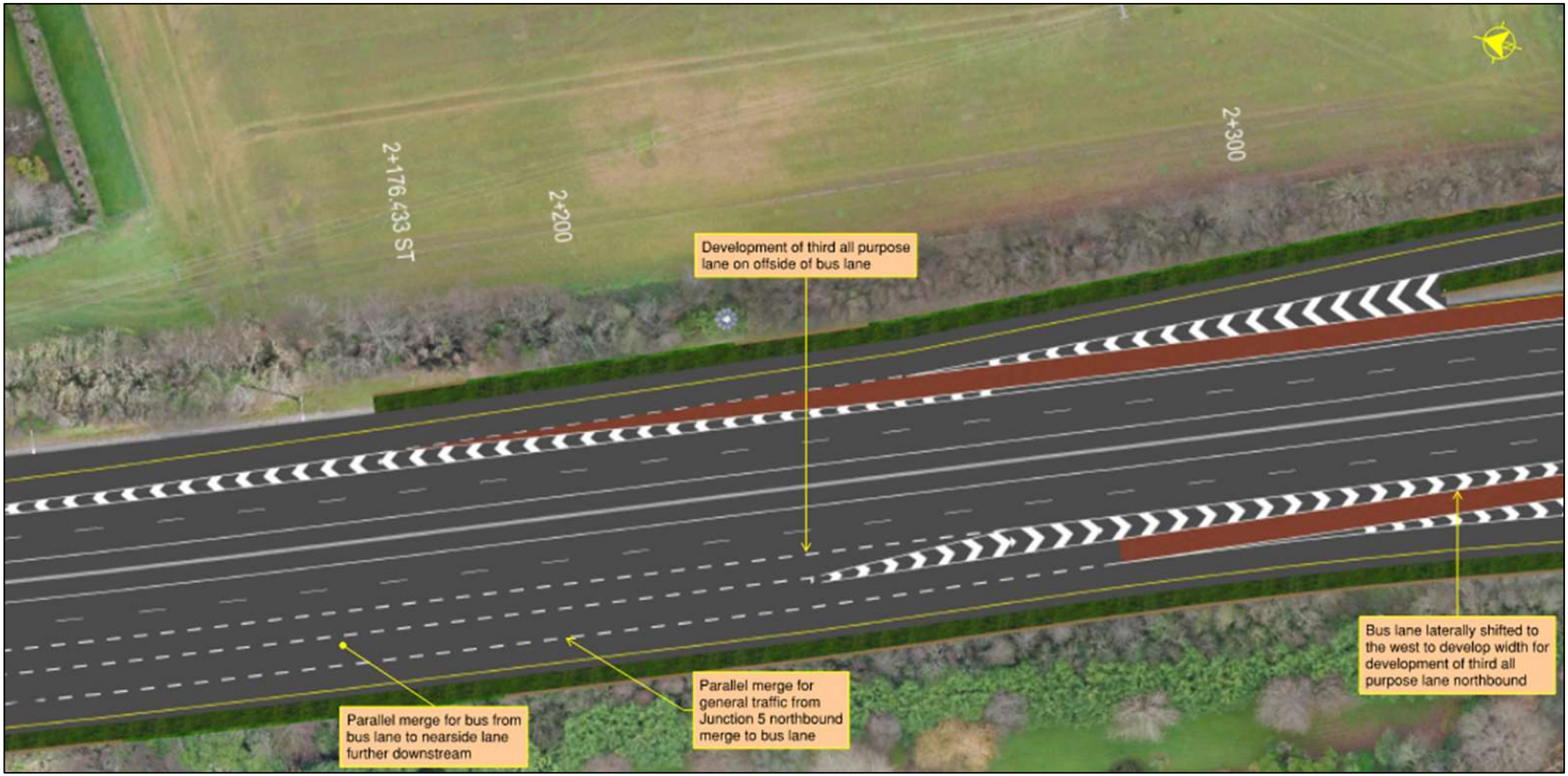


Figure 41: Junction 5 northbound merge - proposed works

However, it may be preferable to consider alternative options which provide a simpler layout, even if this results in a discontinuity of the dedicated bus lane.

The following options may be further investigated at the Option Selection stage:

- **Direct taper merge** – This arrangement would result in a reduced extent of the 5-lane cross section north of the Junction 5 northbound merge by employing a direct taper merge from the Junction 5 northbound merge into the bus lane.
- **Ramp metering** – this option would use signals to regulate the flow of traffic joining the motorway and eliminate merging conflicts with the bus lane traffic.
- **'Do Minimum'** – this option would involve the termination of the bus lane upstream of the Junction 5 merge, at which point the bus would be forced to manoeuvre into the adjacent traffic lane. The dedicated bus lane would then be discontinued, and the existing lane gain merge retained in its present form. The dedicated bus lane could recommence further downstream at the M11 diverge such that bus priority is provided on approach to Loughlinstown Roundabout. This alternative option is illustrated schematically in **Figure 42** below.

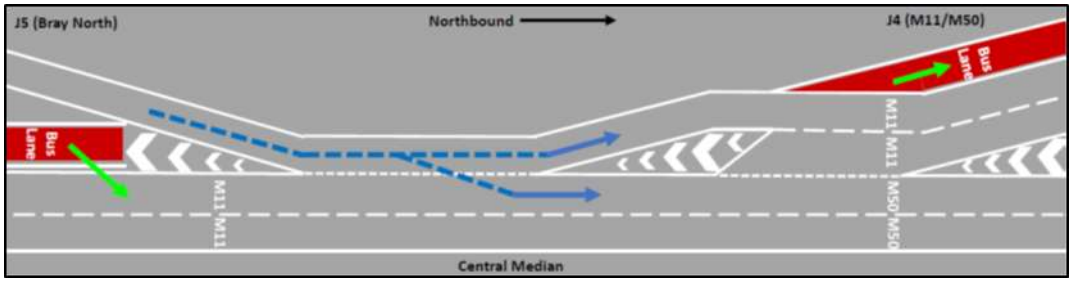


Figure 42: Alternative bus lane layout between junction 5 and junction 4 northbound

Although the alternative option would result in discontinuity of the bus lane, it would ensure a simpler, more intuitive layout for vehicles weaving between Junction 5 and Junction 4. Furthermore, an initial understanding of the M11 journey times would indicate that the majority of the AM peak delay in the northbound direction is concentrated to the south of Junction 5, with speeds typically increasing at this point due to the lane gain.

Accordingly, the elimination of continuous bus priority over this section may be acceptable if it does not add delay to the services using the facility. This requires further traffic analysis and confirmation at the Option Selection Stage.

6.2.9 Junction 5 overbridge

Road Geometry and Cross Section

The Junction 5 overbridge crosses the N11/M11 on the 2-lane section of the mainline. In the existing scenario, the carriageway caters for:

- 2 x 3.6m lanes, a 3.0m nearside shoulder in the southbound carriageway

- 3 x 3.65m lanes, a 3.0m nearside shoulder in the northbound carriageway

As widening is required to cater for the bus lane, it is proposed that the existing steel barriers in front of the existing median pier are replaced with compliant concrete barriers underneath the bridge.

In the southbound direction of travel, the geometry is on a right-hand curve over the length of the underbridge. This creates a constraint for SSD in the southbound offside lane. Additionally, the new concrete barrier creates a higher obstruction for visibility in the offside lane. As a result, the required SSD of 295m for a design speed of 120 km/h is not achieved. The design achieves SSD of 215m for the high object and 204m for the low object, which is 1-2 steps below desirable minimum standard.

In the northbound direction, nearside lane visibility would also be reduced slightly below desirable minimum standards, achieving 265m to the high and low objects.

Considering the above, the following design departures would need to be sought and approved in future design stages:

- SSD for southbound offside lane to high object (achieves 215m)
- SSD for southbound offside lane to low object (achieves 204m)
- SSD for southbound nearside lane to high object (achieves 277m)
- SSD for northbound nearside lane to low object (achieves 265m)

Additionally, a relaxation would be required for the southbound nearside lane visibility to the low object.

Structure Assessment

This bridge consists of 4 spans of 20.4m, 20.15m, 18.7m and 15.2m. The bridge deck is constructed as a continuous cast in-situ reinforced concrete voided slab, supported on reinforced concrete abutment walls at its ends and reinforced concrete intermediate piers between spans. Steel pot bearings between the deck and substructure at support locations allow the deck to move freely in the horizontal plane. The bridge passes over the M11 mainline at a skew of 20°.

The proposed reconfiguration of the carriageway under this bridge is not expected to the pose any headroom clearance issues. As discussed above, the existing steel vehicle restraint systems in the eastern and western verges which are fixed to the intermediate piers (**Figure 43**) will be replaced. Similarly, the VRS in the central median of the northbound carriageway will be replaced with a compliant concrete VRS.



Figure 43: Vehicle Restraint System fixed to bridge pier

A summary of the engineering feasibility assessment for Section 2 of the scheme is presented in **Section 6.2.10**.

6.2.10 Section 2 Summary

Table 8: Summary of engineering feasibility assessment in Section 2 – Junction 4 (M11/M50) to Junction 5 (Bray North)

	N11/M11 Mainline Cross Section	M11 / M50 Overbridge	Ballybride Road Footbridge	Crinken Lane Bridge	J4 SB Merge / J5 SB Diverge	J5 NB Merge / J4 NB Diverge	Junction 5 Overbridge
Degree of Widening Required to Provide Bus Lane Cross Section	Widening required along full length (extensive sections of widening beyond nearside pavement edge)	Extensive widening (offside) – widening contained within existing deck.	Localised widening – nearside of M11/M50 diverge	Medium widening – both sides	Medium widening beyond nearside pavement edge required to develop bus lane on merge and diverge	Medium widening beyond nearside pavement edge required to develop bus lane on merge and diverge	Medium widening – both sides
Geometric Design Departures	No new departures likely to be required on mainline (TBC during detailed design).	Offside lane SSD reduced to below existing – Departure required. Bus lane separation reduced to 0m on structure.	Separation width reduced to 0.5m, hard strip reduced to 0.0m. Values would not comply with NTA/WCC cross section but comply with TII recommendations.	Offside lane SSD reduced (no worse than existing, relaxation required)	No new departures likely to be required on mainline (TBC during detailed design).	No new departures likely to be required on mainline (TBC during detailed design).	Offside and nearside SSD reduced (less than existing), departures required
Impacts to structure	Impacts to overbridges discussed separately – impact to minor structures (gantries etc.) to be assessed at detailed design.	Medium impact – parapet to be replaced, existing ducts in verge impacted. No impact to superstructure	No impact envisaged (TBC in future design stages)	No impact envisaged (TBC in future design stages)	No impact to overbridges	No impact to overbridges	No impact envisaged (TBC in future design stages)
Safety / Operational Issues	N/A	Reduced safety standard for general motorists Possible speed limit reduction	Slight reduction to optimal safety due to reduction in widths	Low impact relative to existing due to SSD relaxation	Bus lane traffic required to merge with traffic lanes upstream of J5 diverge.	Safety / operational issues likely at J5 merge due to existing lane gain arrangement	Medium impact due to SSD departures
Continuous Bus Priority	Achieved	Achieved	Achieved	Achieved	Not fully achieved	Unlikely be operationally feasible to achieve priority through J5 merge without ramp metering.	Achieved
Pedestrian & Cycle Facilities	Not applicable on Motorway Section						
Additional works	Drainage, Pavement, Utilities etc. (to be determined at Option Selection Stage)	Cutting down verge Potential utility impacts	Sewer main transverse crossing (exact location and depth unknown)	Existing barriers to be removed and	Drainage, Pavement, Utilities etc. (to be	Drainage, Pavement, Utilities etc. (to be	Drainage, Pavement, Utilities etc. (to be

	N11/M11 Mainline Cross Section	M11 / M50 Overbridge	Ballybride Road Footbridge	Crinken Lane Bridge	J4 SB Merge / J5 SB Diverge	J5 NB Merge / J4 NB Diverge	Junction 5 Overbridge
		Potential drainage impacts	Existing barriers to be removed and replaced with concrete barriers	replaced with concrete barriers	determined at Option Selection Stage)	determined at Option Selection Stage)	determined at Option Selection Stage)
Constraint Level	**Level 2**	**Level 3**	**Level 2**	**Level 2**	**Level 2**	**Level 3**	**Level 3**

6.3 Section 3 – Junction 5 (Bray North) to Junction 6 (Bray/Fassaroe)

6.3.1 Overview / Key Findings

- Widening of the existing M11 carriageway is required along the entire section to accommodate the bus lane;
- In the southbound direction, continuous bus priority is interrupted by the Junction 5 (Bray North) merge and Junction 6 (Bray/Fassaroe) diverge;
- In the northbound direction, limited exclusive bus priority is achieved due to the short distance between the Junction 6 (Bray/Fassaroe) merge and the Junction 5 (Bray North) diverge;
- No significant impacts to existing major structures; and
- Realignment of Junction 6 (Bray/Fassaroe) southbound diverge required.

6.3.2 Key Constraints

From Junction 5 (Bray North) to Junction 6 (Bray / Fassaroe), the M11 mainline consists of a two-lane motorway in both the northbound and southbound directions.

The following key constraints have been identified within this section:

- Existing road cross section;
- Junction 5 southbound merge/Old Connaught Avenue Bridge;
- Junction 6 southbound diverge; and
- Junction 6 northbound merge.

The impact of each of these constraints on the engineering feasibility of the bus lane is discussed in turn below.

6.3.3 Existing M11 Cross Section

Between Junction 5 (Bray North) and Junction 6 (Bray/Fassaroe), widening of the mainline carriageway will be required along the full length to incorporate the bus lane cross section as outlined in **Section 4.2**. This widening will be split between widening into the existing central median and widening beyond the nearside edge approximately as follows:

- In the northbound direction, widening will be confined to the central median along approximately 57% of the section (~0.87km);
- In the northbound direction, widening beyond the nearside edge of pavement will be required along approximately 43% of the section (~0.65km);
- In the southbound direction, widening will be confined to the central median along approximately 43% of the section (~0.77km); and

- In the southbound direction, widening beyond the nearside edge of pavement will be required along approximately 57% of the section (~1.03km);

The approximate extent of areas requiring widening in both the central median and nearside verge are illustrated on the drawings included in **Appendix C**. Exact extents of widening will be subject to detailed design.

While the design has sought to limit widening into the central reserve as much as possible, widening beyond the nearside edge of pavement is required at merge and diverge locations to provide the required auxiliary lanes, tapers, nosing arrangements and fork diverge treatment. Widening outside the nearside edge of pavement is also required where central median widening would exacerbate visibility problems.

A typical cross section of the proposed M11 motorway with bus lane within section 3 of the scheme is presented in **Figure 44** below.



Figure 44: Typical M11 cross section with bus lane between Junction 5 – Junction 6.

6.3.4 Junction 5 SB merge / Old Connaught Avenue Bridge

Geometry – Merge Arrangement

The existing Junction 5 (Bray North) merge layout provides a direct taper merge with approximately 155m taper length and 75m nose length. It should be noted that a direct taper merge without a parallel auxiliary lane is not permitted under current standards.

As outlined in **Section 4.4.2**, the preferred merge treatment is the parallel merge treatment. At this location, the geometry is constrained by the Old Connaught bridge, south of the merge. Provision of a parallel lane merge would require demolition and reconstruction of the bridge, which may render the project not feasible.

In order to cater for the bus lane within the hard shoulder, and with the given constraints, widening is proposed on the eastern side of the existing carriageway to cater for a direct taper merge from the slip road into the bus lane. Subsequently, slip road traffic shares the bus lane and has an extended parallel merge to manoeuvre into the nearside lane of the mainline.

This design caters for the following:

- 100m taper merge length - As noted previously, a direct taper merge as a merge treatment for slip road traffic onto the mainline is not permitted under current standards. This achieves the requirements for an Urban Motorway with a design speed of 100 km/h as outlined in TII standard DN-GEO-03060.

  The taper merge in this scenario involves the slip road traffic merging onto the bus lane, which is only operating at peak times, under reduced speed environment and infrequent use.
- 50m nose length – This is compliant with the requirements for an Urban Motorway with a design speed of 100 km/h as outlined in TII standard DN-GEO-03060.
- Separation width reduced to 0.0m underneath Old Connaught Avenue bridge – This would be non-conforming with the desirable cross section proposed in **Section 4.2** as well as the TII Standards and Literature Review, and is likely to require a departure from standard in future stages.

Geometry – Old Connaught Avenue Bridge

In the southbound direction of travel, the geometry is on a right-hand curve over the length of the underbridge. This creates a constraint for SSD in the southbound offside lane. Additionally, the new concrete barrier creates a higher obstruction for visibility in the offside lane.

As a result, the required SSD of 295m for a design speed of 120 km/h is not achieved. In the offside lane, the design achieves SSD of 215m for the high object and 217m for the low object. This is no worse than the existing SSD of 215m for the high object and low object.

The following design departures would need to be sought and approved in future design stages for the intermittent restriction of sight distance at the bridge.

- SSD for southbound offside lane to high object (achieves 215m, 1 step below desirable minimum).
- SSD for southbound nearside lane to high object (achieves 272m, 1 step below desirable minimum as relaxation is not permitted for visibility to a car on approach to a merge).

Relaxations would be required for:

- SSD for the southbound offside lane to the low object which achieves 217m.
- SSD for the southbound nearside lane to the low object which achieves 272m

The proposed arrangement is illustrated in **Figure 45**.



Figure 45: Junction 5 southbound merge – proposed layout

Structure Assessment

Old Connaught Avenue Bridge is a 4-span bridge of reinforced concrete slab construction. The 4 spans are 12.7, 17.4m, 17.6m and 12.9m giving a total length of 60.6m. the bridge crosses over the mainline with a skew of 15°. The deck is presumed to be of voided slab construction, which would be consistent with the construction method used for the nearby Junction 5 overbridge. The deck is supported by buried reinforced concrete (assumed to be buried bankseat) abutments at its ends and reinforced concrete columns at intermediate piers. Steel pot bearings between deck and substructure at support locations allow the deck to move freely in the horizontal plane.

The vertical headroom clearance at this bridge was checked and assessed to be sufficient for the proposed carriageway alignment.

No information is currently available for the foundations for this bridge. The proposed carriageway encroaches slightly into the existing ground adjacent to the central pier. A further review of the substructure at this location is recommended during further design stages.

6.3.5 Junction 6 southbound diverge

The existing Junction 6 southbound diverge layout is not compliant with current TII standards. It features a loop ramp arrangement downstream of a non-standard nose treatment which does not include a flared development as per TII Standard DN-GEO-03060. The length of auxiliary lane (145m), taper length (50m) and auxiliary lane width (2.7m) are less than the required minimums.

In addition, the length of nose is significantly inadequate and the geometry of the diverge slip road provides a very short 70m separation from the nose to the yield line at the roundabout. This is not adequate for the deceleration required from the mainline design speed to the roundabout yield line.

Additionally, due to the thick vegetation on the eastern side of the mainline, the roundabout is largely unsighted on the diverge and contains a number of existing departures for visibility approaching a junction.

In order to cater for the bus lane within the hard shoulder, widening is proposed on the eastern side of the existing carriageway. This allows width to be built up between the bus lane and the nearside traffic lane such that a ‘soft nose’ is created in advance of the existing Junction 6 physical nose. This re-alignment allows for the fork diverge movement to occur in advance of the physical nose.

It should be noted that the above approach is seen as a ‘Do Minimum’ approach which achieves the objectives of providing continuous bus priority, and that can be implemented as an interim solution. This option does not seek to address any of the inherent safety issues associated with the diverge slip road.

As such, the re-alignment of the slip road to the east would require slight modification and approval of the departures associated with the existing substandard slip road geometry.

Despite this being a Do Minimum option, there are still substantial impacts to the existing vegetation on the eastern side.

This would require substantial clearing and re-vegetation, and the environmental impacts of such a proposal are not known at this stage. The proposed arrangement is illustrated in **Figure 46**.

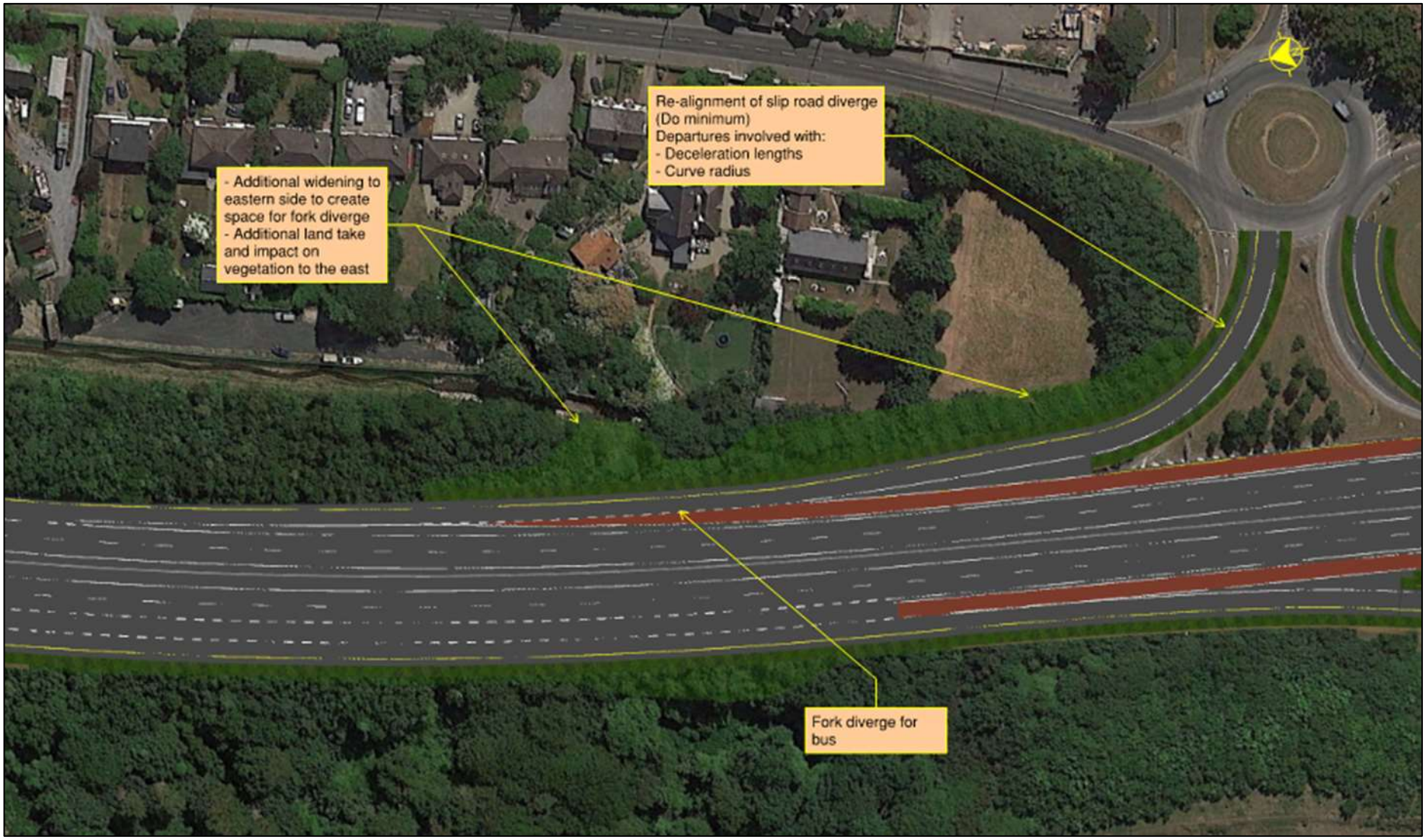


Figure 46: Junction 6 southbound diverge – proposed layout

6.3.6 Junction 6 northbound merge

The existing Junction 6 northbound merge layout is a parallel merge lane treatment, providing an auxiliary lane of approximately 280m length, a 55m auxiliary taper length and 75m nose length. The existing width of the auxiliary lane, at just 2.5m, is sub-standard and creates a potentially hazardous situation for merging and mainline traffic alike.

To cater for the bus lane within the hard shoulder, widening is proposed on the western side of the existing carriageway to cater for a parallel merge from the slip road into the bus lane. Subsequently, an extended parallel merge is provided from the bus lane into the nearside lane of the mainline.

This design caters for the following:

- 260m auxiliary lane length – This arrangement provides the opportunity for slip road traffic to find a gap and have a smooth transition into the bus lane / hard shoulder relative to the direct taper. Subsequently, slip road traffic can use the bus lane / hard shoulder to undertake a parallel merge on to the nearside mainline lane.
- 75m nose length – This is compliant with the requirements of Table 7.1 of DN-GEO-03060 for a Type 1 Dual Carriageway with a design speed of 100 km/h.
- Separation width reduced to 0.0m underneath Junction 6 overbridge – This would be non-conforming with the desirable cross section proposed in **Section 4.2** as well as the TII Standards and Literature Review, and is likely to require a departure from standard in future stages.

The proposed arrangement is illustrated in **Figure 47**.

A summary of the engineering feasibility assessment for Section 3 of the scheme is presented in **Section 6.3.7**.



Figure 47: Junction 6 northbound merge – proposed layout

6.3.7 Section 3 Summary

Table 9: Summary of engineering feasibility assessment in Section 3 – Junction 5 (Bray North) to Junction 6 (Bray/Fassaroe)

	N11/M11 Mainline Cross Section	Junction 5 SB Merge / Old Connaught Avenue Bridge	Junction 6 SB Diverge	Junction 6 NB Merge
Degree of Widening Required to Provide Bus Lane Cross Section	Widening required along full length (extensive sections of widening beyond nearside pavement edge)	Short section of widening on slip road to provide TJR layout at merge	Extensive nearside widening to accommodate TJR fork diverge. Localised realignment of slip road.	Short section of widening on slip road to provide TJR layout at merge
Geometric Design Departures	No new departures likely to be required on mainline (TBC during detailed design).	Departure - Nearside and offside SSD to high object requires (No worse than existing) Departure for taper merge from slip road into bus lane	Departures - Substandard existing slip road geometry is not resolved; new departures would be required for adjustments to existing issues	No new departures likely to be required on mainline (TBC during detailed design).
Impacts to structures	Impacts to overbridges discussed separately – impact to minor structures (gantries etc.) to be assessed at detailed design.	No impact envisaged (TBC in future design stages)	N/A	N/A
Safety / Operational Issues	N/A	Medium impact due to SSD/Taper departures	Addition of bus traffic likely to add to existing safety issues for southbound diverge traffic due to existing departures	Merging traffic may impede bus priority without ramp metering.
Continuous Bus Priority	Achieved	Achieved	Achieved	Achieved
Pedestrian & Cyclist Movement	Not applicable on Motorway Section			
Additional works	Drainage, Pavement, Utilities etc. (to be determined at Option Selection Stage)	Slip road needs re-alignment	Slip road needs to be reconfigured Extensive clearing of vegetation Environmental impacts not known	Drainage, Pavement, Utilities etc. (to be determined at Option Selection Stage)
Constraint Level	**Level 2**	**Level 2**	**Level 3**	**Level 3**

6.4 Section 4 – Junction 6 (Bray/Fassaroe) to Junction 7 (Bray South)

6.4.1 Overview / Key Findings

- Widening of the existing N11 carriageway is required along the entire section to accommodate the bus lane;
- Not feasible to provide exclusive bus priority in the southbound direction due to existing minor accesses and associated weaving issues;
- Not feasible to provide exclusive bus priority in the northbound direction due to existing R117 junction and short weaving area between junctions;
- Reconstruction works are required on St. Valery's Bridge;
- Visibility departures are required; and
- Provision of pedestrian and cyclist facilities reliant on adjacent schemes.

6.4.2 Key Constraints

The M11 motorway terminates at Junction 6 (Bray / Fassaroe), transitioning into the N11 dual carriageway. At this point, the speed limit of the road reduces from 120 km/h on the motorway to 100 km/h on the dual carriageway. The geometric standard of the N11 dual carriageway between Junction 6 and Junction 8 (Kilmacanoge) drops considerably. This is characterised by sub-standard and inconsistent junction layouts, direct local road and private property accesses, and inadequate separation and weaving lengths between junctions.

The following key constraints have been identified within this section:

- Existing N11 cross section;
- Junction 6 southbound merge / Junction 6 overbridge;
- Junction 6 northbound diverge;
- Saint Valery's Bridge;
- Local Road and Property Accesses;
- Junction 7 northbound merge; and
- Pedestrian and cyclist movement.

6.4.3 Existing Road Cross Section

Between Junction 6 (Bray/Fassaroe) and Junction 7 (Bray North), widening of the mainline carriageway will be required along the full length to incorporate the bus lane cross section as outlined in **Section 4.2**. This widening will be split between widening into the existing central median only and widening beyond the nearside edge approximately as follows:

- In the northbound direction, widening will be confined to the central median along approximately 63% of the section (~0.93km);
- In the northbound direction, widening beyond the nearside edge of pavement will be required along approximately 37% of the section (~0.55km);
- In the southbound direction, widening will be confined to the central median along approximately 39% of the section (~0.76km); and
- In the southbound direction, widening beyond the nearside edge of pavement will be required along approximately 61% of the section (~1.2km);

The approximate extent of areas requiring widening in both the central median and nearside verge are illustrated on the drawings included in **Appendix C**. Exact extents of widening will be subject to detailed design.

While the design has sought to limit widening into the central reserve as much as possible, widening beyond the nearside edge of pavement is required at merge and diverge locations to provide the required auxiliary lanes, tapers, nosing arrangements and fork diverge treatment. Widening outside the nearside edge of pavement is also required where central median widening would exacerbate visibility problems.

A typical cross section of the proposed M11 motorway with bus lane within section 4 of the scheme is presented in **Figure 48** below.



Figure 48: Typical M11 cross section with bus lane between Junction 6 – Junction 7.

6.4.4 Junction 6 southbound merge / Junction 6 overbridge

Geometry - Merge

The existing Junction 6 (Bray/Fassaroe) merge layout provides a parallel merge treatment with approximately 185m auxiliary lane length, 55m auxiliary taper length and 90m nose length. From a geometric perspective, the Junction 6 southbound merge is one of the few compliant merge treatments within this section of the N11 / M11. The parallel merge extends under the Junction 6 overbridge, which creates a constraint for widening.

In order to cater for the bus lane within the hard shoulder, and with the given constraints, widening is proposed on the eastern side of the existing carriageway to cater for a parallel merge from the slip road into the bus lane. Subsequently, slip road traffic shares the bus lane and has an extended parallel merge to manoeuvre into the nearside lane of the mainline. This is considered to be a safer treatment and is the desirable merge treatment where space permits.

This design caters for the following:

- 150m auxiliary lane length – This arrangement provides the opportunity for slip road traffic to find a gap and have a smooth transition into the bus lane / hard shoulder relative to the direct taper. Subsequently, slip road traffic can use the bus lane / hard shoulder to undertake a parallel merge on to the nearside mainline lane. This achieves the requirements for a Type 1 Dual Carriageway with a design speed of 100 km/h as outlined in TII standard DN-GEO-03060.
- 70m nose length – This is compliant with the requirements of a Type 1 Dual Carriageway with a design speed of 100 km/h as outlined in TII standard DN-GEO-03060.
- Separation width reduced to 0.0m underneath Junction 6 overbridge – This would be non-conforming with the desirable cross section proposed in **Section 4.2** as well as the TII Standards and Literature Review, and is likely to require a departure from standard in future stages.
- The hard shoulder adjacent to the slip road would be reduced to 0.5m, and verge reduced to 2.0m in order to avoid impacting the spill through earthworks for the Junction 6 overbridge abutment.

Geometry – Junction 6 Overbridge

In both the northbound and southbound directions, the desired bus lane cross section can be achieved. Desirable minimum SSD, compliant with TII standard, is also provided for the offside, nearside and bus lanes.

The proposed arrangement is illustrated in **Figure 49**.

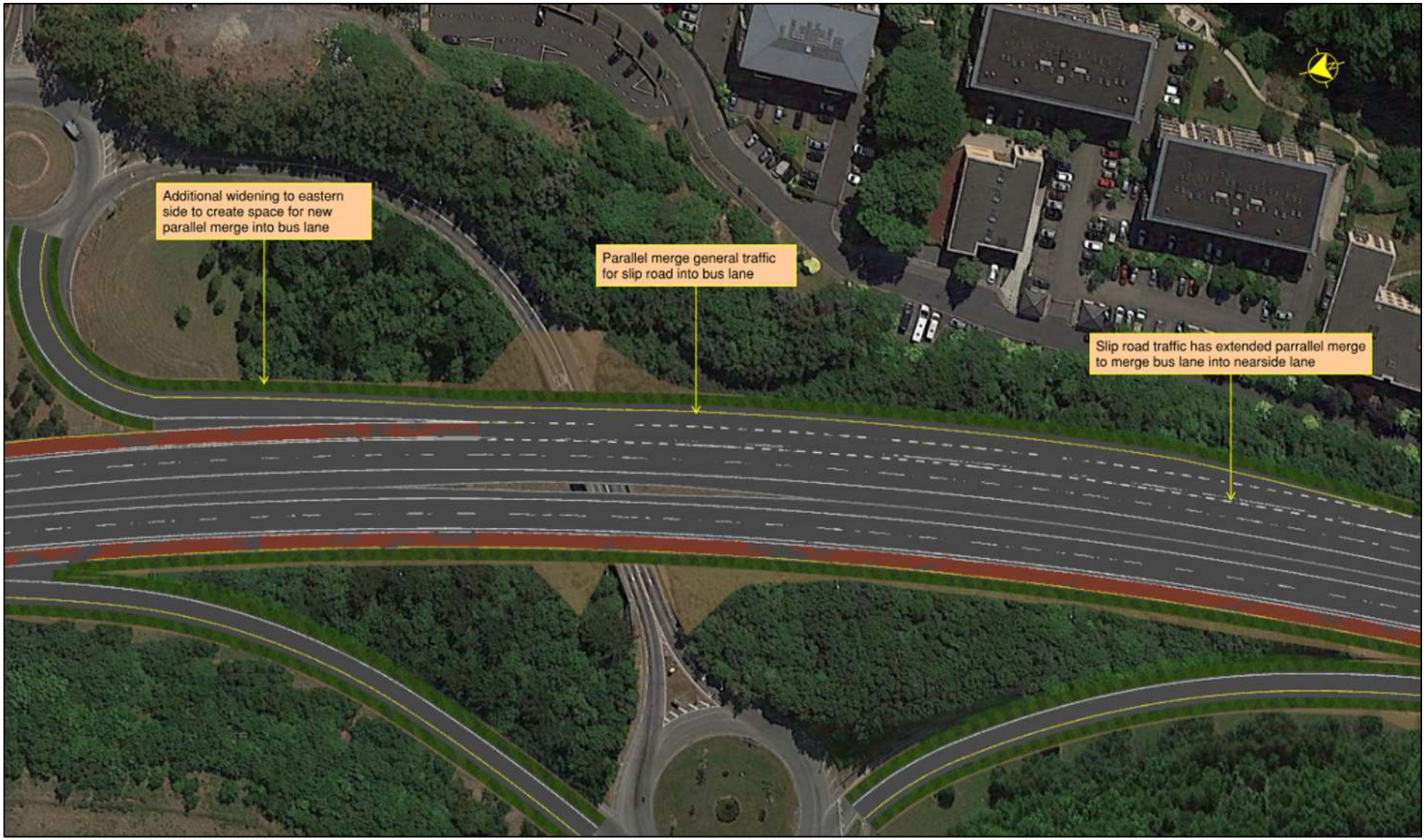


Figure 49: Junction 6 southbound merge – proposed layout

Structure Assessment

Junction 6 Overbridge (also referred to as Dargle Road Interchange Bridge) is a 2-span bridge comprising prestressed concrete girders and reinforced concrete deck slab. The bridge crosses over the N11 mainline at a skew of 23°The two spans are 26.5m and 27.0m, totalling 55.5m. The deck is supported by reinforced concrete abutment walls at its ends and a double column and headstock reinforced concrete intermediate pier. Elastomeric bearings at support locations allow the bridge to expand and contract during normal service conditions.

The vertical headroom clearance at this bridge was checked and assessed to be sufficient for the proposed carriageway alignment. Code compliant concrete barriers are proposed beneath the bridge, set back from the piers to provide adequate vehicle intrusion and working widths.

No information is currently available for the foundations for this bridge. The proposed carriageway encroaches slightly into the existing ground adjacent to the central pier (refer to **Figure 50** below). While it is not anticipated that this encroachment will cause a clash, a further review of the substructure at this location is recommended during further design stages.

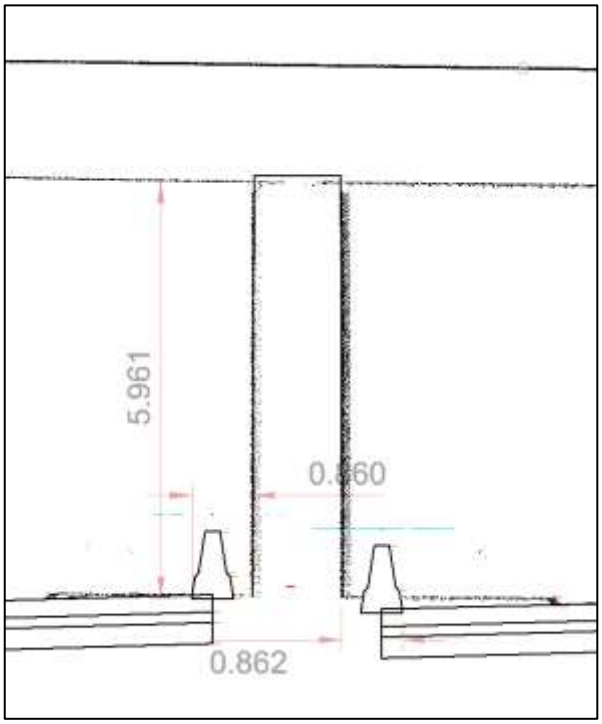


Figure 50: Section showing potential clash between new concrete VRS and the intermediate pier

6.4.5 Junction 6 northbound diverge

The existing Junction 6 northbound diverge layout provides a parallel diverge layout which is not in compliance with current TII standards. The auxiliary lane length (165m) and taper length (35m) are below the required minimums, while the nose length is a compliant 75m.

In order to cater for the bus lane within the hard shoulder, widening is proposed on the western side of the existing carriageway.

This allows width to be built up between the bus lane and the nearside traffic lane such that a ‘soft nose’ is created in advance of the existing Junction 6 physical nose. This re-alignment allows for the fork diverge movement to occur in advance of the physical nose. An illustration of the proposed configuration is provided in **Figure 51**.

The diverge forms part of a weaving area which extends north from the R117 Enniskerry Road. The interaction of the two streams of traffic from a weaving perspective is discussed further in **Section 6.4.5**.



Figure 51: Junction 6 northbound diverge – proposed layout

6.4.6 Saint Valery's Bridge

Geometry

The existing Saint Valery's bridge cross section is presented in **Figure 52** below and caters for the following:

- Two 3.7m lanes, 3.0m nearside shoulder and 0.5m offside shoulder in the southbound bridge
- 3.5m nearside lane, 3.7m offside lane, 3.3m nearside shoulder and 0.3m offside shoulder in the northbound bridge

Narrow concrete verges are present on both bridges. It should be noted that the existing northbound and southbound bridges contain steel railing parapets which are not compliant with current TII standards. As widening is required to fit the desired cross section for the bus lane outlined in **Section 4.2**, it is proposed that the existing parapets are replaced with a compliant H2 containment 1250mm steel post and rail system. Additional discussion on the parapets is provided in the structures section below. The proposed cross section is illustrated in **Figure 53** below.



Figure 52: Existing cross section at St. Valery's Bridge (northbound)

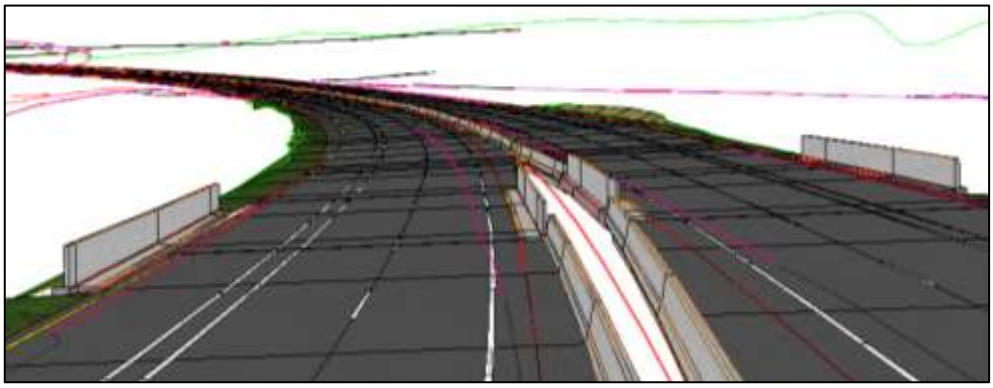


Figure 53: Saint Valery's bridge – proposed cross section

It should be noted that the requirement to upgrade the parapets to compliant H2 systems increases the obstruction height for SSD checks. The geometric design has optimised the approach geometry such that SSD is maximised at the constraint of the bridge. Notwithstanding the above, the following departures would be required at future design stages:

- Southbound carriageway – the bus lane does not achieve the target SSD of 160m for an 85km/h design speed. Due to the obstruction of the H2 parapets, the bus lane achieves a reduced sight distance of approximately 145m for the high object and 130m for the low object, which is one step below desirable minimum for the 85km/h design speed. This is not anticipated to be a safety issue, as the posted speed for the bus lane is proposed at 60 km/h.
- Northbound carriageway – the mainline offside lane does not achieve the target SSD of 215m for a 100 km/h design speed. Due to the obstruction of the H2 parapets on the offside, the design achieves a reduced sight distance of approximately 165m for the high object and 162m for the low object. This is a reduction from the existing condition, where approximately 190m is achieved to the high object and 175m to the low object.

  The geometry has been optimised to maximise the available SSD within the constraints of the existing bridge. The reduction in SSD can be attributed to shifting the offside lane closer to the parapet, as well as the upgrade of the parapet to a taller 1250mm H2 system. While this is a drop in existing standard from a visibility perspective, it can be reasoned that the safety of the bridge has also been improved due to the upgrade in parapets and the higher level of containment this provides. The reduction in SSD for the offside lane equates to a one step reduction from the desirable minimum SSD for the high object and low object, which is considered to be an appropriate compromise in this constrained environment.

Structure Assessment

St. Valery's bridge was constructed in 1971 and comprises two single span bridges carrying the N11 Mainline over the River Dargle. The bridge has a span of 19.5m and is composed of 2 No. independent bridge decks, both of reinforced concrete beam and slab construction, one carrying the northbound carriageway and the other the southbound carriageway. Both decks are supported by a shared reinforced concrete abutment wall via an integral connection at the top of the abutment wall. The bridge crosses the Dargle at a skew angle of 22°.

The proposed reconfiguration of the carriageways will result in a widening of the trafficable surface above the bridge deck, without the need to physically widen the structure. This is achieved by encroaching into the existing verges on the bridge.

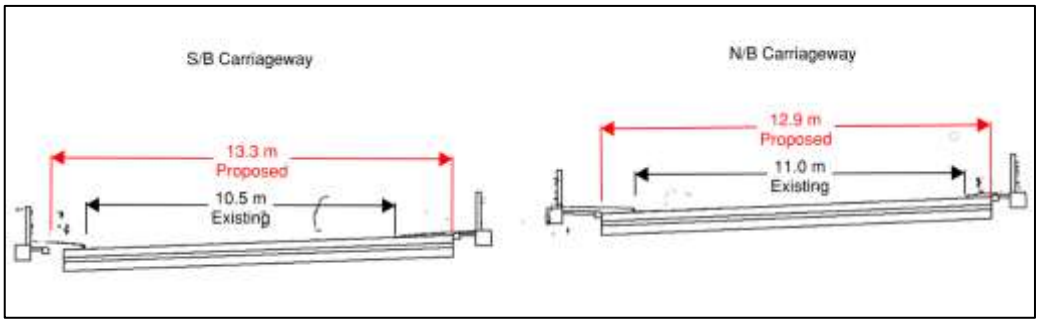


Figure 54: Approximate widths of existing and proposed carriageways at St Valery's Bridge

The widening of the carriageway in this scenario will result in an additional design lane being applied to the structure when assessed in accordance with EN1991-2 (Traffic Loads on Bridges). While the introduction of an additional design lane will result in additional load on the structure, the effect on the primary structural members will be minimal as the loads associated with this additional design lane are minimal.

A Structural Assessment was carried out by Roughan & O'Donovan Consulting Engineers in 2004. This report assessed the bridge to safely carry 40 tonnes of live loading. It was additionally assessed to resist 45 units of HB loading. Furthermore, the quantitative assessment calculated a maximum Stress Index of 0.72 for the primary load carrying members, which implies a good level of residual load carrying capacity is available in the primary members.

Hence, it is assessed that the widening of the carriageway above the deck structure is feasible with respect to the potential impacts of additional traffic loading to the structure. An updated Structural Assessment Report may be required during further design stages.

In addition to the vertical traffic loading, the existing bridge parapets were also reviewed. These were found to be non-compliant and would need to be replaced, particularly since the existing VRS would be removed and the traffic lanes moved closer to the existing parapet edge. The structural connection with the deck was also checked and found to be inadequate. Hence, the deck would need to be locally strengthened as part of the parapet replacement works.



Figure 55: Existing Steel parapet railing and VRS over the bridge

A conceptual arrangement of the proposed strengthening works for the parapet support is shown in **Figure 56** below. This would require breaking the edge of the concrete deck back and reinstating a more robust connection.

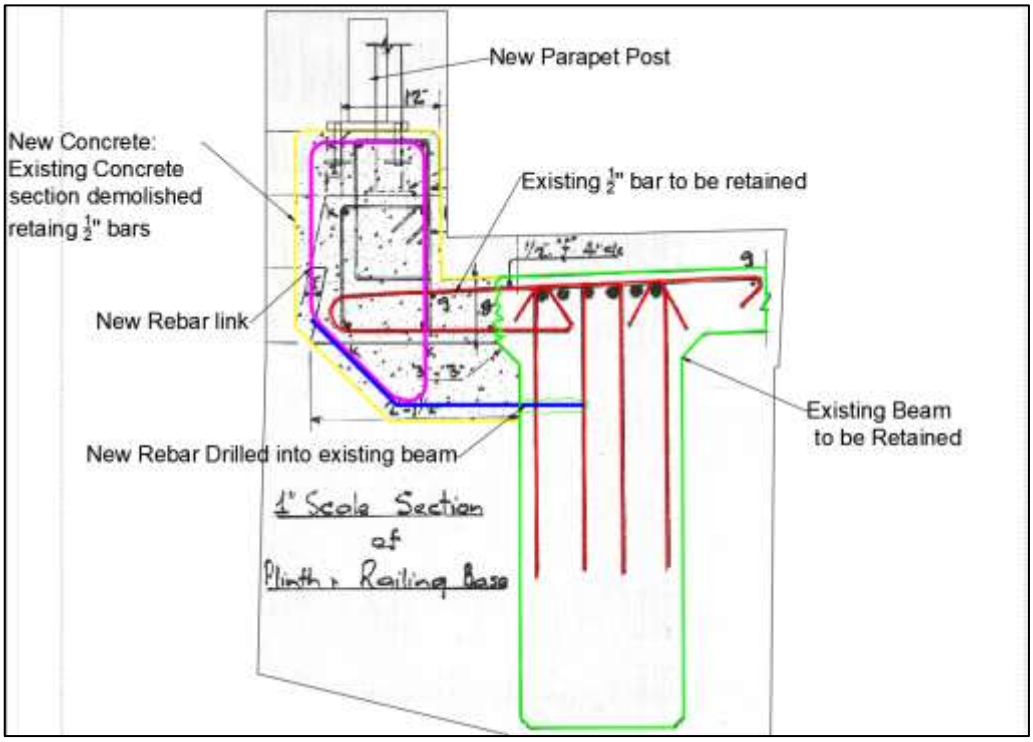


Figure 56: Proposed strengthening works of deck edge to support compliant bridge parapet

There is a 200mm-ST-40bar gas transmission main which connects to an Above Ground Installation (AGI) located at Hollybrook to the east of Junction 7 (Bray South). It crosses under the inner cantilever of the northbound deck as shown in **Figure 57** below. Any strengthening works to the deck edge adjacent to this gas main would need to be carefully considered. The gas main may need to be temporarily or permanently relocated to carry out works along this edge.



Figure 57: 200mm gas main passing longitudinally over St. Valery's Bridge

6.4.7 Local Road and Property Accesses between J6 and J7

Southbound Direction

In the short distance between Junction 6 (Bray/Fassaroe) and Junction 7 (Bray South), there are number of local road and property accesses with direct connection to the N11 mainline. The presence of these minor junctions and accesses is not conducive to the safe and efficient operation of the existing dual carriageway. In the southbound direction, the following junctions intersect with the mainline with direct Left-In Left-Out access:

- Silverbridge Halting Site access;
- Dargle Lane;
- Herbert Road; and
- Private Residential Access.

These contain inherent safety issues with inconsistent layouts, and substandard sight distance which would be exacerbated by the provision of a bus lane within the hard shoulder. Furthermore, the presence of these accesses is likely to impede bus priority significantly, as the bus lane will double-up as a merge diverge auxiliary lane for each successive access, with vehicles weaving in and out of the bus lane.

From a safety and operational perspective, the preferred approach would be to close each non-standard intermediate access between the principal junctions. This would minimise interaction between bus lane traffic and weaving traffic and optimise the dedicated priority of the bus to the highest degree.

However, it is recognised that the closure of these accesses may not be strictly feasible within the scope of an interim bus lane scheme, hence, the following alternative options have been investigated.

In the southbound direction the following approach is proposed:

- Silverbridge Halting Site Access retained with merging/diverging vehicles accessing the junction using the bus lane. While closure of the access may be preferable, it may be acceptable to retain the junction on the assumption that usage is likely to be low, however, discussions will be required with Wicklow County Council to ascertain the future proposals for this site.
- A new segregated parallel service road is proposed, commencing on approach to the L152 Dargle Lane Junction and continuing past the L1956 Herbert Road Junction. The form of the segregated parallel service road can reflect that already implemented successfully on other routes such as the N4 outside Dublin, as illustrated in **Figure 58** below. Traffic exiting the N11 for these junctions will be required to diverge into the parallel service road which can be posted at a 60km/h speed limit. Bus lane traffic will also use the segregated service road through this area. For traffic entering the N11 from these accesses, the junctions will be stop controlled, with traffic turning into the parallel service road and then merging onto the N11 mainline downstream of Herbert Road. The segregated service road is considered to be the 'Do-Minimum' option in respect of achieving operational safety and is considered necessary for the following reasons:
    - Junction sight distance (looking north) from the L152 Dargle Lane Junction and L1956 Herbert Road Junction is currently sub-standard due to their presence on the inside of a bend – refer to **Figure 59** below. The associated risks of this reduced visibility will be exacerbated if the hard shoulder is converted into a bus lane;
    - The segregated parallel service road can be used to control speeds through these junctions, which will reduce the risk associated with the sub-standard junction visibility; and
    - The segregated parallel service road will reduce the number of weaving movements, by effectively combining the L152 Dargle Lane Junction and L1956 Herbert Road Junction into one access off the N11 mainline as illustrated in **Figure 60**; and
- Closure of the private residential access to N11/M11, which at present, is precariously located along the Herbert Road merge lane without proper visibility or any refuge from high speed traffic – refer to **Figure 61** below. It is proposed that this property access to re-routed to an existing local access road to the east of the N11/M11, as illustrated in **Figure 62** below.



Figure 58 Existing segregated parallel service road (N4 near Celbridge)



Figure 59: Existing L1956 Herbert Road junction with restricted visibility



Figure 60: Proposed segregated parallel service road at L1956 Herbert Road junction



Figure 61: Existing residential access south of L1956 Herbert Road junction



Figure 62: Proposed relocation of residential access south of L1956 Herbert Road junction

It should be reiterated that the above proposals are considered to be the minimum measures necessary to convert the hard shoulder to a bus lane through this section of the scheme. Moreover, it is noted that the weaving lengths between Junction 6 and Junction 7 southbound would remain non-compliant with design standards and would therefore require agreement with TII.

Northbound Direction

In the northbound direction, the following elements are closely spaced between Junction 6 and Junction 7:

- Junction 7 northbound merge;
- R117 Enniskerry Road left-in left-out Junction;
- Direct access to Dublin Oak Academy; and
- Junction 6 northbound diverge.

Again, the presence of the intermediate R117 junction has the potential to create safety and operational issues for the bus lane, so the preference would be to close the junction. However, in keeping with the alternative of providing a practicable interim solution, the following alternative options are suggested:

- R117 Enniskerry Junction to be retained and operate as a stop-controlled junction. Vehicles access/egressing to and from the junction will enter the bus lane which would double-up as a merge and diverge auxiliary lane;
- Closure of the direct access from the Dublin Oak Academy is also proposed. It is understood that this access is rarely used in the existing situation, with the main access provided from the L1001 Kilcroney Lane local road.

An illustration of the proposed changes in the northbound and southbound directions is provided in **Figure 63**.



Figure 63: Junction 6 to Junction 7 – proposed works

Structures Assessment – Enniskerry Footbridge

Enniskerry Footbridge is a 3-span steel truss bridge supported on reinforced concrete bankseat abutments at its ends and reinforced concrete intermediate piers. The 3 spans are 21m, 62.6m and 21.3m totalling 104.9m. A combination of fixed and sliding bearings are used at support locations. The bridge passes over the N11 Mainline.

No vertical or horizontal clearance issues are expected as a result of the reconfigured mainline.

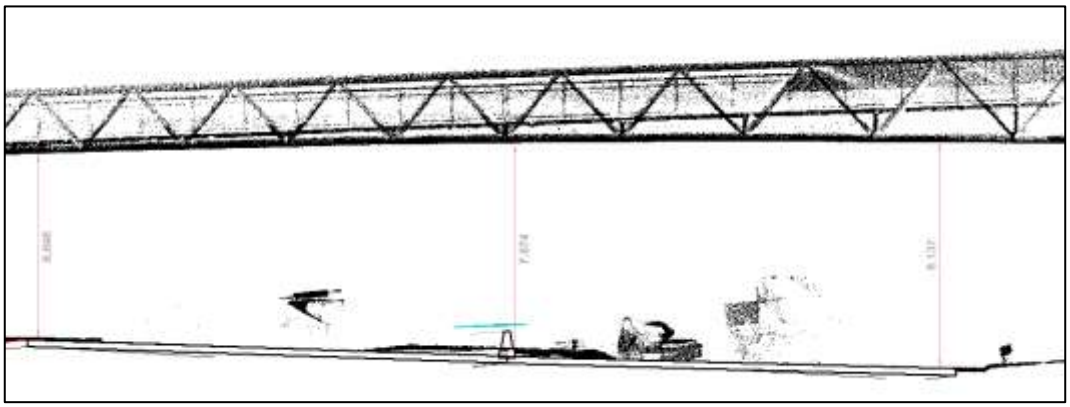


Figure 64: Section through Enniskerry Footbridge showing vertical clearances

6.4.8 Junction 7 Northbound Merge

The existing Junction 7 (Bray South) northbound merge has an auxiliary lane which extends to R117 Enniskerry Road due to the proximity of the downstream diverge. The merge/diverge area acts as a common weaving area for both movements, but at 290m in length, the weaving area between the Junction 7 merge and the R117 diverge is significantly sub-standard.

The present merge/diverge treatment is illustrated schematically in **Figure 65** below. Under this arrangement, merging traffic from Junction 7 can either proceed directly along the auxiliary lane to the exit for the R117, or can manoeuvre across a single lane to proceed northbound on the N11.

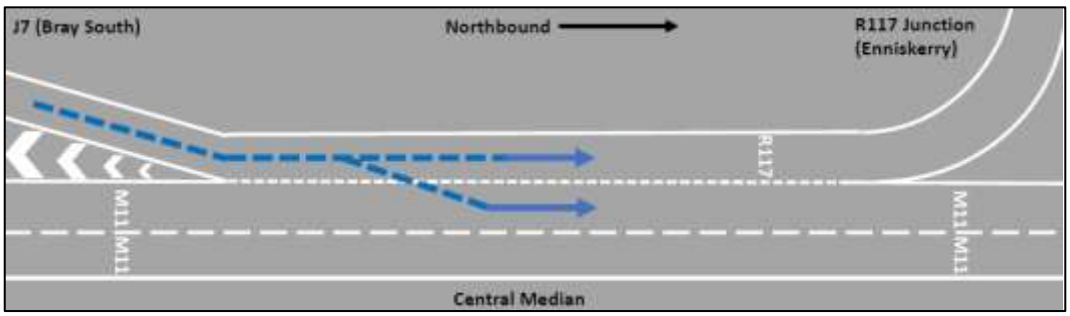


Figure 65: Existing Junction 7 – R117 layout (northbound)

As outlined in **Section 4.4.2**, the preferred merge treatment comprises of a parallel auxiliary merging lane to assist traffic merging from the slip road on to the bus lane, and subsequently an extended shared bus lane/merging lane to assist traffic to merge onto the nearside mainline lane. However, the presence of the auxiliary lane in the existing scenario creates an added complexity when seeking to apply the preferred merge treatment.

With the addition of the bus lane, one option is to widen on the western side of the existing carriageway to cater for a parallel merge from the slip road into the bus lane. Merging traffic then has the opportunity to merge into the nearside lane as a standard parallel merge. At the R117 Enniskerry Road junction, diverging traffic must enter the bus lane prior to undertaking their turn movement into the junction. This possible arrangement is illustrated schematically in **Figure 66**.

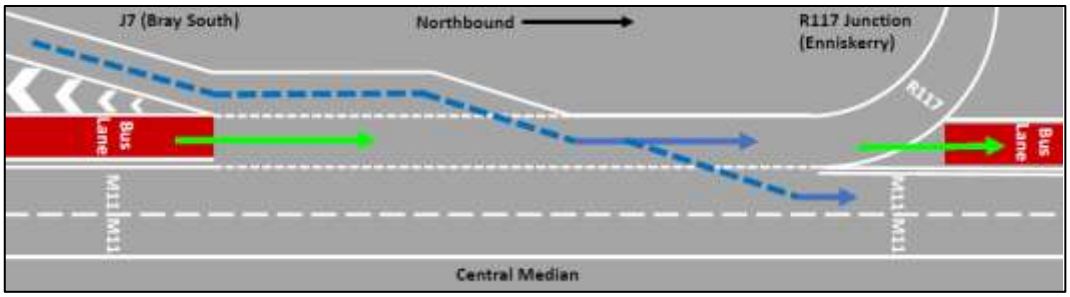


Figure 66: Proposed Junction 7 – R117 layout (northbound) with bus lane

This design option would cater for the following;

- 180m auxiliary lane length - This arrangement provides the opportunity for slip road traffic to find a gap and have a smooth transition into the bus lane / hard shoulder relative to the direct taper. Subsequently, slip road traffic can use the bus lane / hard shoulder to undertake a parallel merge on to the nearside mainline lane. This achieves the requirements for a Type 1 Dual Carriageway with a design speed of 100 km/h as outlined in TII standard DN-GEO-03060.
- 90m nose length – This is greater than the requirements of a Type 1 Dual Carriageway with a design speed of 100 km/h as outlined in TII standard DN-GEO-03060.

While this design arrangement would adopt the preferred parallel auxiliary lane treatment, the short weaving length of 310m between the successive merge and diverge is likely to create a number of operational difficulties, which may lead to a potentially unsafe outcome. These operational issues can be summarised as follows:

- In the current scenario (**Figure 65**), a vehicle merging from the Junction 7 slip road and wishing to continue northbound on the N11 must manoeuvre across one lane only. In the proposed scenario (**Figure 66**), the same vehicle would need to make two manoeuvres within a very short weaving area.
- Due to the short weaving area and close proximity to the R117 Enniskerry Road Junction, the runout length from the end of the parallel merge to the end of the diverge area to Enniskerry Road is reduced to 85m.

The provision of the parallel merge may, in effect, exacerbate the weaving problem as merging traffic may make full use of the auxiliary lane before merging, thereby leaving very little weaving room before the R117 diverge.

In light of the problems above, an alternative option may be to adopt the direct taper merge into the bus lane from Junction 7. This option could be investigated in future design stages to mitigate this issue. A direct taper merge would result in pulling the end of taper further south and effectively increasing the weaving area.

6.4.9 Pedestrian and Cyclist Facilities

There is currently no additional provision for pedestrians and cyclists on Section 4 of the N11 / M11 between Junction 6 and Junction 7. It is expected that any pedestrians and cyclists currently utilising the national road are low in volume. They would need to be using the existing hard shoulder of the busy dual carriageway which presents many inherent safety issues.

The hard shoulder doubles up as merge / diverge space in some areas, leaving no defined position on the road for cyclists and pedestrians. As outlined in **Section 6.4.7**, there are also a multitude of accesses within this section and several potential conflict zones. The bus lane is proposed within the hard shoulder, and some physical segregation in the form of a raised concrete median is proposed through Dargle Lane and Herbert Road. The provision of the bus lane within the hard shoulder is expected to exacerbate the existing safety issues for pedestrians / cyclists.

Considering the above, it is recommended that cyclists and pedestrians are encouraged to seek alternative routes, which cater specifically for pedestrian and cyclists requirements.

The Wicklow County Council Development Plan 2016-2022 (Bray Municipal District Local Area Plan (2018)) identifies a number of planned green routes and footway / cycleway improvements which could provide safe offline amenity for pedestrians and cyclists. **Figure 67** illustrates potential connectivity between Junction 6 and Junction 7 utilising the planned upgrades. Further information is required on the current status and delivery timings for the proposed upgrades.

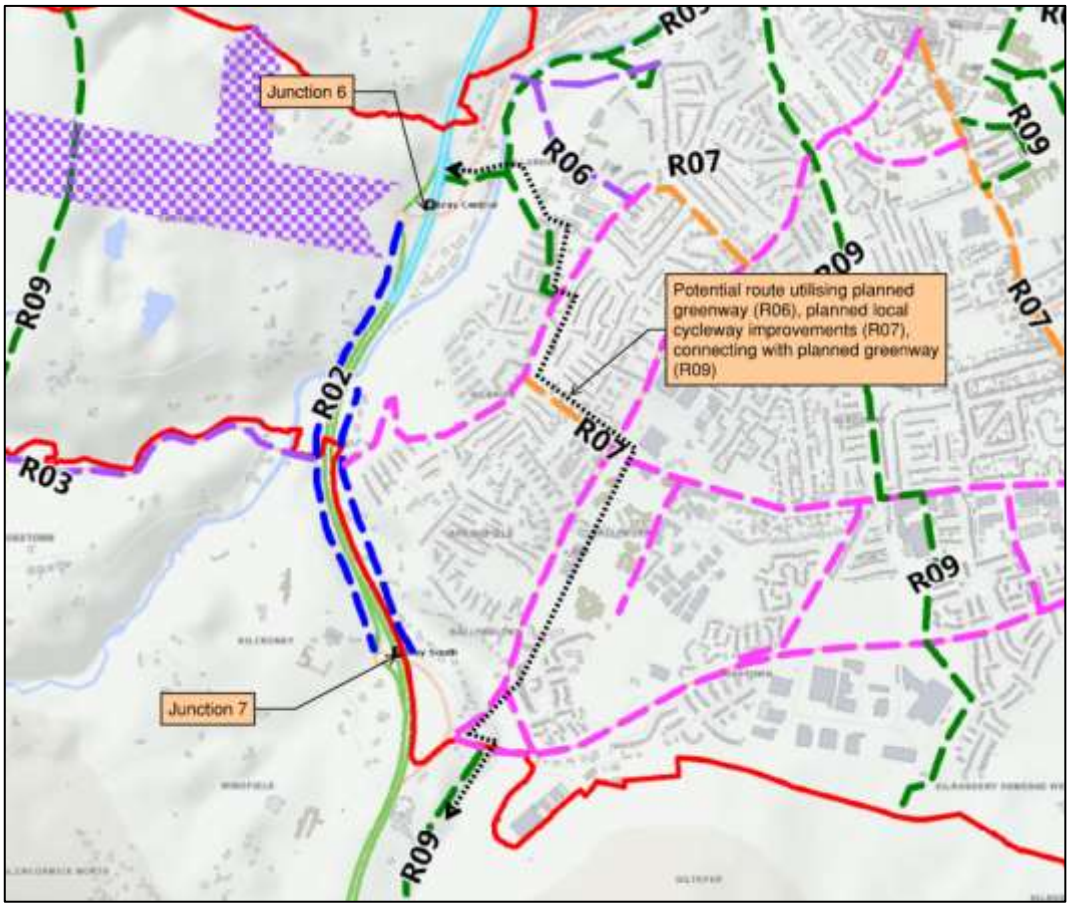


Figure 67: Section 4 Pedestrian and Cyclist Facilities based on planned upgrades by WCC

A summary of the engineering feasibility assessment for Section 4 of the scheme is presented in **Section 6.4.10**.

6.4.10 Section 4 Summary

Table 10: Summary of engineering feasibility assessment in Section 4 – Junction 6 (Bray/Fassaroe) to Junction 7 (Bray South)

Summary	N11/M11 Mainline Cross Section	J6 SB Merge / J6 Overbridge	J6 NB Diverge	Saint Valery Bridge	Local road and Property Accesses b/w J6 and J7	Junction 7 NB merge
Degree of Widening Required to Provide Bus Lane Cross Section	Widening required along full length. Widening required in median and verge.	Short section of widening on slip road to provide TJR layout at merge	Extensive nearside widening to accommodate TJR fork diverge. Localised realignment of slip road.	Extensive widening – nearside and offside of existing bridge	Medium widening on both sides - mainline and access approaches	Short section of widening on slip road to provide TJR layout at merge
Geometric Design Departures	No new departures likely to be required on mainline (TBC during detailed design).	Bus lane separation reduced to 0m under J6 overbridge.	No new departures likely to be required on mainline (TBC during detailed design).	Departures – SSD for SB nearside bus lane, SSD for NB offside (SSD is less than existing)	Departures required for weaving lengths and Junction SSD	No new departures likely to be required on mainline (TBC during detailed design).
Impacts to structures	Impacts to overbridges discussed separately – impact to minor structures (gantries etc.) to be assessed at detailed design.	No impact envisaged (TBC in future design stages)	No impact envisaged (TBC in future design stages)	High impact – strengthening works required to retrofit new compliant parapets	N/A	N/A
Safety / Operational Issues	N/A	Merging traffic may impede bus priority without ramp metering.	Diverging traffic may impede bus priority if queuing extends to nose area.	Some reduction in sight distance relative to existing Improved barrier and containment system on bridge	Weaving issues if intermediate accesses retained. Significant likelihood that bus priority will be impeded by weaving traffic at accesses.	Merging traffic may impede bus priority without ramp metering.
Continuous Bus Priority	Not achieved on mainline – bus lane doubles us as auxiliary lane(s)	Achieved	Achieved	Achieved	Not achieved on mainline – bus lane doubles us as auxiliary lane(s)	Achieved
Pedestrian & Cyclist Movement	An offline facility is recommended due to several existing deficiencies which are likely to be exacerbated by provision of the bus lane. There are a number of planned footway / cyclist improvements within Bray as outlined in the WCC Development Plan 2016-2022 (Bray Municipal District Local Area Plan (2018)) which could be utilised to provide this connectivity. Further information is required on the current status of these planned upgrades.					

Summary	N11/M11 Mainline Cross Section	J6 SB Merge / J6 Overbridge	J6 NB Diverge	Saint Valery Bridge	Local road and Property Accesses b/w J6 and J7	Junction 7 NB merge
Additional works	Drainage, Pavement, Utilities etc. (to be determined at Option Selection Stage) Existing Gas transmission main in N11 median between J6-J7 may need to be relocated.	Slip road needs to be reconfigured 38kV Underground Electrical potentially impacted (exact location and depth TBC)	38kV Underground Electrical potentially impacted (exact location and depth TBC)	Gas transmission main underneath NB bridge likely to require relocation	Drainage, Pavement, Utilities etc. (to be determined at Option Selection Stage)	Retaining wall on western side may require reconstruction. Water main potentially impacted (location and depth TBC)
Constraint Level	**Level 3**	**Level 2**	**Level 2**	**Level 3**	**Level 3**	**Level 3**

6.5 Section 5 – Junction 7 (Bray South) to Junction 8 (Kilmacanoge)

6.5.1 Overview / Key Findings

- Widening of the existing N11 carriageway is required along the entire section to accommodate the bus lane;
- Not feasible to provide exclusive bus priority in the southbound direction due to short weaving length between Junction 7 (Bray South) and Kilmacanoge Parallel Service Road;
- In the northbound direction, very limited exclusive bus priority is achieved between the existing merge north of Avoca/Glencormack and Junction 7 (Bray South) diverge;
- Not feasible to provide exclusive bus priority through Kilmacanoge due to existing space constraints;
- Realignment of Junction 7 (Bray South) southbound diverge required.
- Departure required for sub-standard southbound merge layout at Junction 7 (Bray South); and
- Provision of pedestrian and cyclist facilities reliant on adjacent schemes.

6.5.2 Key Constraints

The N11 dual carriageway continues as a sub-standard alignment south of Junction 6 (Bray / Fassaroe). The mainline gradient in the vicinity of Junction 7 (Bray South) reaches almost 5%, exceeding the permitted maximum of 3% (or 4% with relaxation) for a Type 1 Dual Carriageway. This gradient departure coincides with a horizontal curve less than the desirable minimum radius of 720m for a design speed of 100 km/h.

South of Junction 7, further sub-standard horizontal curvature is present at Jameson's corner north of Kilmacanoge Village. In this vicinity, the southbound carriageway speed limit is reduced abruptly to 60 km/h due to the proliferation of direct commercial and residential accesses through the village. A speed limit reduction to 80km/h is in place along the adjacent northbound carriageway.

It should be noted a parallel service road for the southbound carriageway through Kilmacanoge Village is currently under construction.

The following key constraints have been identified within this section:

- Existing N11 cross section;
- Junction 7 southbound diverge / Junction 7 overbridge;
- Junction 7 southbound merge;
- Junction 7 northbound diverge;
- Kilmacanoge town centre / parallel service roads; and

- Pedestrian and cyclist movement.

6.5.3 Existing Road Cross Section

Between Junction 7 (Bray North) and Junction 8 (Kilmacanoge), widening of the mainline carriageway will be required along the full length to incorporate the bus lane cross section as outlined in **Section 4.2**. This widening will be split between widening into the existing central median only and widening beyond the nearside edge approximately as follows:

- In the northbound direction, widening will be confined to the central median along approximately 70% of the section (~1.01km);
- In the northbound direction, widening beyond the nearside edge of pavement will be required along approximately 30% of the section (~0.42km); and
- In the southbound direction, widening will be confined to the central median along approximately 100% of the section (~1.18km) with no widening beyond the outer nearside edge of pavement proposed. This is due to the inclusion of the Kilmacanoge Parallel Service Road into the bus lane scheme with no further widening proposed.

The approximate extent of areas requiring widening in both the central median and nearside verge are illustrated on the drawings included in **Appendix C**. Exact extents of widening will be subject to detailed design.

While the design has sought to limit widening into the central reserve as much as possible, widening beyond the nearside edge of pavement is required at merge and diverge locations to provide the required auxiliary lanes, tapers, nosing arrangements and fork diverge treatment. Widening outside the nearside edge of pavement is also required where central median widening would exacerbate visibility problems.

A typical cross section of the proposed N11 with bus lane within section 5 of the scheme is presented in **Figure 68** below.



Figure 68: Typical M11 cross section with bus lane between Junction 7 – Junction 8.

6.5.4 Junction 7 Southbound Diverge / Junction 7 Overbridge

The existing Junction 7 southbound diverge layout is not compliant with current TII standards. Similar to Junction 6, the nose does not develop under a flared arrangement as per Figure 7.6.1 of TII Standard DN-GEO-03060. Instead, a very short nose treatment is provided, followed by a tight radius curve on approach to the junction. The length of auxiliary lane (105m) and nose length (36m) are less than the required minimums.

Additionally, due to the thick vegetation on the eastern side of the mainline, the roundabout is largely unsighted on the diverge and contains a number of existing departures for visibility approaching a junction.

Given the complexity of the site, a number of options are considered as follows.

Option 1 - 'Do Minimum'

The 'Do Minimum' option involves reconfiguring the existing diverge such that a fork diverge treatment can be applied to allow for safe continuous bus priority to be implemented as an interim solution. This option does not seek to address any of the inherent safety issues associated with the existing geometry of the diverge slip road.

In order to cater for the bus lane within the hard shoulder, widening is proposed on the eastern side of the existing carriageway. This allows width to be built up between the bus lane and the nearside traffic lane such that a 'soft nose' is created in advance of the existing Junction 7 'hard nose'. This space allows for the fork diverge movement to occur in advance of the physical nose. An illustration of the proposed configuration is provided in **Figure 69.**

It should be noted that the above approach is seen as a 'Do Minimum' approach which achieves the objectives of providing continuous bus priority, and that can be implemented as an interim solution. This option does not seek to address any of the inherent safety issues associated with the diverge slip road. As such, the re-alignment of the slip road to the east would require slight modification and approval of the departures associated with the existing substandard slip road geometry.

Despite being a 'Do Minimum' option, substantial engineering works would be required, resulting in direct impacts to the existing vegetation on the eastern side of the existing carriageway. This would require substantial clearing and re-vegetation, and the environmental impacts of such a proposal are not known at this stage.

Option 2 - Diverge Slip Upgrade

The 'Diverge Slip Upgrade' option involves substantial reconfiguration of the diverge treatment and slip road in order to achieve safe continuous bus priority as well as address the existing safety issues with the diverge slip road.

The premise of this option involves re-aligning the diverge ramp horizontally and vertically to provide a direct connection to the eastern roundabout at Junction 7. It should be noted that no geometry or grading investigation has been undertaken on this option at this stage. A schematic of the potential alignment is illustrated in **Figure 70.**

This option would also result in substation clearing and re-vegetation to the east of the existing alignment relative to Option 1, and the environmental impacts of such a proposal are not known at this stage.

Due to the extent of works involved, this option may be mis-aligned with the project objectives of implementing a bus lane on the N11/M11 as an interim solution on the scheme. Additionally, any such major upgrade to a diverge ramp would need to be closely coordinated with any proposed junction modifications for the main *N11/M11 Scheme*. There is a risk that the broader *N11/M11 Scheme* may recommend an option which would render interim works redundant.

Option 3 - 'Do Nothing

The 'Do Nothing' option involves terminating the bus lane in the southbound direction in advance of the existing Junction 7 southbound diverge and recommencing it on approach to Kilmacanoge Town Centre. This option would however compromise bus priority completely within this section.

Further analysis and investigation of the options is required at the Option Selection phase to determine the optimum layout.

This would broadly involve:

- Microsimulation modelling of the bus lane in peak periods;
- Environmental impact assessment of options;
- Further geometric modelling of Option 1 and Option 2; and

- Further development of the preferred option for reconfiguring Junction 7 under the main *N11/M11 Scheme*.

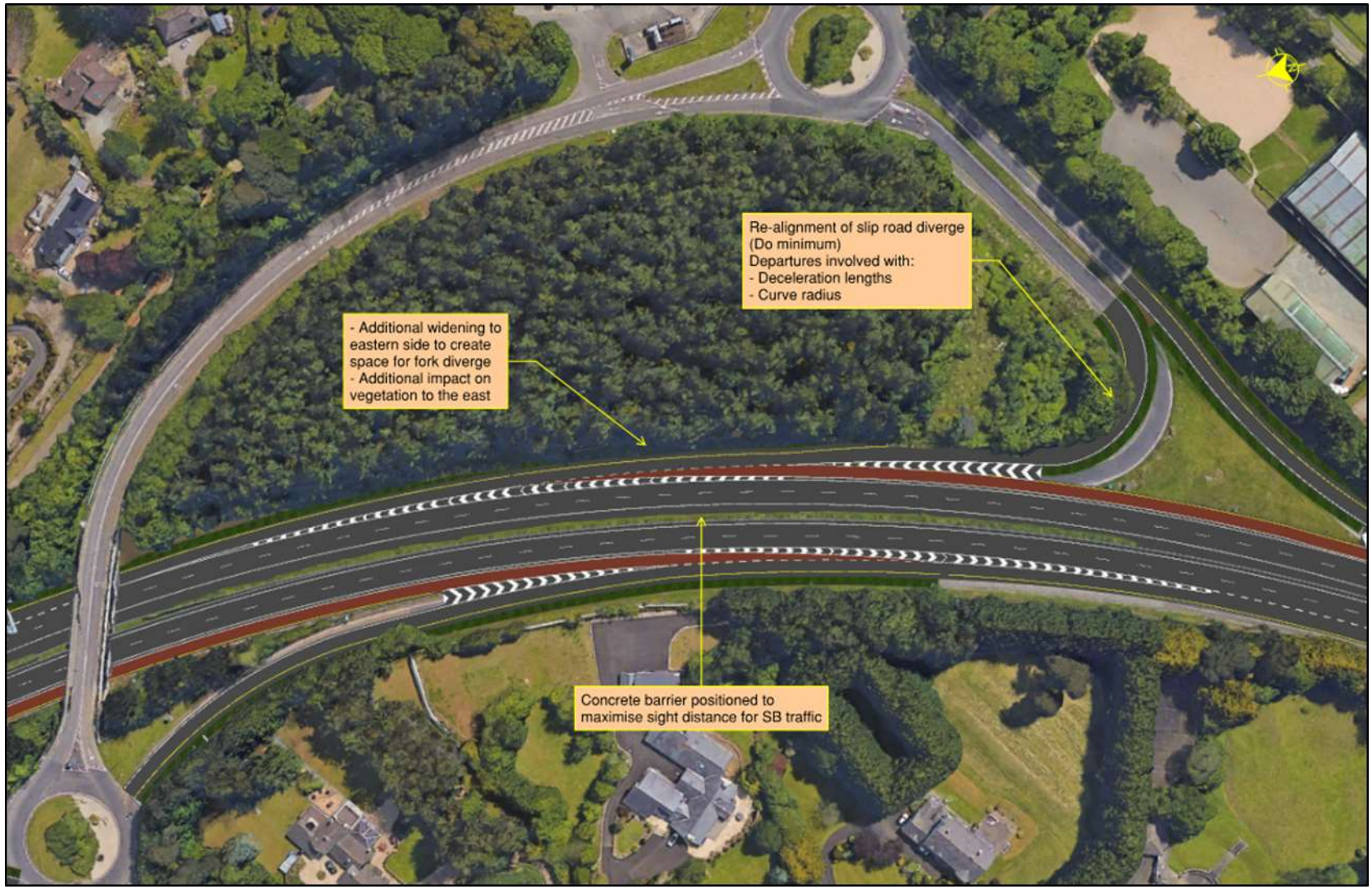


Figure 69: Junction 7 southbound diverge – Option 1 proposed work

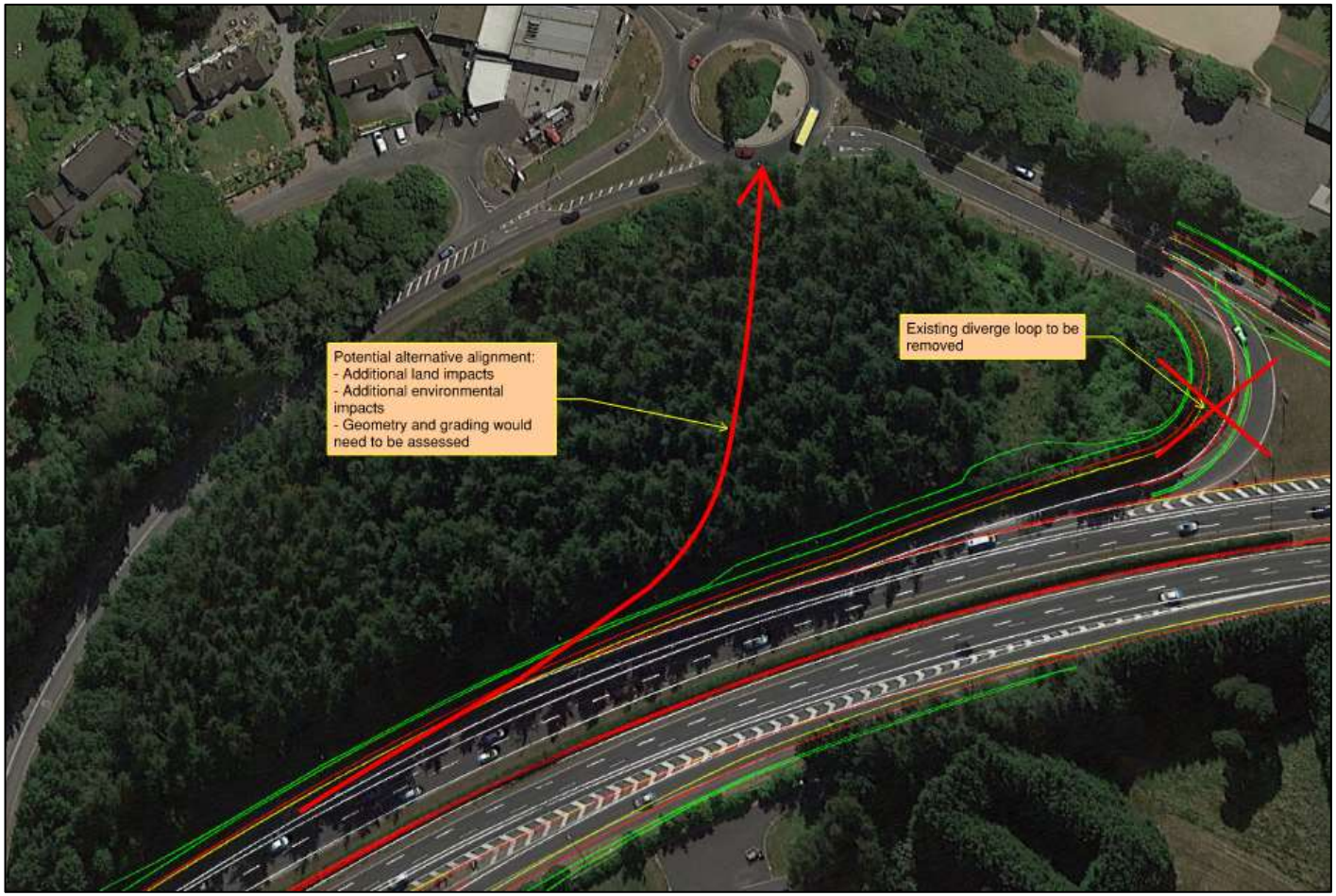


Figure 70: Junction 7 southbound diverge – Option 2 proposed works

Geometry - Junction 7 Overbridge

Under all of the above options, the Junction 7 overbridge creates a constraint for SSD in the southbound direction of travel. The geometry is on a right-hand curve over the length of the underbridge. This creates a constraint for SSD in the southbound offside lane. Additionally, the new concrete barrier creates a higher obstruction for visibility in the offside lane.

As a result, the required SSD of 215m for a design speed of 100 km/h is not achieved. The design achieves SSD of 172m for the high object and 160m for the low object. A departure would be required for SSD to the high object, while a relaxation to one step below desirable minimum would be required for SSD to the low object.

Structure Assessment

Junction 7 Overbridge (also called Wingfield Interchange Bridge) is a 2-span beam and slab bridge that carries the R768 over the N11 mainline. The bridge has spans of 26.63m and 26.56m giving a total span length of 53.19m. The bridge is semi-integral; 5 prestressed concrete girders are supported on bearings at abutment locations while there is an integral connection between the deck and the intermediate pier.

The existing headroom clearance beneath this bridge was assessed to be close to the minimum required (5.03m for any adjustments to an existing carriageway). Hence, any proposed adjustment to the vertical alignment in this location will need to be reviewed during further design stages.

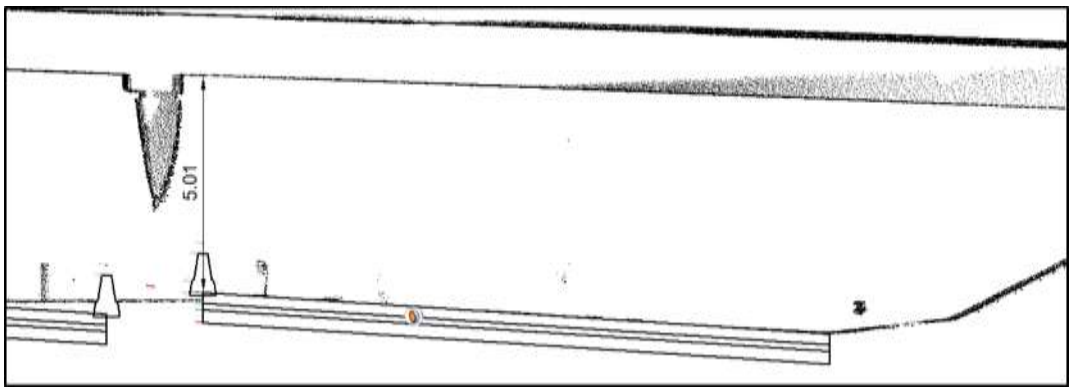


Figure 71: Headroom Clearance Northbound Carriageway

The proposed southbound lane creates a cutting which would reduce the depth of ground cover above the pile cap at the eastern abutment from 800mm currently to 500mm. The revised lane configuration would allow for vehicle axle loads to be placed above the foundation pile cap and as a result, the pile cap's structural capacity would require assessment prior to any upgrade works. The proposed cross section and pavement design at this location requires further investigation in future stages.

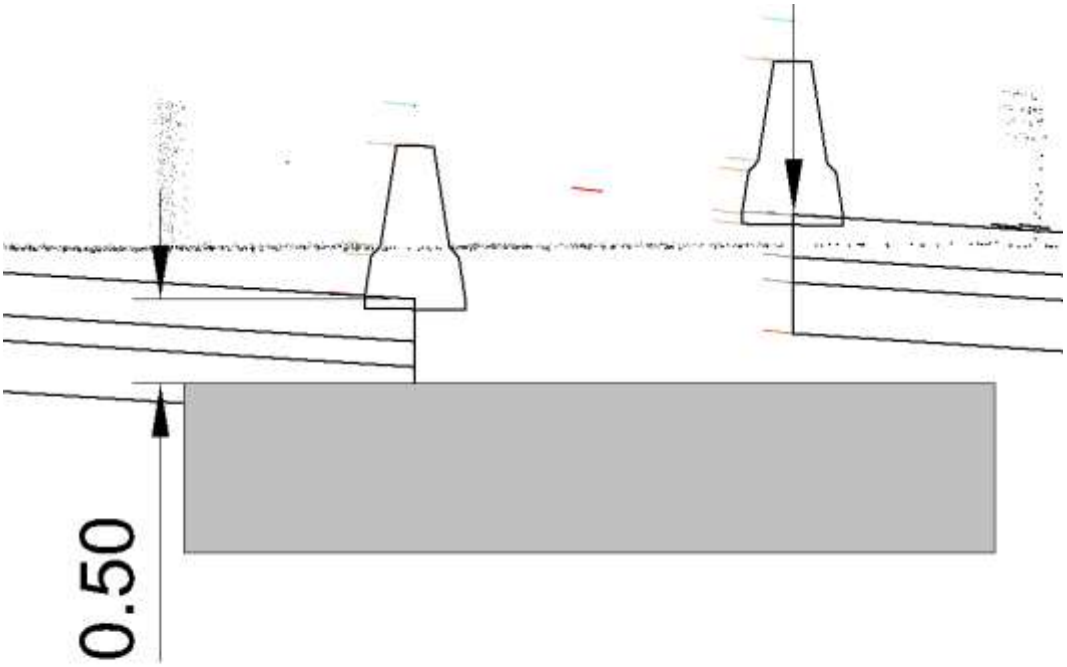


Figure 72: Section showing reduced cover to intermediate pier footing / pile cap

Potential Impacts at Ballywaltrim Lane

As noted in the discussion on geometry above, the existing Junction 7 overbridge is a constraint to achieving adequate forward visibility in the southbound direction of travel. This is due to the location of the structure on a tight right-hand curve of approximately 600m radius (one step below desirable minimum). In the existing scenario, SSD for traffic in the offside lane is already obstructed by the median pier and central reserve vegetation and would constitute a departure against current standard requirements. Consequently, further widening into the median to provide space for the bus lane would worsen forward visibility, as the offside traffic lane (i.e. lane 2) would shift closer to the median pier. The problem is illustrated in **Figure 73** below.

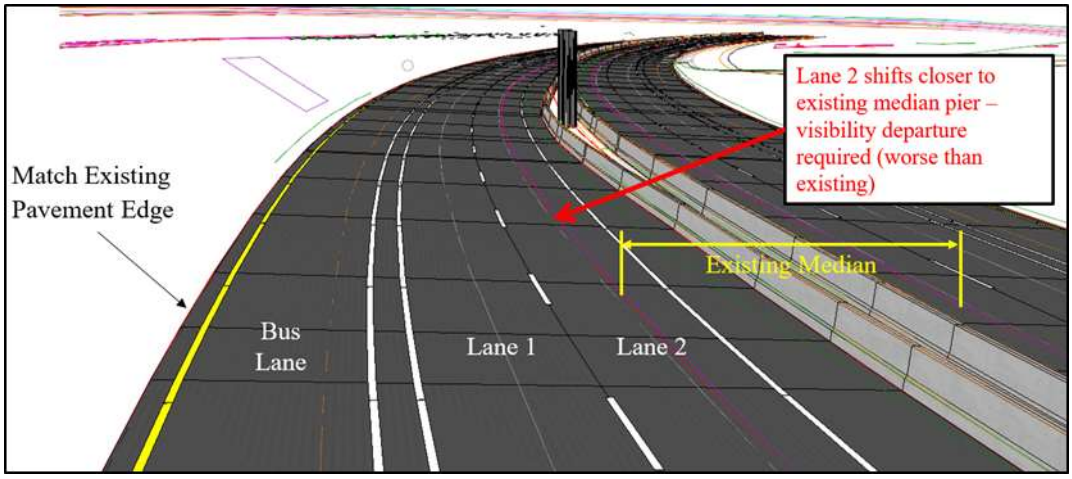


Figure 73: Visibility impact of widening into median – N11 at Junction 7 (southbound)

In order to ensure that the existing standard of visibility – which is already a departure – is not worsened, the combination of the tight horizontal curve and the obstructions to visibility within the median (pier, barrier), effectively prevents widening into the median in this area. As such, it is necessary to instead widen the N11 beyond the outer nearside edge of pavement to provide space for the bus lane. To maintain the existing standard of visibility in the median, widening of approximately 2.2m would be required at the nearside verge, as illustrated in **Figure 74** below.

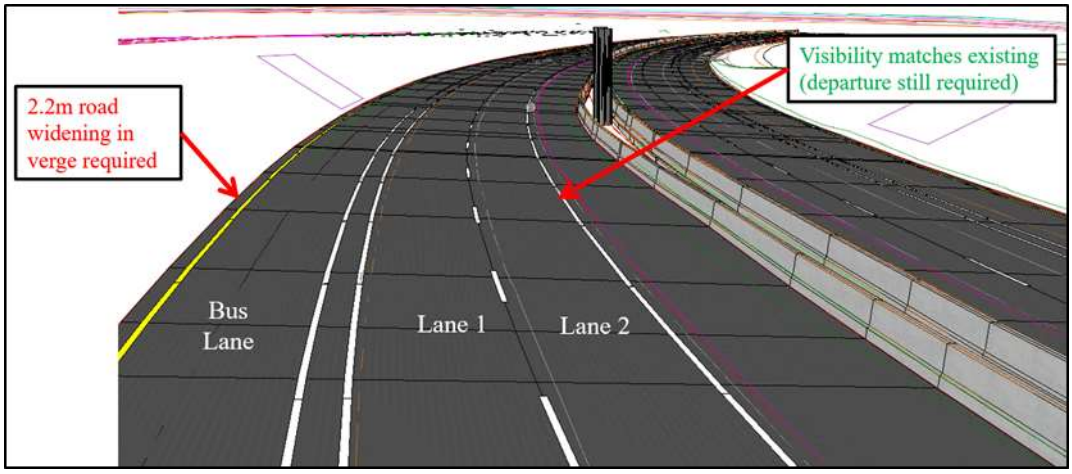


Figure 74: Widening into nearside verge to maintain existing visibility – N11 at Junction 7 (southbound)

A consequence of this nearside widening to cater for the bus lane is that the existing N11 embankment running along the eastern side of the route adjacent to Ballywaltrim Lane would be shifted further east. As illustrated in **Figure 75** below, a standard 1V:2H embankment slope would partially encroach onto the local road.

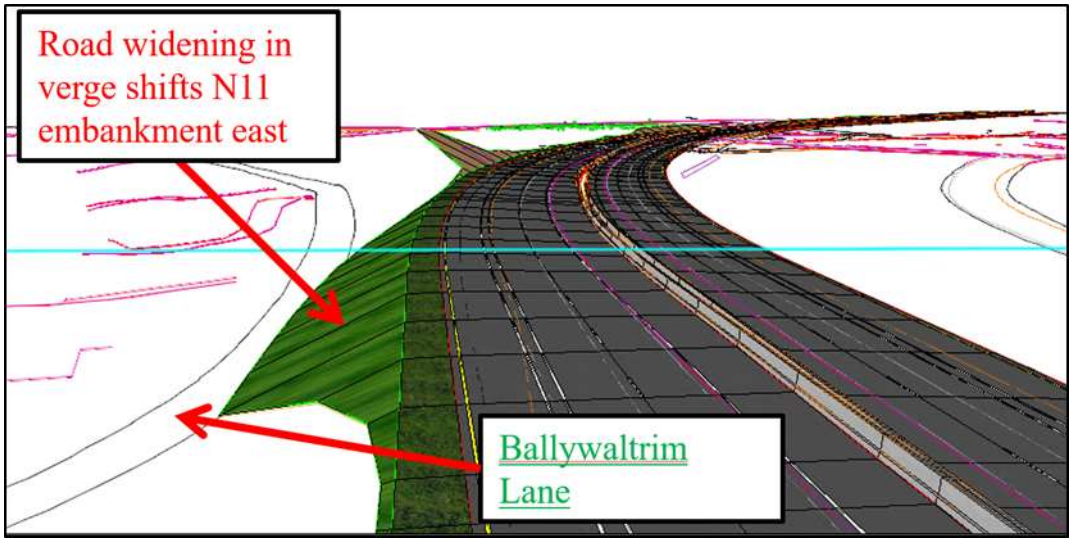


Figure 75: Verge widening resulting in encroachment onto Ballywaltrim Lane

To resolve this issue, it is likely that a steepened embankment slope or retaining structure would be required over a length of approximately 60m, as illustrated in **Figure 76** below. The exact details of any steepened slope or retaining wall treatment would need to be investigated in future design stages.

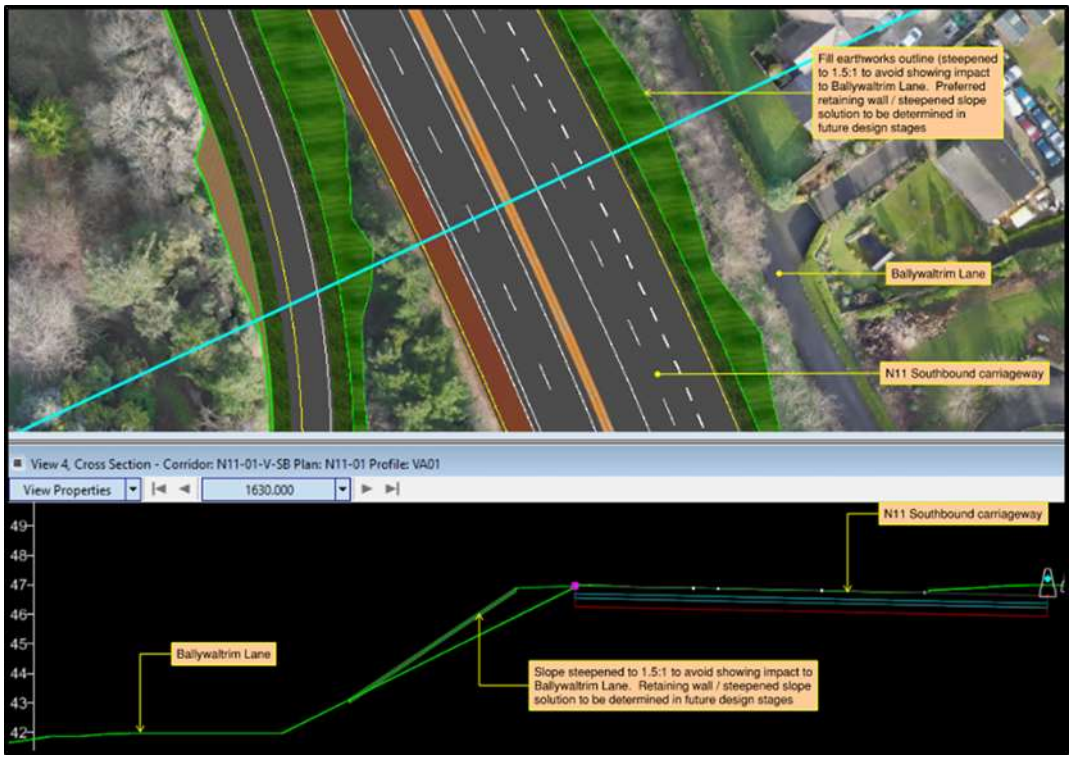


Figure 76: Impacts to Ballywaltrim Lane – N11 at Junction 7 (southbound)

6.5.5 Junction 7 Southbound Merge

The existing junction 7 southbound merge layout provides a parallel merge treatment with approximately 245m auxiliary lane length and 80m auxiliary taper length.

It should be noted however, that the approach angle is not compliant with current TII standards and this results in a short nose length of just 25m. The parallel merge extends adjacent to the Brennanstown Riding School buildings and boundary wall, which create a constraint for widening.

As outlined in **Section 4.4.2,** the preferred merge treatment is the parallel merge treatment. At this location, the geometry is constrained by the Brennanstown Riding School. Provision of a parallel lane merge would require partial acquisition and demolition of one of the buildings attached to the riding school. The planning and cost associated with this may render the interim bus lane not feasible.

In order to cater for the bus lane within the hard shoulder, and with the given constraints, widening is proposed on the eastern side of the existing carriageway to cater for a direct taper merge from the slip road into the bus lane. Subsequently, slip road traffic shares the bus lane and has an extended parallel merge to merge into the nearside lane of the mainline.

This design is illustrated in **Figure 77** and caters for the following:

- 75m taper merge length - As noted previously, a direct taper merge as a merge treatment for slip road traffic onto the mainline is not permitted under current standards. The taper merge in this scenario involves the slip road traffic merging onto the bus lane, which is only operating at peak times, under reduced speed environment and infrequent use. The taper merge length satisfies the requirements for an Urban 80 km/h Type 1 Dual Carriageway, and would require a departure from standard for a 100 km/h Type 1 dual carriageway.
- 40m nose length – this would require a departure from standard for a 100 km/h Type 1 dual carriageway. The proposed arrangement achieves the requirements for an Urban 80 km/h Type 1 Dual Carriageway.
- Separation width reduced to 0.5m adjacent to Brennanstown Riding School – While this is a reduction from the desirable cross section proposed in **Section 4.2,** it is consistent with the proposed separation width in the TII Standards and Literature Review and therefore considered to be appropriate in this constrained environment.

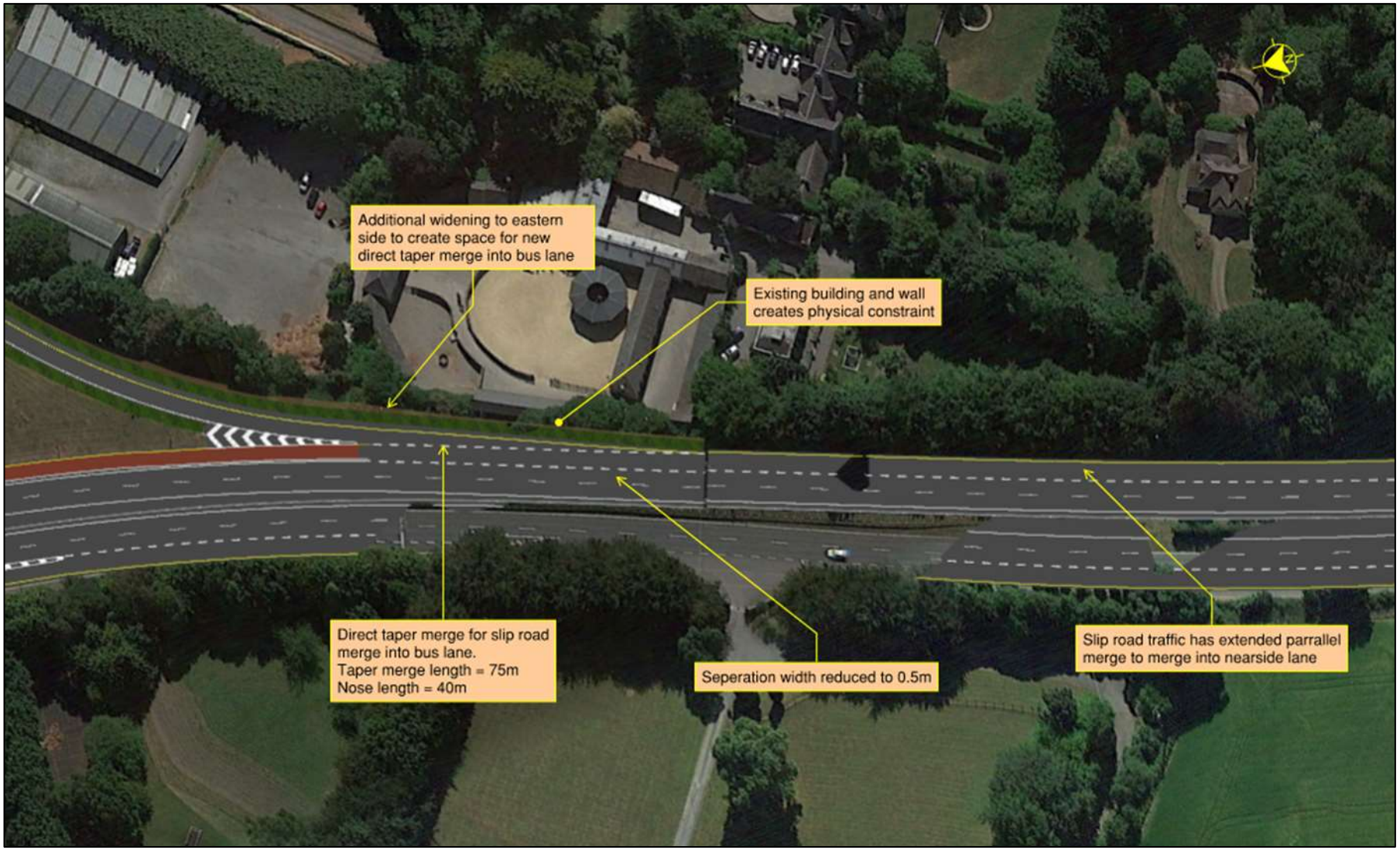


Figure 77: Junction 7 southbound merge – proposed works

6.5.6 Junction 7 Northbound Diverge

The existing Junction 7 northbound diverge layout provides a parallel diverge layout which is not in compliance with current TII standards. The auxiliary lane length (95m) and taper length (35m) are below the required minimums, while the nose length is a compliant 210m.

In order to cater for the bus lane within the hard shoulder, widening is proposed on the western side of the existing carriageway. This allows width to be built up between the bus lane and the nearside traffic lane such that a 'soft nose' is created in advance of the existing Junction 7 'hard nose'. This space allows for the fork diverge movement to occur in advance of the physical nose. An illustration of the proposed configuration is provided in **Figure 78.**

Due to the re-alignment of the slip road to the west, a retaining wall may be required on western side on approach to roundabout. This requires further investigation in future design stages.

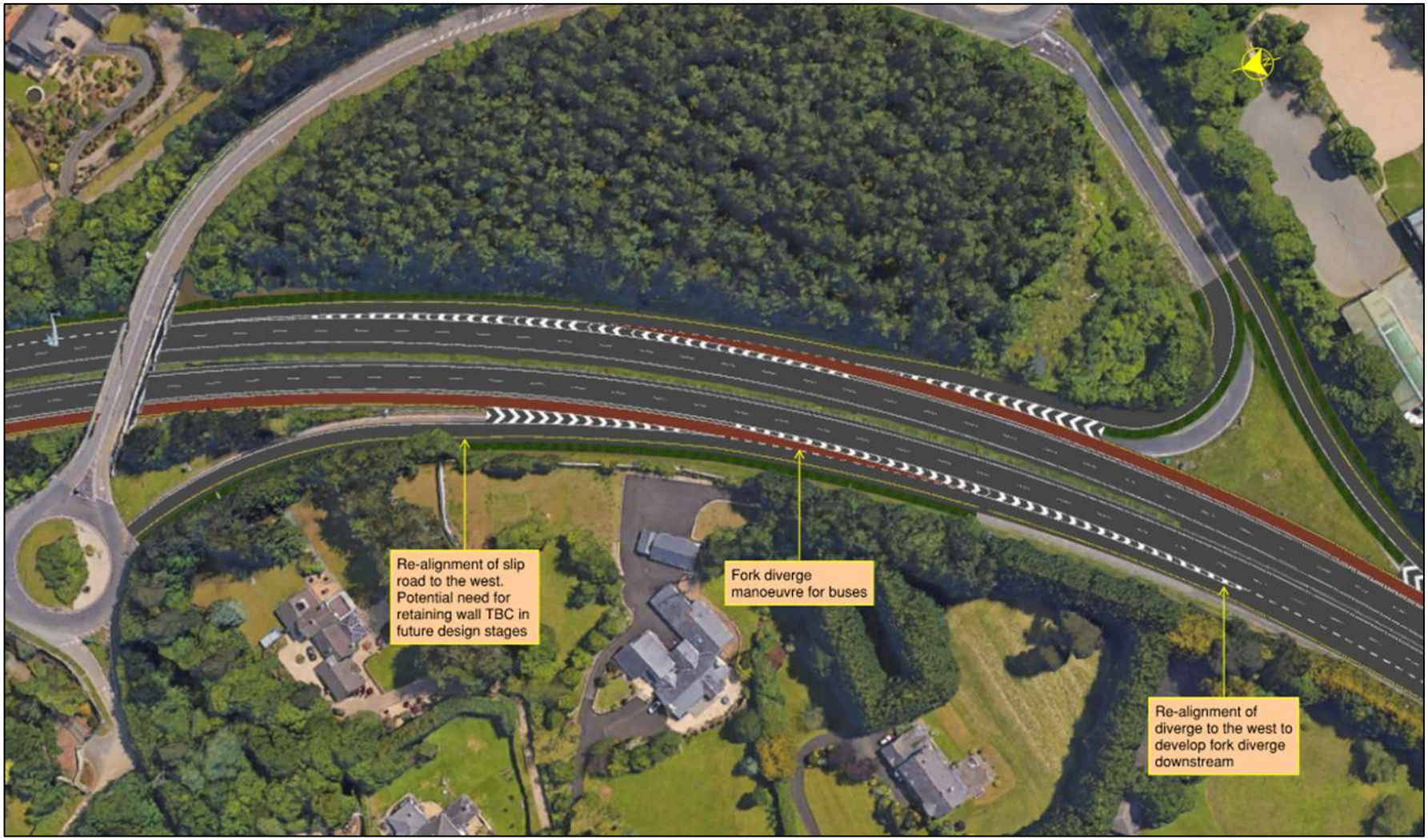


Figure 78: Junction 7 northbound diverge – proposed works

6.5.7 Kilmacanoge Town Centre / Parallel Service Roads

As noted previously, a parallel service road is currently under construction in the southbound direction of the N11. These works involve widening of the mainline to the south of Junction 7 and development of an auxiliary lane and segregated lane for left-in left-out access to/from the various properties. The segregation develops approximately 50m north of the Lavendar Nursery access. Separation is provided in the form of a 1250mm wide raised concrete island. It is proposed that the segregated lane is posted at a speed of 50 km/h, while the mainline N11 would retain a 100 km/h posted speed.

In the southbound direction, the construction of the parallel service road leaves no additional space for a separate dedicated bus lane. Accordingly, it is proposed that the interim bus lane would utilise the segregated lane along this section, continuing to the Kilmacanoge roundabout at the end of the diverge slip road and terminating at the end of the Junction 8 southbound diverge slip road. Alternatively, it may be preferable for bus traffic to join the mainline all-purpose lanes in advance of the Kilmacanoge parallel service road, thereby avoiding the need to take the diverge and navigate through the roundabout before re-joining the N11.

On the northbound carriageway, the short weaving distance of only ~60m between the existing Junction 8 merge and the subsequent diverge providing access to Avoca and the L1019 to Glencormack prevents the implementation of a dedicated bus lane in this section. This is due to the following reasons:

- If the bus lane were to commence to the south of Junction 8, it would not be feasible to provide the TJR arrangement through the junction given the existing space restrictions;
- The alternative may be for the bus to diverge at Junction 8 and then merge again, but this would require the bus to navigate through the mini roundabout to the west of the N11 and the busy petrol station access area, which is considered undesirable; and
- If the bus lane commences to the north of the Junction 8 merge, it would result in conflicts with merging traffic and diverging traffic to Avoca / Glencormack within an already sub-standard weaving area.

For these reasons, the most appropriate solution from a safety and operational perspective is to commence the northbound bus lane at a point beyond the existing merge from Avoca / Glencormack. This means that dedicated bus priority would not be provided through Kilmacanoge village.

The proposal for Kilmacanoge town centre is illustrated in **Figure 79** below.



Figure 79: Kilmacanoge Town Centre / Parallel Service Road – Proposed Works

6.5.8 Pedestrian and Cyclist Movement

There is currently no additional provision for pedestrians and cyclists on Section 5 of the N11 / M11 between Junction 7 and Junction 8. It is expected that any pedestrians and cyclists currently utilising the national road are low in volume. They would need to be using the existing hard shoulder of the busy dual carriageway which presents many inherent safety issues.

The hard shoulder doubles up as merge / diverge space in some areas, leaving no defined position on the road for cyclists and pedestrians. Conversion of the existing hard shoulder to a bus lane is expected to exacerbate the existing issues. Considering the above, it is recommended that an offline facility which caters specifically for pedestrian and cyclists is the appropriate measure within this section.

It should be noted that The Wicklow County Council Development Plan 2016-2022 (Bray Municipal District Local Area Plan (2018)) identifies a greenway link from Kilmacanoge to Bray Retail Park on Southern Cross Road. This facility would provide a safe connection for pedestrians and cyclists with high amenity value between Junction 7 and Junction 8 as illustrated in **Figure 80**. Confirmation is required on the current status and delivery plan for this greenway connection.

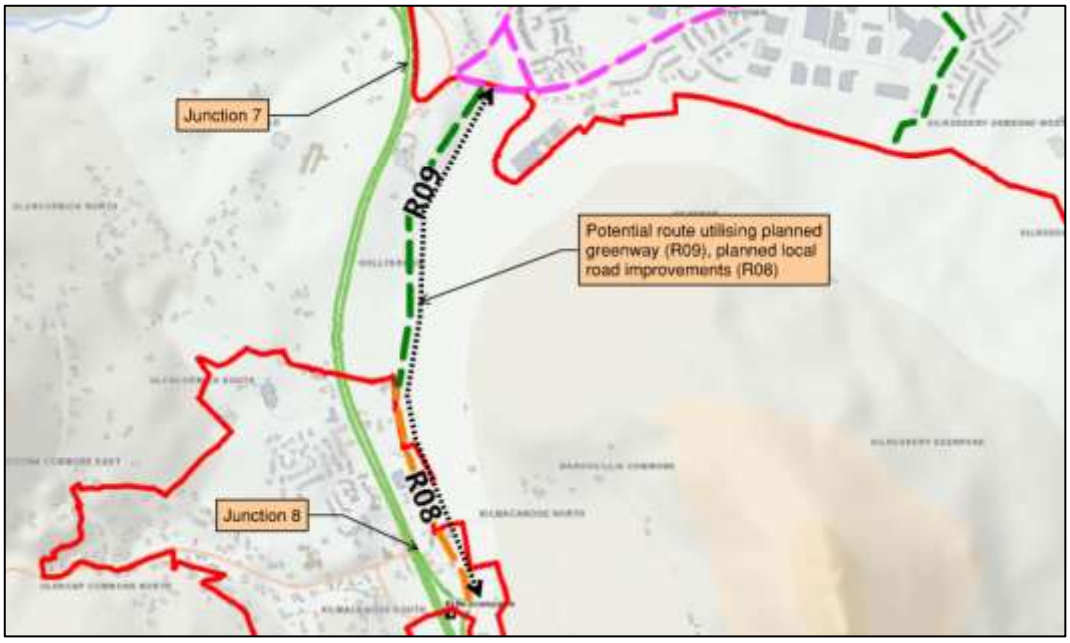


Figure 80: Section 5 Pedestrian and Cyclist Facilities based on planned upgrades by WCC

A summary of the engineering feasibility assessment for Section 5 of the scheme is presented in **Section 6.5.9**.

6.5.9 Section 5 Summary

Table 11: Summary of Section 5 – Junction 7 (Bray South) to Junction 8 (Kilmacanoge).

Summary	N11/M11 Mainline Cross Section	J7 SB Diverge / J7 Overbridge	Junction 7 SB Merge	Junction 7 NB Diverge	Kilmacanoge Town Centre
Degree of Widening Required to Provide Bus Lane Cross Section	Widening required along full length. Widening required in median and verge.	Extensive nearside widening to accommodate TJR fork diverge. Localised realignment of slip road.	Short section of widening on slip road to provide TJR layout at merge	Extensive nearside widening to accommodate TJR fork diverge. Localised realignment of slip road.	No widening proposed beyond that included in Kilmacanoge Parallel Service Road Scheme
Geometric Design Departures	No new departures likely to be required on mainline (TBC during detailed design).	Departure - offside SSD to high object requires (No worse than existing) Departures - Substandard existing slip road geometry is not resolved; new departures would be required for adjustments to existing issues	Departures - Substandard existing slip road geometry is not resolved; new departures would be required for adjustments to existing issues Departure for taper merge from slip road into bus lane	No new departures likely to be required on mainline (TBC during detailed design).	No new departures likely to be required on mainline (TBC during detailed design).
Impacts to structures	No impacts envisaged.	Proposed cross section at J7 overbridge and potential impact to pile cap to be further investigated	N/A	N/A	N/A
Safety / Operational Issues	N/A	Issues with identified departures and existing substandard geometry Diverging traffic may impede bus priority if queuing extends to nose area.	Safety issues for southbound merge traffic due to existing departures. Merging traffic may impede bus priority without ramp metering.	Diverging traffic may impede bus priority if queuing extends to nose area.	No change to existing issues.
Continuous Bus Priority	Not achieved on mainline – bus lane doubles up as auxiliary lane(s) / parallel service road	Achieved	Achieved	Achieved	Not achieved on mainline – bus lane doubles up as auxiliary lane(s) / parallel service road
Pedestrian and Cyclist Facilities	An offline facility is recommended. The planned greenway between Kilmacanoge town centre and Bray Retail park as outlined in the Bray Municipal District Local Area Plan (2018) would provide the connectivity and high pedestrian and cyclist amenity required for this section.				

Summary	N11/M11 Mainline Cross Section	J7 SB Diverge / J7 Overbridge	Junction 7 SB Merge	Junction 7 NB Diverge	Kilmacanoge Town Centre
Additional works	Drainage, Pavement, Utilities etc. (to be determined at Option Selection Stage)	Slip road needs re-alignment Extensive clearing of vegetation Environmental impacts not known	Slip road needs to be re-alignment Potential impact to signage gantry Sewer main crossing (exact location and depth TBC)	Slip road needs to be reconfigured Retaining wall may be required on western side of slip road on approach to roundabout	Existing median islands to be reconstructed New concrete islands to be constructed Multiple utilities (exact depths and locations TBC): - Gas transmission main - Water main - Sewer main - Communications
Constraint Level	**Level 3**	**Level 3**	**Level 3**	**Level 3**	**Level 3**

6.6 Pavement

The introduction of a dedicated hard shoulder bus lane onto the N11/M11 is, from a pavement perspective, technically feasible. The technical solution may however vary in complexity depending on the following design parameters:

- Changes in overall carriageway geometry;
- Subgrade condition;
- Traffic loads;
- Existing pavement construction build up; and
- Existing pavement condition.

6.6.1 Changes in overall carriageway geometry

It is not expected for the vertical level of the existing pavement assets to be significantly changed, but if that was to change in the future, the following should be considered.

In the case where the road level is to be raised, the positive impact is that the existing pavement will be thickened which in most cases would lead to a life extension of the existing pavement asset. A raised pavement may however negatively impact other assets:

- Drainage paths may be disturbed;
- Vehicle Restraint Systems (VRS) may need to be raised;
- The clearance below structures such as bridges, gantries or overhead lines will be reduced; and
- Ironwork will need to be raised also.

In the case where the road level is to be lowered, the existing pavement will need to be assessed for rehabilitation as its traffic bearing capacity will be impacted by the reduction in build-up thickness. Lowering of the road level may similarly disturb drainage paths, VRS systems may need to be realigned and ironworks lowered. Another point to note is that in most instances, it might not be possible to lower the level of the pavement in proximity to sub-pavement structures, such as pier/gantry bases and culverts.

Where the carriageway lanes are proposed to be realigned, the pavement will be impacted differently by the relocation of traffic paths. Areas of pavement that were up to now not heavily trafficked, i.e. outside the wheel tracks, will now be exposed to higher stresses and strains. Pavement materials age differently depending on their location across the carriageway. The relocation of traffic paths may in some rare instances lead to accelerated deterioration of the pavement. The location of existing longitudinal joints in all layers of the existing pavement shall not end within the wheel tracks of the realigned traffic.

If such a situation cannot be avoided, the upper layers of the pavement may need to be renewed and a geotextile inserted at the vertical of the longitudinal joints to delay any reflective cracking.

No carriageway narrowing is expected along the route under consideration. The only impact of such change should only be limited to the relocation of carriageway edge assets. Where the carriageway is proposed to be widened, the existing adjacent carriageway's foundation and pavement shall be assessed to determine material types and condition, thicknesses of each layer and the condition of the interlayer bond. This is key to developing a widening design ensuring drainage continuity and structural consistency across the overall carriageway.

6.6.2 Subgrade condition

No information was available in terms of subgrade condition (CBR values) for the areas of carriageway to be widened. Such data will be essential to design the foundation of the widened sections of road and ensure drainage path continuity between the existing and new pavement structures.

Traffic Loads

No forecasted traffic data was provided for the feasibility study. For bus only lanes, bus traffic data and the Client's expected pavement design life are required, for the design of the upper pavement (above foundation) in widened areas and for the design of areas to be rehabilitated.

For all other lanes, general traffic data and the Client's expected pavement design life are required, for the design of the upper pavement (above foundation) in widened areas and for the design of areas to be rehabilitated. Traffic data can be sourced from the TII Traffic Data Site website and traffic design parameters from PE-PAG-02017 if not provided by the Client, TII or GJ Maintenance Ltd (MMaRC owner).

Existing pavement build up

The northern 3km part of the route is expected to be a fully flexible pavement with about 350mm[4] of bituminous upper pavement. This is likely to be a "long life" (>80msa) pavement. The accommodation of the bus lane should be relatively straightforward on that part. This is assuming that the structural condition of the existing pavement is good.

The following 3km part of the route is expected to be a fully flexible pavement with about 290mm of bituminous upper pavement. This is likely to have been designed for a 25msa Traffic Design with a 40-year design life. The accommodation of the bus lane should be relatively straightforward on that part as well unless the life of the existing pavement is to be extended. This is assuming that the structural condition of the existing pavement is good.

[4] The approximate bituminous upper pavement thicknesses provided in this paragraph have been sourced from the "TII PAMS – Cway_Width_Depths_2019" shapefile.

The southern and last 3km of the route are also expected to be a fully flexible pavement but with this time only between 120 and 200mm of bituminous upper pavement before tying into what seems to be another “long life” pavement.

It is likely to be a legacy pavement not designed with the current TII standards. The accommodation of the bus lane will be more complex as the minimum depth of bituminous material for the widened areas would need to be a minimum of 200mm bituminous materials.

Construction data in the form of construction records (as-built records), GPR data and/or cores shall be requested from the Client, TII or GJ Maintenance Ltd (MMaRC owner) to confirm the above and obtain more details on each layer material type, thickness and condition. The pavement build-up of the hard shoulder shall be confirmed even though it is expected to be the same as in all other lanes. Finally, the pavement build-up of all slip roads shall be confirmed as they may be different from the mainline ones.

Existing pavement condition

In the northern 6km part of the route, the introduction of a bus lane is unlikely to adversely affect the initial design life of the existing pavement. Therefore, any existing structural and/or surface defect shall be dealt with by the current MMaRC Contractor, GJ Maintenance Ltd.

The scenario for the southern 3km part of the route is more complicated as the pavement build-up for the widened areas will not be able to match the one of the existing pavement. At that stage, three solutions can be suggested depending on the structural condition of the existing pavement and the changes in road geometry:

If the structural condition of the existing pavement is poor to very poor, the whole carriageway could be fully reconstructed and brought to current TII standards. The new pavement design would likely match the one of the preceding and following sections of the N11/M11;

If the structural condition of the existing pavement is good to fair, the existing pavement could be rehabilitated in line with TII Publication AM-PAV-06050 to match the design of the widened areas of pavement. This would likely mean overlaying the existing pavement with the consequences listed in the “raised vertical level” paragraph of this section of the report. A geotextile may be used at the interface between the existing and the widened pavement to prevent cracking from a differential in settlement.

If the structural condition of the existing pavement is very good and the other two options are not available, the existing pavement may be left in place. The use of drainage layers and adjustments to crossfall may be required to ensure water is not trapped beneath the pavement at the interface between existing and widened areas. A geotextile may be used at the interface between the existing and the widened pavement to prevent cracking from a differential in settlement.

Where the existing pavement’s structural condition is to be assessed, this shall be undertaken in line with AM-PAV-06050.

Most of the datasets should be available from TII Pavement Asset Management System (PAMS) but others such as Falling Weight Deflectometer (FWD) and calibrating cores data and Visual Condition Survey records will very likely need to be procured.

Where the existing pavement is proposed to be left in place, the existing pavement's surface condition shall be the responsibility of the current MMaRC Contractor, GJ Maintenance Ltd.

6.7 Drainage

No information on the existing road drainage network on the N11/M11 has been available for the purposes of undertaking the engineering feasibility study. Consequently, it is not possible, at this stage, to determine the design implications in detail at specific locations along the scheme. Notwithstanding, the geometric assessments have confirmed that widening of the existing N11/M11 carriageway/paved area will be necessary along the majority of the corridor to provide the desired bus lane cross section. This will unquestionably have major implications for the existing drainage network, and it is likely that much, if not all, will have to be upgraded or replaced where widening results in a direct impact. Other drainage considerations which should be noted at this stage include the following:

- As discussed already in the report, sections of the existing N11/M11 under consideration for the bus priority scheme pre-date the implementation of modern design standards and the formation of the National Roads Authority (now TII). Hence, it is unlikely that the existing drainage network conforms to modern design standards.
- Widening of the N11/M11 carriageway will increase the impermeable catchment area to be drained compared to the existing scenario. Notwithstanding, a basic principle of the design should be that existing maximum discharge rates from the highway drainage system to the receiving watercourses will not be increased, and therefore there will be no additional impact on flood risk from the mainline works of road widening.
- Conversion of the hard shoulder to a bus lane and reducing hard strip to 0.5m wide will pose a safety hazard due to stone scatter from verge drains. The following two methods could be used to counter the safety issue (note, this is only in the case where existing filter drains meet capacity needs and can be retained):
    - Spraying of the top surface of exposed filter material with bitumen where filter drains can be retained in good condition following a CCTV conditional assessment.
    - Use of bitumen bonded filter material in the top 200mm of the trench where the filter drain is subjected to maintenance and repair.
- Existing cross drains may require upsizing to meet a 1 in 50 year return period storm event storage capacity (new requirement since N11/M11 drainage constructed).

- Manhole and catchpit covers within the running bus lanes will not be permitted and will need to be relocated.
- It is unlikely that the existing drainage network was designed with the now mandatory 20% allowance for climate change.
- The condition and precise locations of existing drainage outfalls on the N11/M11 is unknown. However, it is very likely that these outfalls do not meet current standard requirements in terms of attenuation and pollution control, including spillage risk. It may be necessary to upgrade/replace existing drainage outfalls entirely to meet current requirements. This may require online attenuation provision given the limited space available.
- Existing TII drainage standards permit a channel flow width equivalent to the '*width of the hard shoulder minus 0.5m'* for a 1 in 5 year storm. This is unlikely to be permissible in circumstances where the hard shoulder is converted to a bus lane and regularly trafficked. This is likely to require additional capacity within the drainage network to limit flow width along the bus lane.

In consideration of the issues above, it is likely that the implementation of the bus priority scheme is likely to require a substantial upgrade or entire replacement of the existing drainage network. Any site specific variations from current standard requirements would need to be discussed and agreed with TII at the option selection and design stages.

6.8 Utilities

A preliminary assessment of utilities within the corridor has been undertaken based on Dial Before You Dig (DBYD) information. The purpose of this exercise has been to identify the major utilities within the section from Loughlinstown Roundabout to Junction 8 (Kilmacanoge) which could potentially be impacted by the proposed works.

Further investigation would be required in future design stages to gather detailed utility data and determine the impacts and extents of proposed mitigation measures.

The following approach has been undertaken for identifying potential clashes:

- Only major utilities within the corridor have been identified. These are classified as any of the following:
  - Gas transmission mains
  - Water trunk mains
  - Foul sewer mains
  - 110 kV / 38 kV underground / overhead electrical assets
- Potential clashes have been defined as any utility within the vicinity of the proposed extent of works (i.e. within the road reserve), with this being a conservative approach. This could be either a longitudinal or transverse crossing.

- The clash identification process has not taken into account the horizontal and vertical alignment, pavement depths, cover etc. This is expected to be undertaken in future design stages, when the concept design is developed, more detailed 3d survey of underground utilities and / or potholed depths of assets is available

The assets identified in Table 12 have been identified as potential clashes, and these are illustrated within the figures provided in **Appendix D**.

Table 12: Locations and Potential Clashes with Major Utilities

Utility Service Description	**Asset Owner**	**Potential Clash Locations**
Electrical 38kV Underground	ESB / ESBI	Transverse crossings: • Between Loughlinstown roundabout and Junction 4 • Junction 6 NB merge • Junction 6 SB merge • Mainline north of Junction 6 Overbridge • Junction 6 NB diverge • Mainline south of Junction 6 Overbridge
Electrical 38kV Overhead	ESB / ESBI	Transverse crossings: • Between Loughlinstown roundabout and Junction 4 • Mainline north of Kilmacanoge town centre
Gas Transmission Main	Gas Networks Ireland (Bord Gáis)	Longitudinal crossings: • Mainline between Junction 6 and Junction 7 (median) • Saint Valery's Bridge • Junction 6 NB diverge • Junction 7 SB merge • Mainline between Junction 7 and Junction 8 (median)
Water Trunk Main	Irish Water	Transverse crossings: • Between Loughlinstown roundabout and Junction 4 • Mainline between Junction 6 and Junction 7 Longitudinal crossings: • Junction 6 NB diverge • Junction 7 NB merge / Enniskerry Road Access • Mainline between Junction 7 and Junction 8 • Junction 7 SB merge
Foul Sewer Main	Irish Water	Transverse crossings: • Between Loughlinstown roundabout and Junction 4 • Ballybride Road footbridge Longitudinal crossings: • Junction 7 SB merge • Mainline between Junction 7 and Junction 8

6.9 Traffic Signs and Road Markings

For the purposes of this study, it is considered that the feasibility impacts associated with ancillary design elements are comparatively minor relative to mainline widening impacts and structure modifications. As such, it is proposed that assessments of traffic signs will be completed during the design phase, however, the following should be noted at this stage.

6.9.1 Existing Signage

The following approach is proposed to assess the impact of the interim bus lane on existing signage:

- Where large signage gantries / cantilever supports are found in the median side / verge side, the revised barrier design would seek to retain the large signs at their current location. New concrete barriers would be tapered to accommodate adequate working width from the sign supports. This may create some intermittent restrictions to SSD which have not yet been quantified.
- Impacts to smaller frangible signs are to be assessed in future stages, and it is expected that there may be a number of smaller signs along the corridor which will need to be further setback to cater for the widening requirements for the bus lane.

6.9.2 Proposed Signage

The following new signage would be considered in future design stages:

- Advanced warning signs at the start of each on-slip, informing road users of the hard shoulder / bus lane arrangement;
- Warning signs at merges and diverges to inform road users of bus traffic sharing the merge / diverge areas;
- Start and End bus lane signs where bus priority would be commenced / terminated; and
- Confirmation signage on the mainline outlining the permitted hard shoulder usage, at a likely spacing of 1000 – 1500m.

Careful consideration will need to be provided to the placement and density of existing signage to ensure that additional signage along the corridor does not result in signage fatigue.

6.9.3 Road Markings

Road markings will be modified along the majority of the N11 / M11 corridor to facilitate the interim bus lane. In addition to the widened sections, it is likely that the full carriageway width will be resurfaced to accommodate the changes to horizontal geometry and lane lines along the corridor.

For the bus lane facility itself, solid white lines are proposed for the separation line between the bus lane and general purpose lanes, unless the emerging bus lane technical standards recommend a different treatment.

Chevrons within this area are not proposed. Consideration may also be given to the provision of rumble strips, to minimise the likelihood of collisional entry. Where continuous edge lines are used drainage gaps shall be included to prevent surface water ponding and the risk of localised ice formation.

Coloured road chippings or paving of the bus lane along its length should be limited. The exception to the above is at the fork diverge treatments, where this treatment is preferred to discourage general traffic from erroneously entering the bus lane.

7 Limitations / Further considerations

It is important to note that this feasibility study has focussed solely on the *engineering* feasibility of providing the dedicated bus lane. As requested in the brief, the assessment has sought to identify areas where road widening is necessary to accommodate the bus lane and to outline options for delivering bus priority through junctions and existing structures. In order to advise on these topics, the analysis has principally focussed on the geometric design of the bus facility. While it is recognised that any bus priority scheme will be subject to a rigorous option selection process, there are inherent limitations within the engineering feasibility study which should be acknowledged at this stage. This chapter discusses some of the key issues listed below, which although not specifically mentioned in the brief, may impact on the viability of the bus priority proposals on the N11/M11 corridor.

- Design standard;
- Legislation;
- TEN-T requirements;
- Cost;
- Extent of Scheme;
- Constructability; and
- Operational issues;

7.1 Design Standard

As noted in **Section 3.1**, there is at present no applicable design standard for the deployment of hard shoulder bus lanes on motorways and dual carriageways in Ireland. The geometric feasibility assessments undertaken for the purposes of compiling this report have taken cognisance of the emerging recommendations of the ongoing TII commission aiming to develop such a standard. At this stage however, these recommendations are very preliminary and remain subject to review and agreement. Alterations to these details may affect the feasibility analysis undertaken and impact on the conclusions of this report.

7.2 Legislation

At present, several pieces of legislation in Ireland do not allow for the use of motorway hard shoulders beyond that already permitted. In particular;

- Under current Irish legislation, use of the hard shoulder is permitted only by certain road users in certain situations. On Motorways, it is an offence under the Road Traffic Act 1961, as amended, to drive on any part of the motorway that is not the carriageway – for example, a hard shoulder – except in the case of an emergency.

- On all purpose roads, the hard shoulder is normally only used for pedestrians and cyclists but can provide a refuge for emergency situations and slow-moving vehicles.
- The Traffic Signs Manual (2019) published by The Department of Transport, Tourism and Sport defines the traffic signs permitted for use on the Irish road network. At present, this manual does not include the signs that would be required to implement a hard shoulder bus priority scheme in Ireland.

Consequently, the implementation of any hard shoulder bus lane in Ireland would require amendments to existing legislation and road regulations.

7.3 TEN-T Requirements

As part of the Comprehensive Trans-European Transport Network (TEN-T), the N11/M11 route shall comply with the provisions of Regulation (EU) No 1315/2013 for the development of the TEN-T network.

Article 17, clause 1(a) notes that road transport infrastructure forming part of the TEN-T network shall, *"comprise, in particular: (a) high-quality roads, including: ….(vi) hard shoulders"*.

In the case where the hard shoulder is converted into the bus lane, even on a temporary basis, consideration may need to be given as to whether this would be compliant with the TEN-T Regulation.

7.4 Cost

The engineering feasibility study has not developed a Feasibility Working Cost (FWC) for the bus lane proposals. While it is understood that costing analysis will be undertaken as part of the option selection phase, it may be prudent to generate an initial high-level cost estimate for the purposes of ascertaining scheme economic viability and to gain appreciation for the scale of works anticipated.

7.5 Extent of Scheme

As outlined in **Section 1.3**, the terms of reference for the *Bus Priority Interim Scheme* confines the extent of the scheme to be from Loughlinstown Roundabout in the north to Kilmacanoge in the south. As such, the engineering feasibility assessments detailed in Chapter 6 examine the provision of a dedicated bus lane exclusively within this section, with the bus lanes terminating in the vicinity of Junction 8 (Kilmacanoge). It is assumed that this northern section of the N11/M11 route has been identified as the primary focus for the study on the basis of the following;

- Existing congestion issues are considered to be most severe and largely confined to this northern section of the N11/M11 route;

- Given the high levels of congestion and associated journey time reliability problems, a dedicated bus lane is considered necessary to enable the bus to provide a faster alternative to the private car within this section of the route;
- Congestion issues are comparatively less severe and journey times more reliable to the south of Kilmacanoge, meaning that dedicated bus priority is not considered necessary to deliver more advantageous public transport journey times and bus traffic can therefore move in the all-purpose lanes.

Clearly, the successful implementation of bus priority measures on the N11/M11 relies heavily on the validity of these assumptions and, by implication, the appropriate definition of scheme extent. For example, bottlenecks outside the extent of the bus priority scheme may impede bus traffic in the absence of a dedicated facility to bypass congestion. While this study has specifically focussed on engineering feasibility only, traffic modelling will be necessary during the option selection stage to affirm that the extent of the scheme is correctly defined such that efficiency of bus movement is maximised as much as reasonably possible.

Although noted that transport modelling is outside the scope of the initial feasibility assessment, it is nonetheless worth examining journey time data along the N11/M11 to understand where the existing bottlenecks occur and hence inform the optimum areas for dedicated bus priority measures. **Figure 81** and **Figure 82** below present existing N11/M11 average journey time profiles across the day in the northbound and southbound directions respectively.

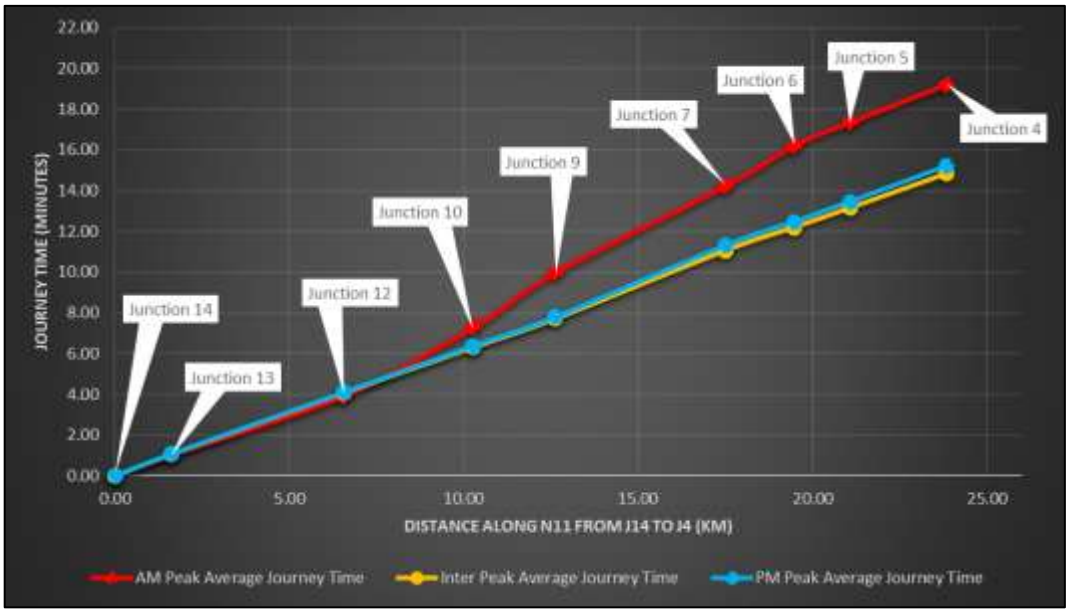


Figure 81: N11/M11 average northbound journey time profiles

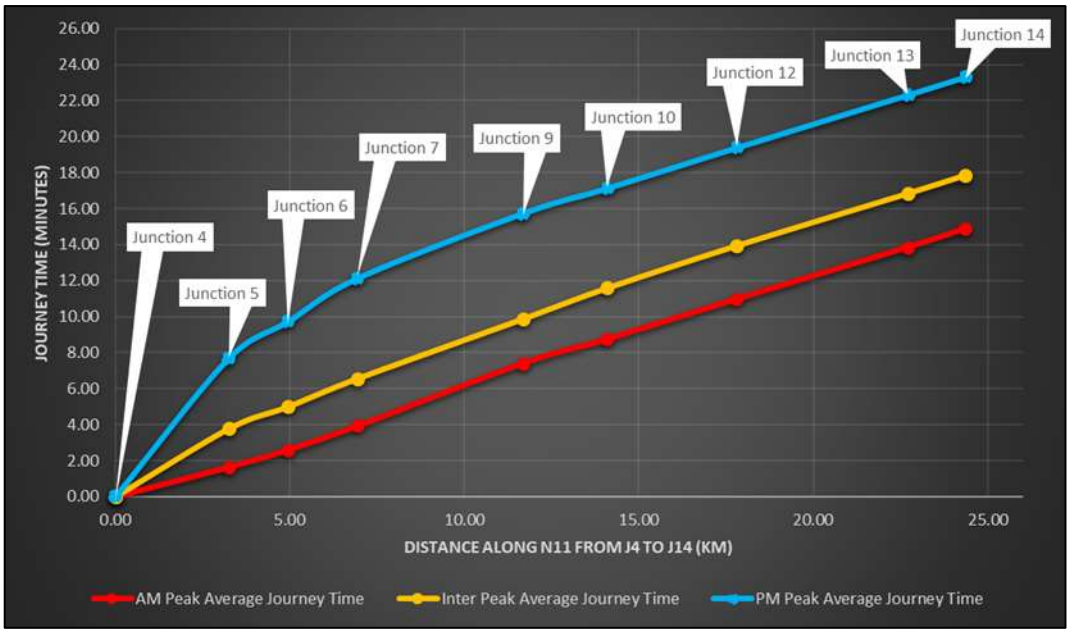


Figure 82: N11/M11 average southbound journey time profiles

In the northbound direction, it is evident from **Figure 81** that there is minimal difference between the peak and off-peak journey times as far as Junction 12 (Newtownmountkennedy). However, from this point onwards, the AM peak journey time begins to increase steadily – indicative of increasing congestion from this point and a resultant absence in journey time reliability. The most pronounced differences in the northbound journey time profiles occur between Junction 10 (Delgany/Drummin) and Junction 9 (Glenview), and again between Junction 7 (Bray South) and Junction 6 (Bray/Fassaroe). This indicates that the delays caused by the various operational problems along the corridor are experienced to the greatest extent along these sections of the route.

In the southbound direction, it is apparent from **Figure 82** that there is a very pronounced difference in the journey time profiles between Junction 4 (M11/M50) and Junction 7 (Bray South), indicating that the majority of the PM peak delay is experienced on this short section of the route. South of Junction 7, the profiles follow a very consistent pattern with more reliability of journey time across the day.

An implication of this journey time analysis is that the *Bus Priority Interim Scheme* may need to consider further priority measures to the south of the extent defined for this engineering feasibility study (i.e. south of Kilmacanoge) to optimise efficiency of bus movement. The section of the existing N11 between Junction 11 (Kilpedder) and Junction 9 (Glenview) is one of the worst performing sections of the route in terms of AM peak northbound journey time and average speed, suggesting that the dedicated bus facilities could be highly beneficial here also. Further transport analysis will be necessary during the option selection stage to explore this particular issue in more detail.

7.6 Constructability

The constructability of online scheme improvements and widening schemes can be inherently complex due to the challenges of working within a confined site, maintaining access arrangements in a safe and intuitive manner and the need to minimise disruption to the live carriageway. The requirement to widen and possibly strengthen the hard shoulder to enable bus running may necessitate the provision of a temporary lane to maintain 2-lane traffic flow, depending on the space available. A detailed constructability analysis should be undertaken during the option selection stage.

7.7 Operational Issues

The engineering analysis undertaken for this study may indicate that the conversion (with widening) of the hard shoulder into a bus lane is technically feasible. However, to meet the objective of delivering a Core Bus Corridor on which bus can provide a faster alternative to private car, operational challenges need to be considered in further detail.

In this regard, it is important to precisely establish how the bus lane traffic may interact with general traffic on the route and the degree to which conflicts, particularly at junctions, may impede bus priority and in doing so, lessen the attractiveness of the services.

As outlined in chapter 6 of this report, it is not technically feasible to operate a nearside hard shoulder bus lane with continuous uninterrupted priority from start to finish given the interaction with the junctions. At each merge and diverge, the bus lane will essentially double-up as an auxiliary lane for general traffic manoeuvring through the junction. This arrangement should ordinarily be acceptable and has been implemented on other schemes (e.g. M1 Belfast). However, the number and close spacing of junctions along the N11/M11 route means that the provision of a dedicated lane exclusively for bus traffic will be intermittent at best.

The preliminary design for the bus lane achieves exclusive bus priority for 42% of the scheme length in the northbound direction and 44% in the southbound direction, as illustrated in the drawings in **Appendix E**. Over the remainder of the scheme length, the bus lane is open to general traffic to execute merging and diverging movements at the junctions along the route.

The doubling-up of the bus lane with the junction merges and diverges under *free flow* conditions is unlikely to impede the progress of the bus. However, it is intended that the bus lane will be operational at peak times only, when congestion issues and network delay reach a critical level. On the existing N11/M11, it is known that certain junction diverge slip roads do not have adequate capacity to accommodate vehicles exiting the route, resulting in queuing extending back onto the mainline. In such instances, the path of the bus through the junction will be temporarily blocked, causing disruption to the service.

Moreover, high volumes of merging traffic on the N11/M11 will be required to merge into the bus lane before manoeuvring into the adjacent general traffic lane. This operational regime has significant potential to impede bus lane traffic where lengthy streams of merging traffic attempt to join the already congested mainline. An illustration of the potential problem is shown in **Figure 83** below.



Figure 83: Merging traffic impeding bus priority

At Junction 7 (Bray North), approximately 1,200 vehicles merge onto the N11 mainline during the AM peak period, all of which must cross the bus lane to find space to merge onto the mainline.

The degree to which such operational challenges may interfere with the bus lane will need to be carefully examined using traffic modelling analysis during the option selection phase. Where it is deemed that bus priority is compromised to an unacceptable degree, solutions such as ramp metering or junction closures may need to be investigated in more detail.

8 Conclusion and Recommendations

8.1 Overview of Findings

The assessment has examined the viability, from an engineering perspective, of providing bus priority measures in the form of a continuous dedicated lane between Loughlinstown Roundabout in the north and Junction 8 (Kilmacanoge) to the south.

While technically feasible to deliver, the assessment demonstrates that major civil engineering works will be required along the majority of the N11/M11 route to deliver the scheme. In summary, the following works, as a minimum, are considered necessary to achieve the objectives of the scheme:

- Widening of the existing N11/M11 carriageway is required along the full length of the route under consideration in order to provide space for the bus lane, as this cannot be accommodated within the existing cross section;
- In between the major junctions, widening will be largely confined within the existing central median. At junction locations, widening will be required along auxiliary lanes, tapers and slip road nosing areas to provide the desired merging/diverging arrangements as per the emerging recommendations of the TII Standards Literature Review;
- No demolitions of any existing primary structures (i.e. overbridges / underbridges) is proposed. However, alterations to certain structures will be necessary to provide compliant parapet systems and possible utility relocations;
- A major upgrade of the drainage network is likely to be required as a consequence of the degree of road widening necessary and the resultant increase in paved impermeable area;
- Existing sub-standard barrier and parapet systems would need to be replaced, particularly within the central reserve and on the N11/M11 mainline beneath existing structures;
- Retaining walls may be required in the vicinity of Junction 7 (Bray South) southbound to minimise impacts on Ballywaltrim Lane;
- A number of significant utility diversions (including major gas transmission mains) are likely to be required;
- Extensive pavement rehabilitation, reconstruction and new pavement construction will be required;
- Additional road signage and new road markings would be required;
- Emergency refuge areas may be required; and
- CCTV and ITS technology may be required to safety manage the operation of the facility and any potential ramp metering systems.

The feasibility assessments have also identified that departures from standard, additional to those intrinsically present on the existing route, will be necessary to achieve a practicable outcome within the existing alignment constraints. Departures from standard will need to be reviewed on a case by case basis and ultimately TII will adjudicate on their acceptability.

In addition to the physical engineering aspects, the feasibility report highlights a number of important considerations warranting further analysis. These issues, including legislative changes, constructability, TEN-T compliance and scheme extent, have not been assessed in detail in this report, but may hinder scheme viability and economic justification to varying degrees.

The report has further identified that, even with the substantive works above, continuous bus priority (i.e. where the additional lane is exclusively for bus traffic) is not achieved along extensive sections of the route (less than 50% both northbound and southbound). Moreover, while the physical infrastructure to enable bus priority can be implemented at the major junctions, operational issues (e.g. merging/diverging traffic streams) are very likely to stymie the attractiveness of the facility.

8.2 Next Steps

Following the completion of the Engineering Feasibility Report, the next step within the terms of reference for the *Bus Lane Interim Scheme* involves a comprehensive and robust option selection process in order to identify an emerging preferred option for delivering on the scheme objectives. To progress to the option selection stage, a number of key activities are discussed below which may form the basis of a post feasibility assessment workshop.

- **Development of Technical Design Standard** – As noted in this report, work on developing a technical standard for the implementation of bus lanes on motorways and dual carriageways is at literature review stage, with some emerging recommendations on preferred layouts currently under review by TII. Further clarity on design parameters (or preferably a published standard) would be a pre-requisite in progressing a detailed option selection appraisal. Agreement on the merge/diverge arrangement, necessity for ramp metering and ITS requirements are or particular importance.
- **Operational viability of bus lanes on N11/M11** – While the scope of the report has been confined to engineering feasibility, serious concerns have been identified in respect of the operational viability of hard shoulder bus lanes on the existing N11/M11. This is due to site-specific circumstances – most notably the proximity of existing junctions along the route and degree to which this may impede bus priority. CCTV surveying at existing merges and diverges may be useful in obtaining a better understanding the likely interaction between bus traffic and junction traffic in the TJR scenario.
- **Development of a Business Case** – the economic case for implementing bus priority on the N11/M11 will require clarity on the envisaged service pattern along the Core Bus Corridor, such that benefits accrued can be quantified and justification for the facility robustly established.

Further studies on the relationship between congestion (average vehicle speeds) and bus journey time/patronage benefits specifically on the N11/M11 corridor will be fundamental in determining if the proposed scheme is ultimately justified on economic grounds.

- **Consideration of Vulnerable Road Users** – The conversion of the hard shoulder into a bus lane (even on a temporary basis) will worsen already hazardous conditions for pedestrians and cyclists presently using the route. Space constraints on the existing N11 dual carriageway will instigate a reliance on adjacent schemes (e.g. planned greenway facilities) to complement the bus lane and deliver a safe alternative for vulnerable road users. Consultation with the Local Authority on the likely progression of such adjacent schemes is required such that holistic options can be developed at the next phase.
- **Alignment with N11/M11 Scheme** – Early benefit realisation through the delivery of a practicable interim solution has been the basis of the engineering feasibility assessments. Nonetheless, it is apparent that the delivery of the scheme envisaged represents a major improvement/upgrade scheme in its own right, with impacts on structures, drainage, road restraint systems, pavement and geometry. Careful consideration as to how the Bus Priority Interim Scheme aligns with the scope, objectives, timeframe and solutions contained within the N11/M11 Scheme is essential to the phased delivery of complimentary solutions for the N11/M11 corridor and the avoidance of redundant works.

8.3 Journey Time Benefits and High-Level Cost Estimate

In early 2021 Arup have carried out some additional assessments, as an initial element of the Phase 2 Option Selection process, the focus of the investigations have been on:

- Assessing the high-level journey time benefits of the current scheme. This has included analysis on existing travel speeds and journey times along the existing corridor, as well as comparisons with other bus priority projects currently in operation; and
- Assessing the likely costs for the scheme. Using the feasibility design as a basis, an order of magnitude cost estimate has been developed which is appropriate for the level of design information currently available.

The findings of these investigations have been summarised into a technical note which is presented as Appendix F of the report.

Appendix A

Bus Lane Feasibility - Constraint Level Drawings

A1 Bus Lane Feasibility - Constraint Level Drawings

A1

FEASIBILITY

DR-M11-001.00 OLD CONNAUGHT AVENUE BRIDGE

JN5 - BRAY NORTH WILFORD

DR-M11-003.00 CRINKEN LANE BRIDGE

MISSING SURVEY

LOUGHLINSTOWN ROUNDABOUT

JN4 - M50/M11

DR-M11-002.00 JUNCTION 5 OVERBRIDGE (COIS CARN M11 ON RAMP)

DR-M11-004.30 STONEBRIDGE ROAD BRIDGE

DR-M11-004.40 M11/M50 OVERBRIDGE

DR-M11-004.00 LORDELLO FOOTBRIDGE (BALLYBRIDE ROAD FOOTBRIDGE)

WW-N11-063.00 JUNCTION 6 OVERBRIDGE (DARGLE ROAD INTERCHANGE BRIDGE)

WW-N11-061.00 JUNCTION 7 OVERBRIDGE (WINGFIELD INTERCHANGE BRIDGE)

WW-N11-060.00 KILMACANOGUE FOOTBRIDGE

WW-N11-062.00 SAINT VALERY BRIDGE (VALERIE BRIDGE)

JN6 - BRAY CENTRAL

JN7 - BRAY SOUTH (KILCRONEY)

JN8 - KILMACANOGE

WW-N11-061.70 JUNCTION 6A FOOTBRIDGE (ENNISKERRY FOOTBRIDGE)

LEGEND:

CONSTRAINT LEVEL 1

CONSTRAINT LEVEL 2

CONSTRAINT LEVEL 3

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Job Title
N11 M11 Upgrade Scheme - Interim Bus Priority Measures J4 to J8

Scale 1:6250 @ A1

Date 07/08/2020

Issue	Date	By	Chkd	Appd
P02	25/09/2020	LH	MA	MA
P01	07/08/2020	EAM	MA	MA

Drawing Title
Bus Lane Feasibility
Key Constraints

Drawing Status
Feasibility

Drawing No
265455-ARP-HGN-BIS-CH-0008

Issue
P02

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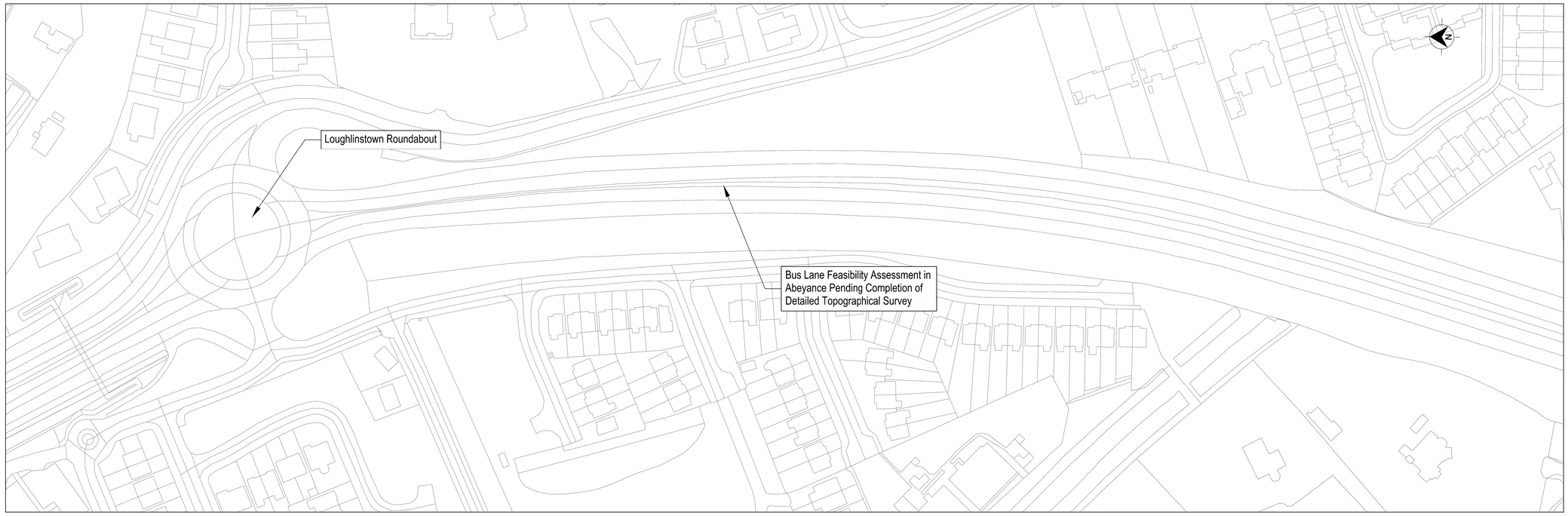
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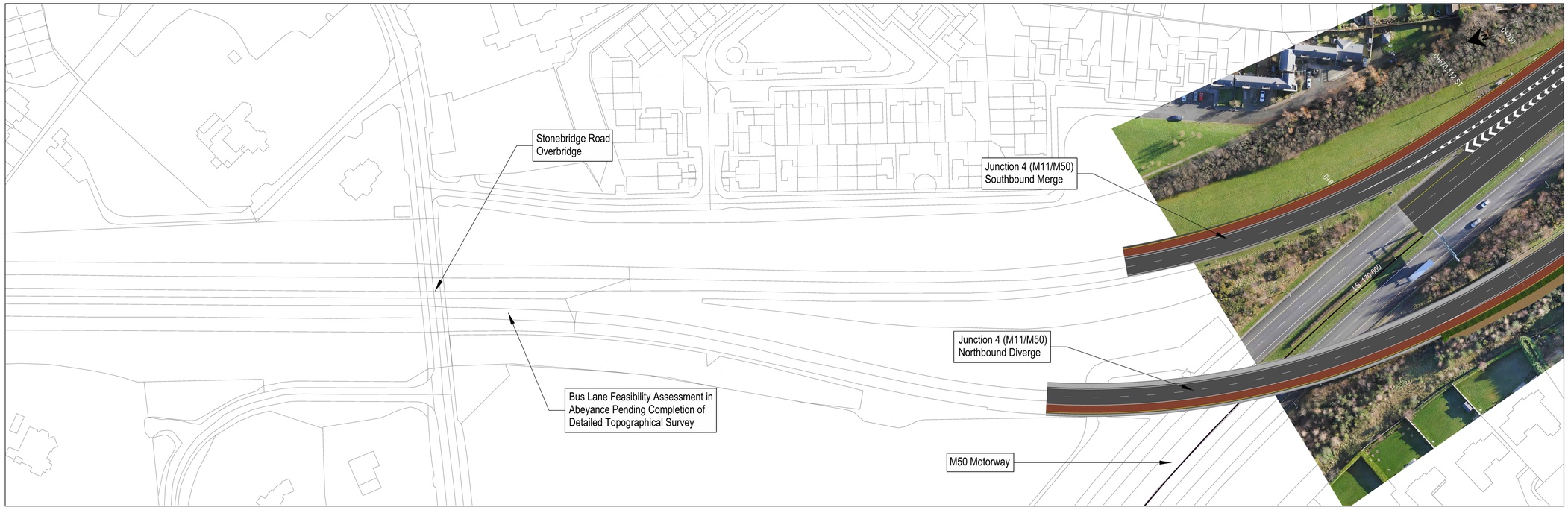
Appendix B

Bus Lane Feasibility – General Layout Drawings

B1 Bus Lane Feasibility – General Layout Drawings

A1





FEASIBILITY

LEGEND

Dedicated Bus Lane

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Job Title
N11 M11 Upgrade Scheme - Interim Bus Priority Measures J4 to J8

Scale at A1
1:1000

Date
10/09/2020

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P01	10/09/2020	LH	MA	ME

Drawing Title
Bus Lane Feasibility General Layout Sheet 1 of 7

Drawing Status
Feasibility

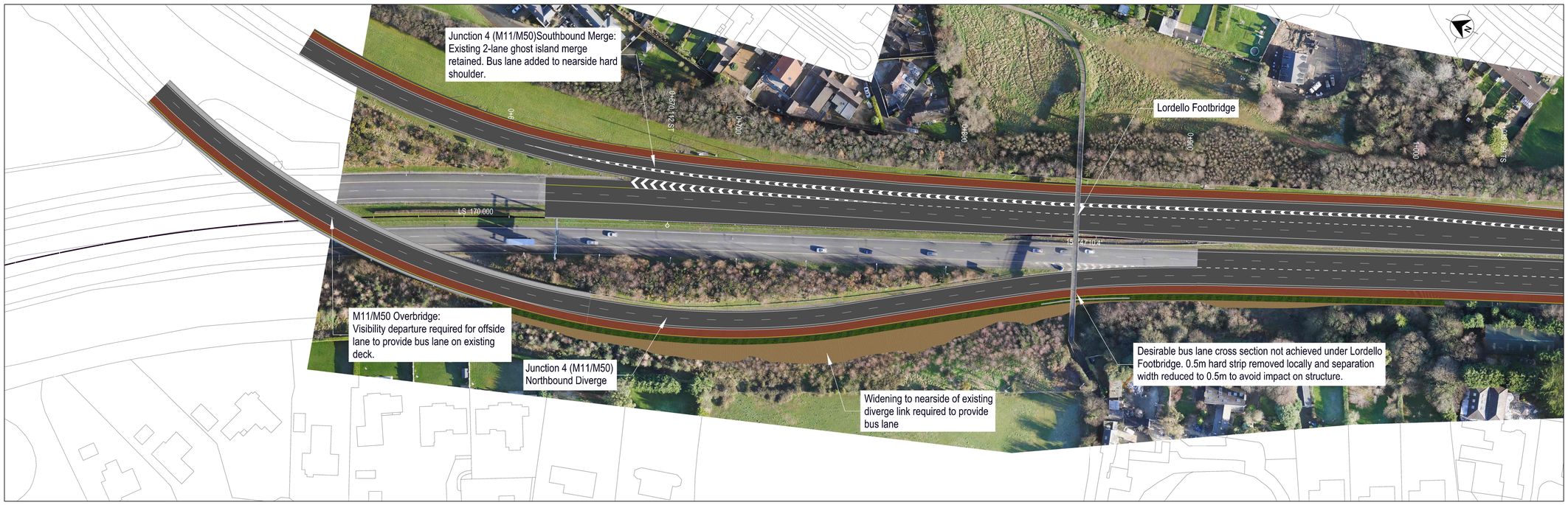
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P02

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A1





FEASIBILITY

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Bus Lane Feasibility General Layout Sheet 2 of 7

Drawing Status
Feasibility

Drawing No **265455-ARP-HGN-BIS-DR-CH-0002**

Issue **P02**

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FEASIBILITY

LEGEND

Dedicated Bus Lane





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N11 M11 Upgrade Scheme - Interim Bus Priority Measures J4 to J8

Scale at A1 **1:1000**

Date **10/09/2020**

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Drawing Title
Bus Lane Feasibility General Layout Sheet 3 of 7

Drawing Status
Feasibility

Drawing No **265455-ARP-HGN-BIS-DR-CH-0003**

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Job Title
N11 M11 Upgrade Scheme - Interim Bus Priority Measures J4 to J8

Scale at A1 **1:1000**

Date **10/09/2020**

Issue	Date	By	Chkd	Appd
P02	21/09/2020	LH	MA	ME
P01	10/09/2020	LH	MA	ME

Drawing Title
Bus Lane Feasibility General Layout Sheet 4 of 7

Drawing Status
Feasibility

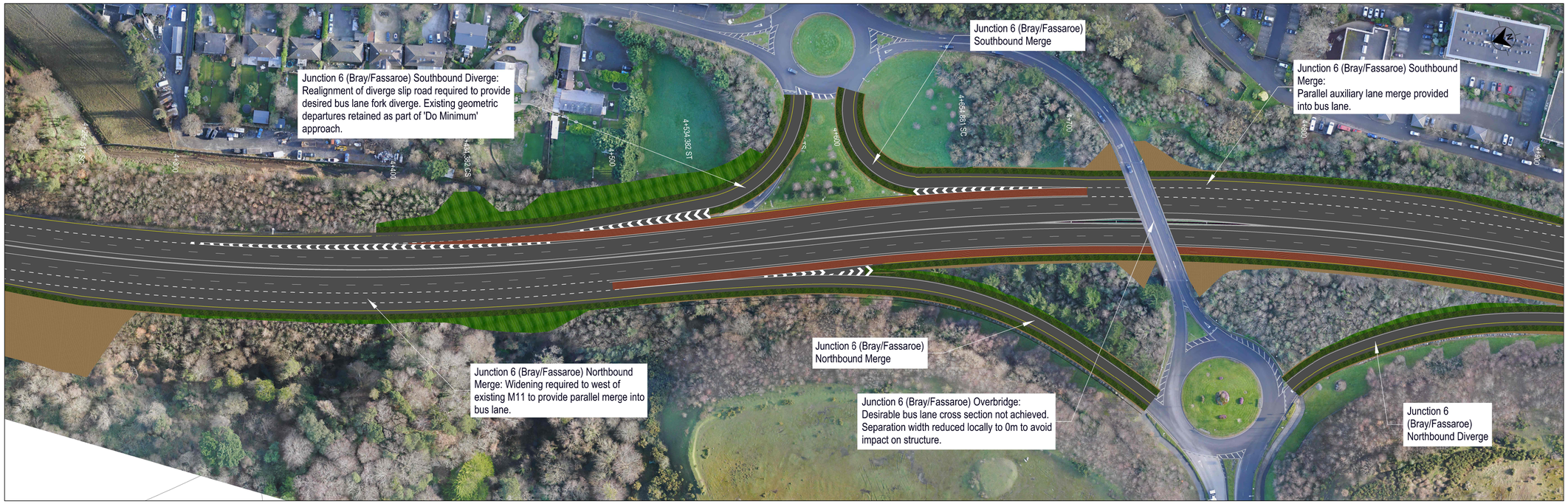
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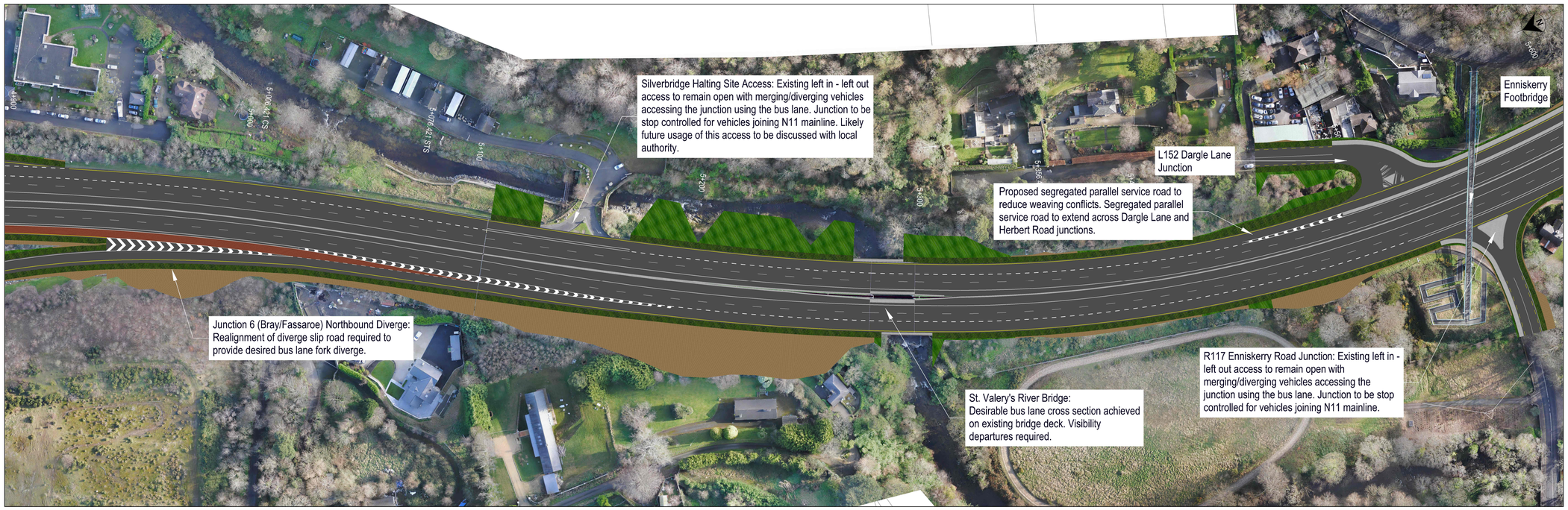
Issue **P02**

Do not scale

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A1





FEASIBILITY

LEGEND

Dedicated Bus Lane

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N11/ M11

Tionscadal Éireann Project Ireland 2040

Clients

Bonneagar Iompair Éireann Transport Infrastructure Ireland

An Roinn Iompair, Turasóireachta agus Spóirt Department of Transport, Tourism and Sport

Comhairle Contae Chill Mhantáin Wicklow County Council

Kildare County Council

National Roads Office

Údarás Náisiúnta Iompair National Transport Authority

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Job Title
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Scale at A1 **1:1000**

Date **10/09/2020**

Issue	Date	By	Chkd	Appd
P02	21/09/2020	LH	MA	ME
P01	10/09/2020	LH	MA	ME

Drawing Title
Bus Lane Feasibility General Layout Sheet 5 of 7

Drawing Status
Feasibility

Drawing No **265455-ARP-HGN-BIS-DR-CH-0005**

Issue **P02**

Do not scale

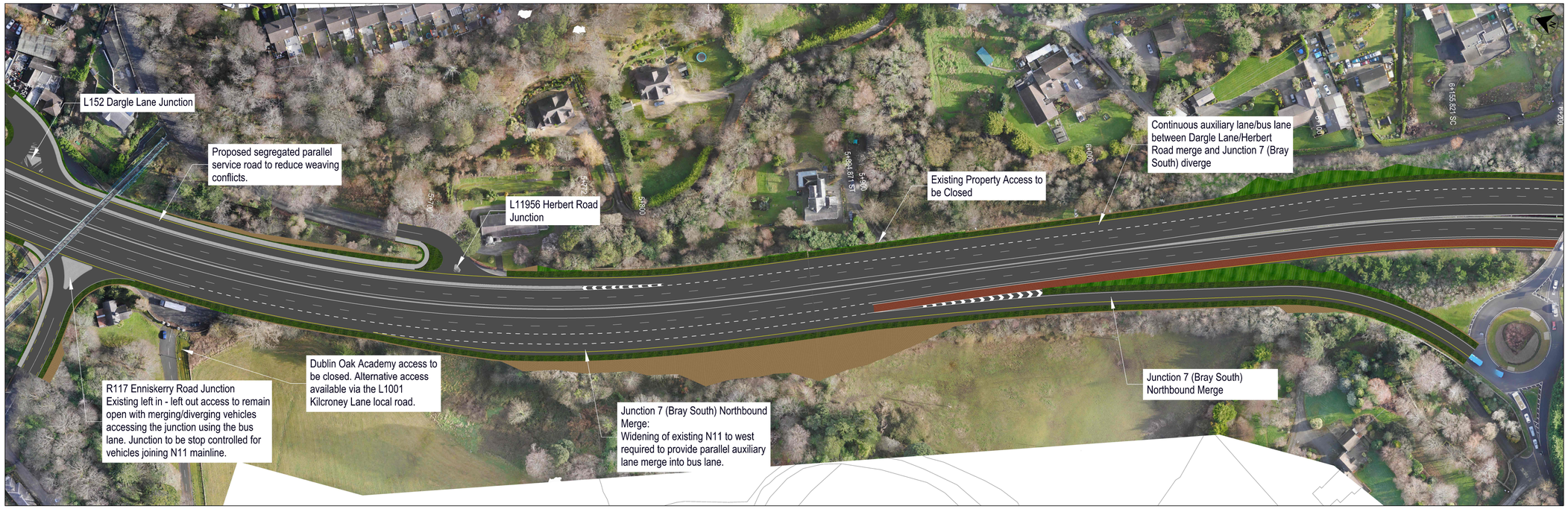
© Arup

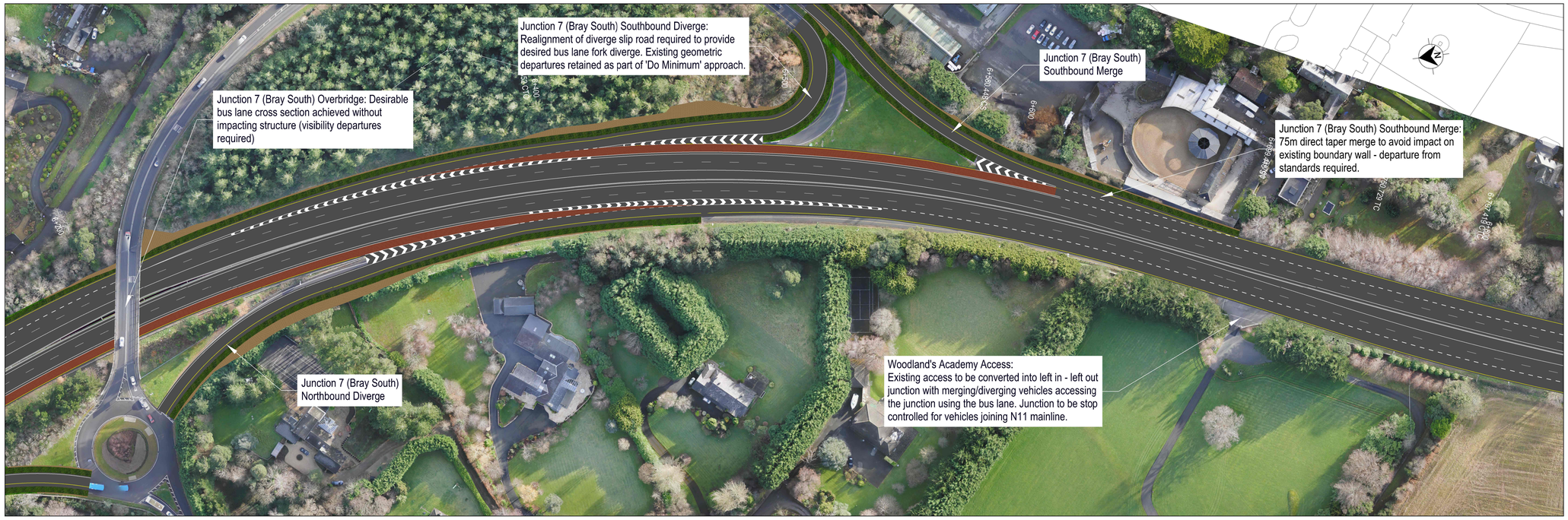
A1

FEASIBILITY

LEGEND

Dedicated Bus Lane





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Comhairle Contae County Council

Wicklow Engines Opportunities Cill Mhatáin Saoirseacha Rialú

Kildare

nro National Roads Office

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Scale at A1 **1:1000**

Date **10/09/2020**

Issue	Date	By	Chkd	Appd
P02	21/09/2020	LH	MA	ME
P01	10/09/2020	LH	MA	ME

Drawing Title
Bus Lane Feasibility General Layout Sheet 6 of 7

Drawing Status
Feasibility

Drawing No **265455-ARP-HGN-BIS-DR-CH-0006**

Issue **P02**

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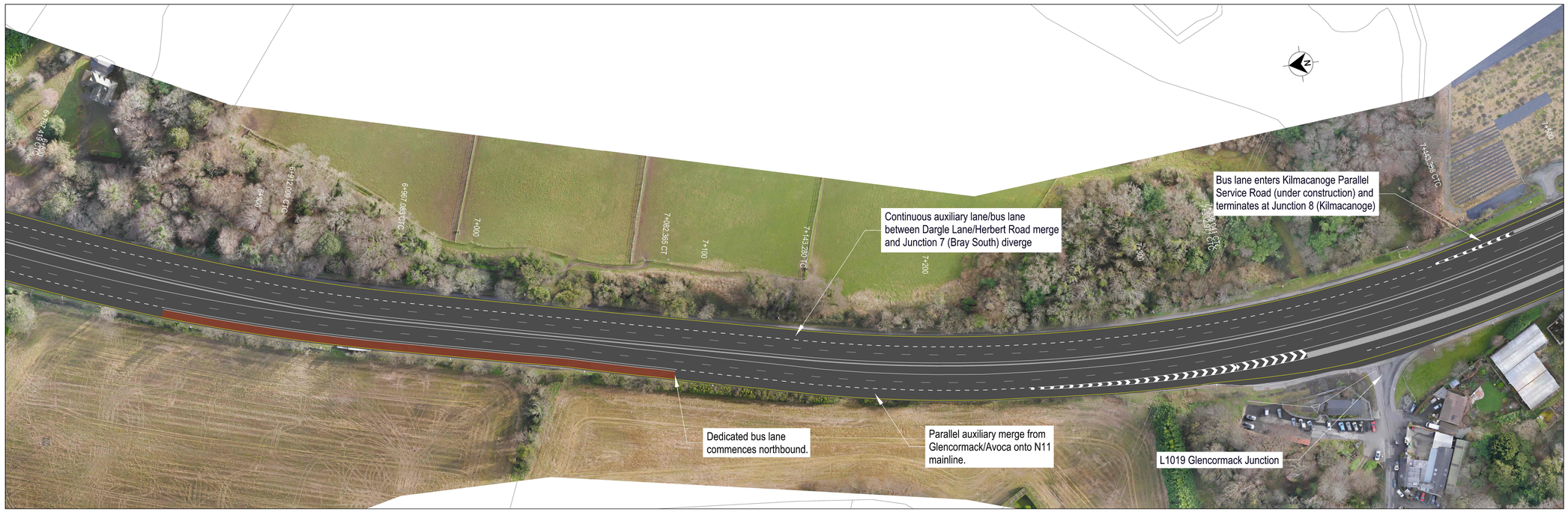
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A1

FEASIBILITY

LEGEND

Dedicated Bus Lane





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Comhairle Contae County Council

WICKLOW ENDLESS OPPORTUNITIES CILL MHATÁIN

KILDARE NRO NATIONAL ROADS OFFICE

NTA Údarás Náisiúnta Iompair National Transport Authority

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Job Title
N11 M11 Upgrade Scheme - Interim Bus Priority Measures J4 to J8

Scale at A1
1:1000

Date
10/09/2020

Issue	Date	By	Chkd	Appd
P02	21/09/2020	LH	MA	ME
P01	10/09/2020	LH	MA	ME

Drawing Title
Bus Lane Feasibility General Layout Sheet 7 of 7

Drawing Status
Feasibility

Drawing No
265455-ARP-HGN-BIS-DR-CH-0007

Issue
P02

Do not scale

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Appendix C

Extent of Widening Required

A1

FEASIBILITY

DR-M11-001.00 OLD CONNAUGHT AVENUE BRIDGE

JN5 - BRAY NORTH WILFORD

DR-M11-003.00 CRINKEN LANE BRIDGE

MISSING SURVEY

LOUGHLINSTOWN ROUNDABOUT

JN4 - M50/M11

DR-M11-002.00 JUNCTION 5 OVERBRIDGE (COIS CARN M11 ON RAMP)

DR-M11-004.30 STONEBRIDGE ROAD BRIDGE

DR-M11-004.40 M11/M50 OVERBRIDGE

DR-M11-004.00 LORDELLO FOOTBRIDGE (BALLYBRIDE ROAD FOOTBRIDGE)

WW-N11-063.00 JUNCTION 6 OVERBRIDGE (DARGLE ROAD INTERCHANGE BRIDGE)

WW-N11-061.00 JUNCTION 7 OVERBRIDGE (WINGFIELD INTERCHANGE BRIDGE)

WW-N11-060.00 KILMACANOGUE FOOTBRIDGE

WW-N11-062.00 SAINT VALERY BRIDGE (VALERIE BRIDGE)

JN6 - BRAY CENTRAL

JN7 - BRAY SOUTH (KILCRONEY)

JN8 - KILMACANOGE

WW-N11-061.70 JUNCTION 6A FOOTBRIDGE (ENNISKERRY FOOTBRIDGE)

LEGEND:

Widening beyond Nearside Pavement Edge

Widening Into Central Reserve Only

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Job Title
N11 M11 Upgrade Scheme - Interim Bus Priority Measures J4 to J8

Scale 1:6250 @ A1

Date 25/09/2020

Issue	Date	By	Chkd	Appd
P01	25/09/2020	LH	MA	MA

Drawing Title
Extent of Carriageway Widening Required

Drawing Status
Feasibility

Drawing No 265455-ARP-HGN-BIS-SK-CH-0001

Issue P01

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Drawing file path & name : \\global\europe\Dublin\Jobs\265000\265455-0004 Internal\4-02-13 Sketches\13.5 Bus Corridor 265455-ARP-HGN-BIS-CH-0009.dwg
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Appendix D

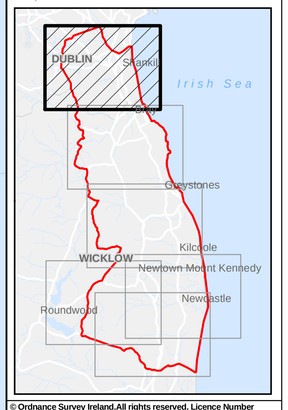
Potential Utility Impacts

OPTIONS SELECTION

Legend:

- Study Area
- Local Authority Boundary
- Gas Transmission Mains
- Gas Distribution Mains

Key Plan



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Job Title
N11/M11 Junction 4 to Junction 14 Improvement Scheme

Scale 1:25000 @ A3

Date October 2019

Issue	Date	By	Chkd	Appd
P02	28/05/2020	VB	MA	MA

Drawing Title
Gas Networks Ireland Gas Supply

Sheet 1 of 6

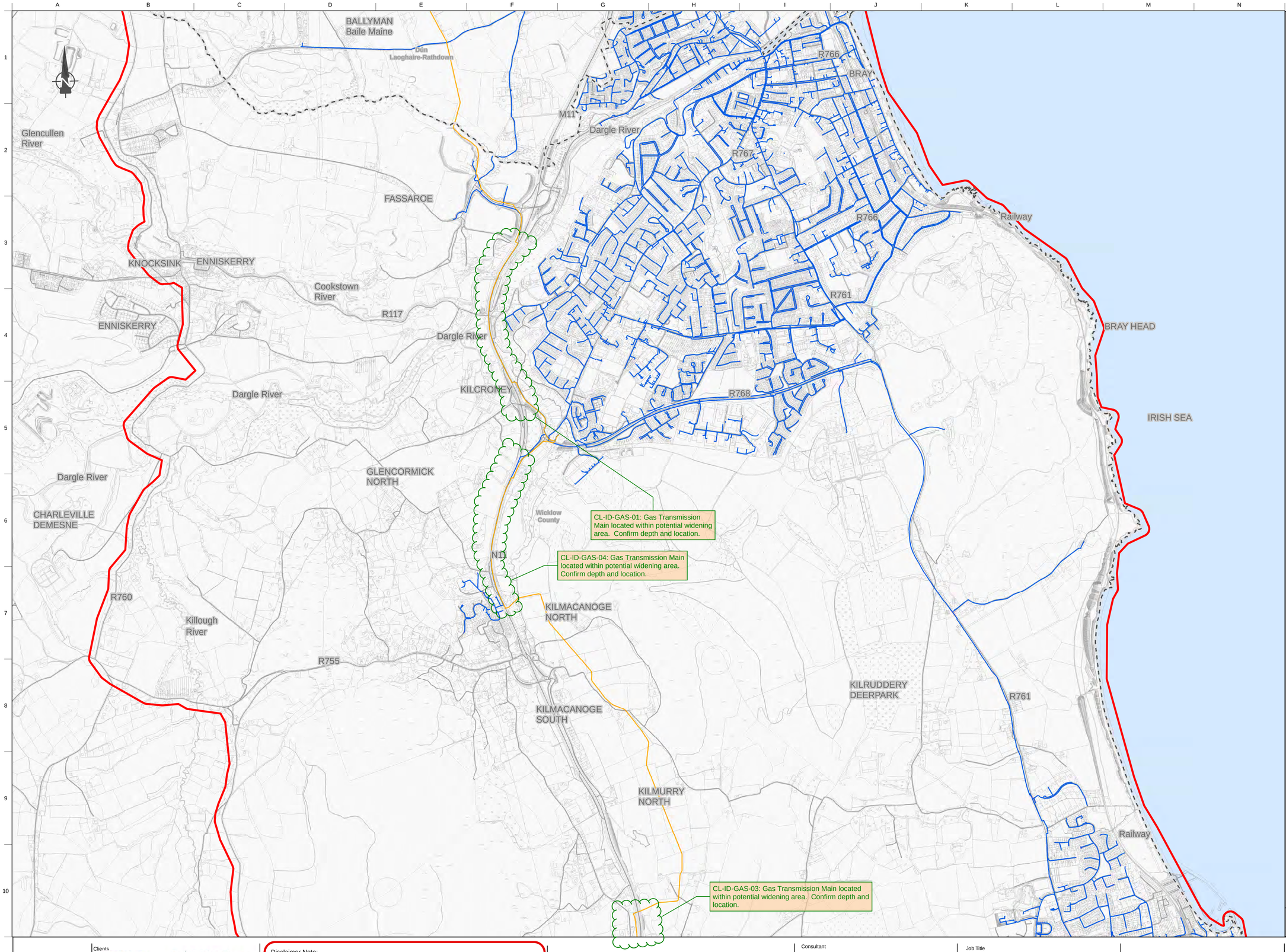
Drawing Status
Options Selection

Drawing No
Figure 8.9

Issue
P02

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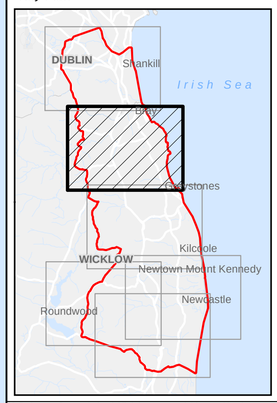


OPTIONS SELECTION

Legend:

- Study Area
- Local Authority Boundary
- Gas Transmission Mains
- Gas Distribution Mains

Key Plan



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Job Title
N11/M11 Junction 4 to Junction 14 Improvement Scheme

Scale 1:25000 @ A3
Date October 2019

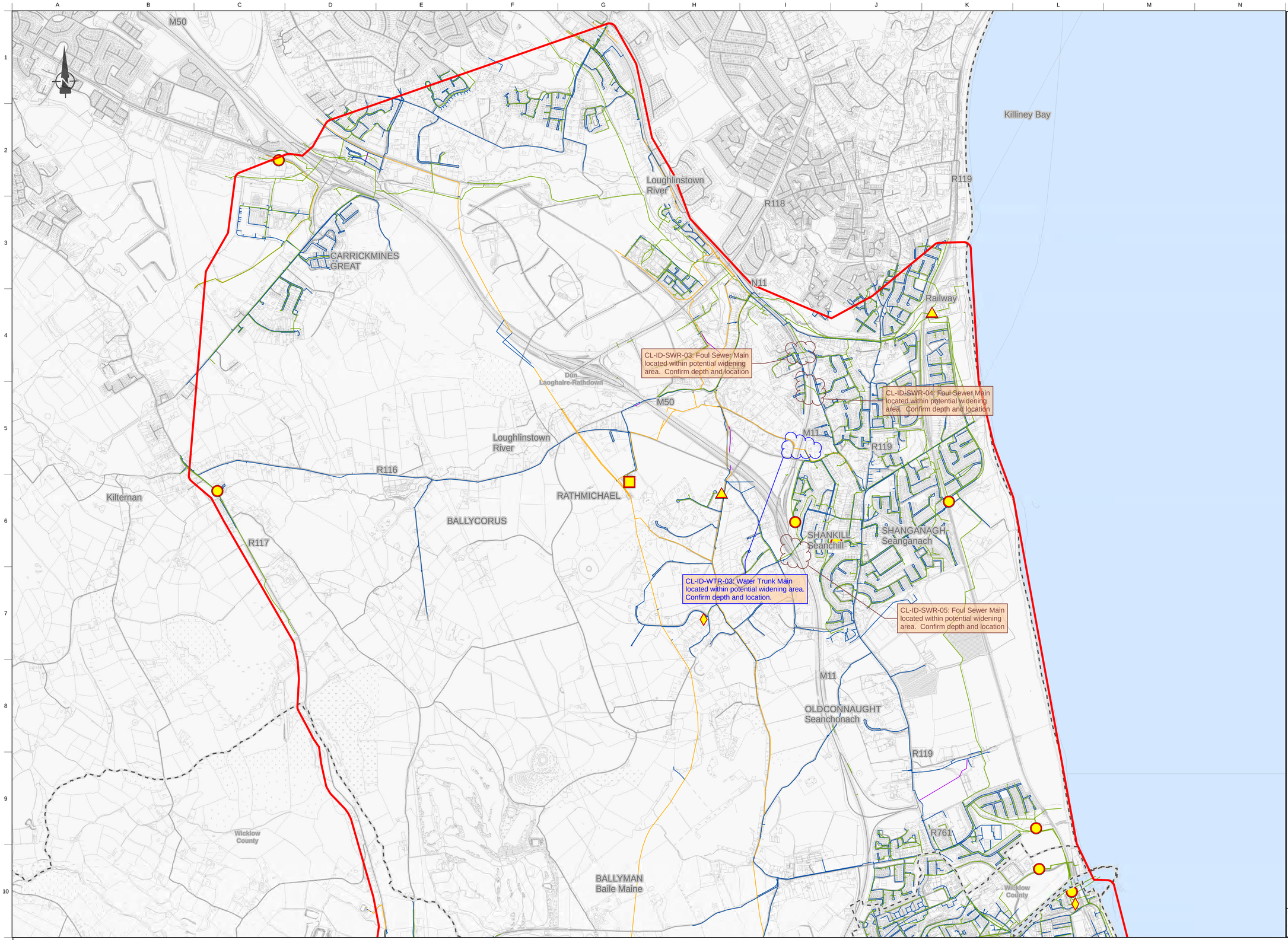
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P02	28/05/2020	VB	MA	MA

Drawing Title
Gas Networks Ireland Gas Supply

Sheet 2 of 6
Drawing Status
Options Selection
Drawing No Figure 8.10
Issue P02

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OPTIONS SELECTION

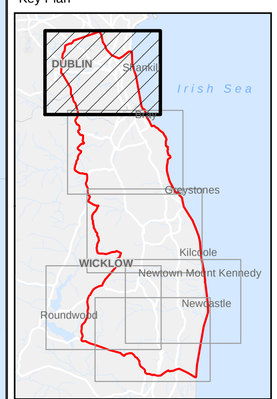
Legend:

- Study Area
- Local Authority Boundary
- Water Pump Station
- Treatment Plant
- Sewer Pump Station
- Reservoirs

Water Mains

- Trunk Main
- Distribution Main
- Water Network Abandoned Line
- Foul Sewer

Key Plan



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Tionscadal Éireann Project Ireland 2040

Clients: TII Transport Infrastructure Ireland; An Roinn Iompair, Turasóireachta agus Spóirt Department of Transport, Tourism and Sport; dlr Comhairle Contae County Council; Wicklow County Council; Kildare County Council; NRO National Roads Office

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Scale 1:25000 @ A3
Date October 2019

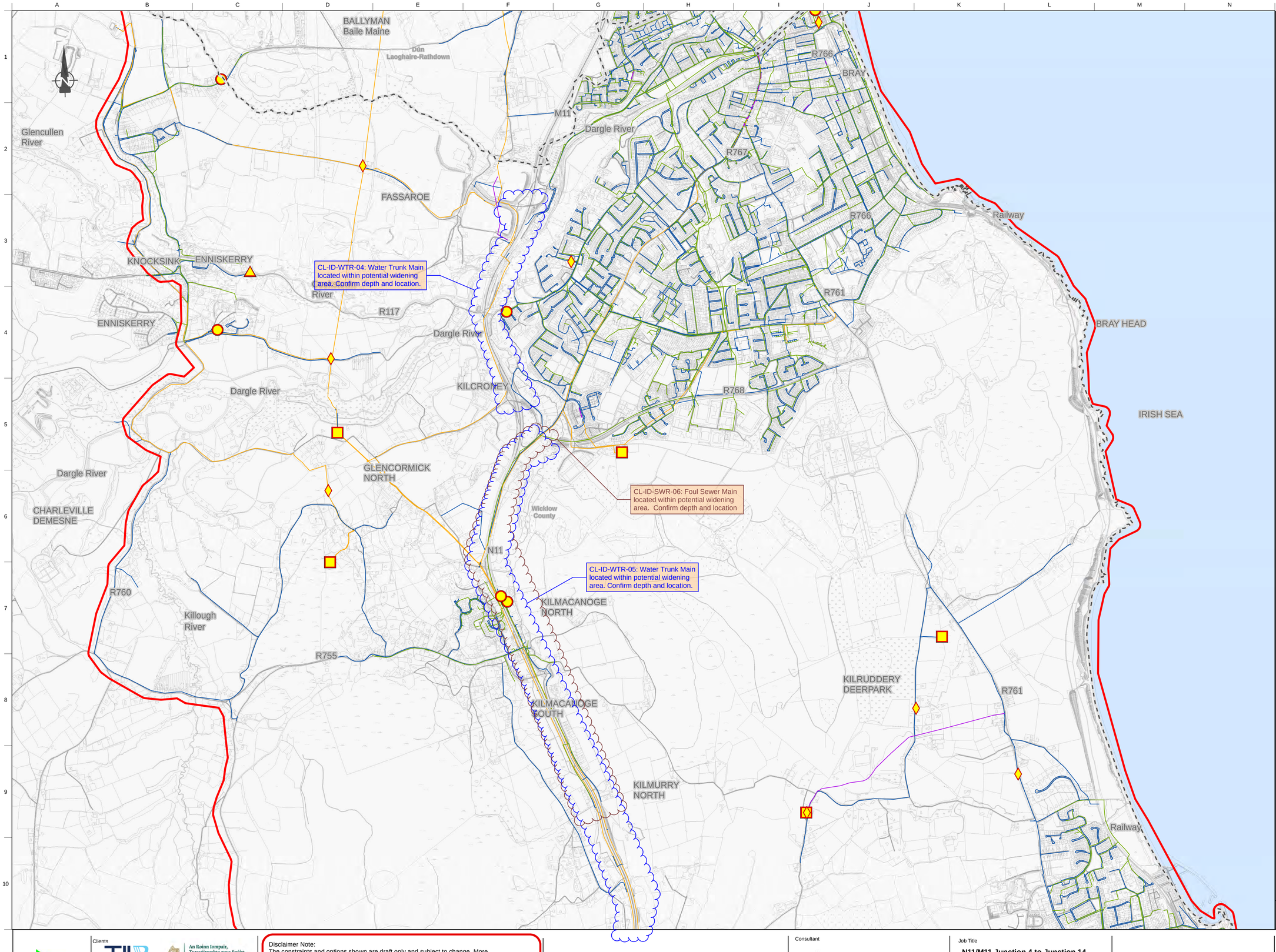
Issue	Date	By	Chkd	Appd
P02	28/05/2020	VB	MA	MA

Drawing Title
Irish Water Foul Sewer Infrastructure

Sheet 1 of 6
Drawing Status
Options Selection
Drawing No Figure 8.15
Issue P02

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OPTIONS SELECTION

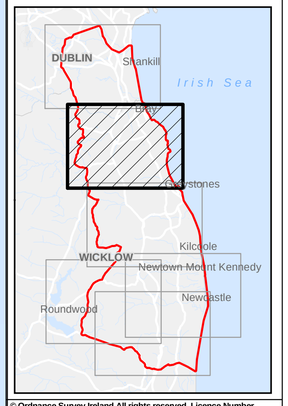
Legend:

- Study Area
- Local Authority Boundary
- Water Pump Station
- Treatment Plant
- Sewer Pump Station
- Reservoirs

Water Mains

- Trunk Main
- Distribution Main
- Water Network Abandoned Line
- Foul Sewer

Key Plan



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Job Title
N11/M11 Junction 4 to Junction 14 Improvement Scheme

Scale 1:25000 @ A3

Date October 2019

Issue	Date	By	Chkd	Appd
P02	28/05/2020	VB	MA	MA

Drawing Title
Irish Water Foul Sewer Infrastructure

Sheet 2 of 6

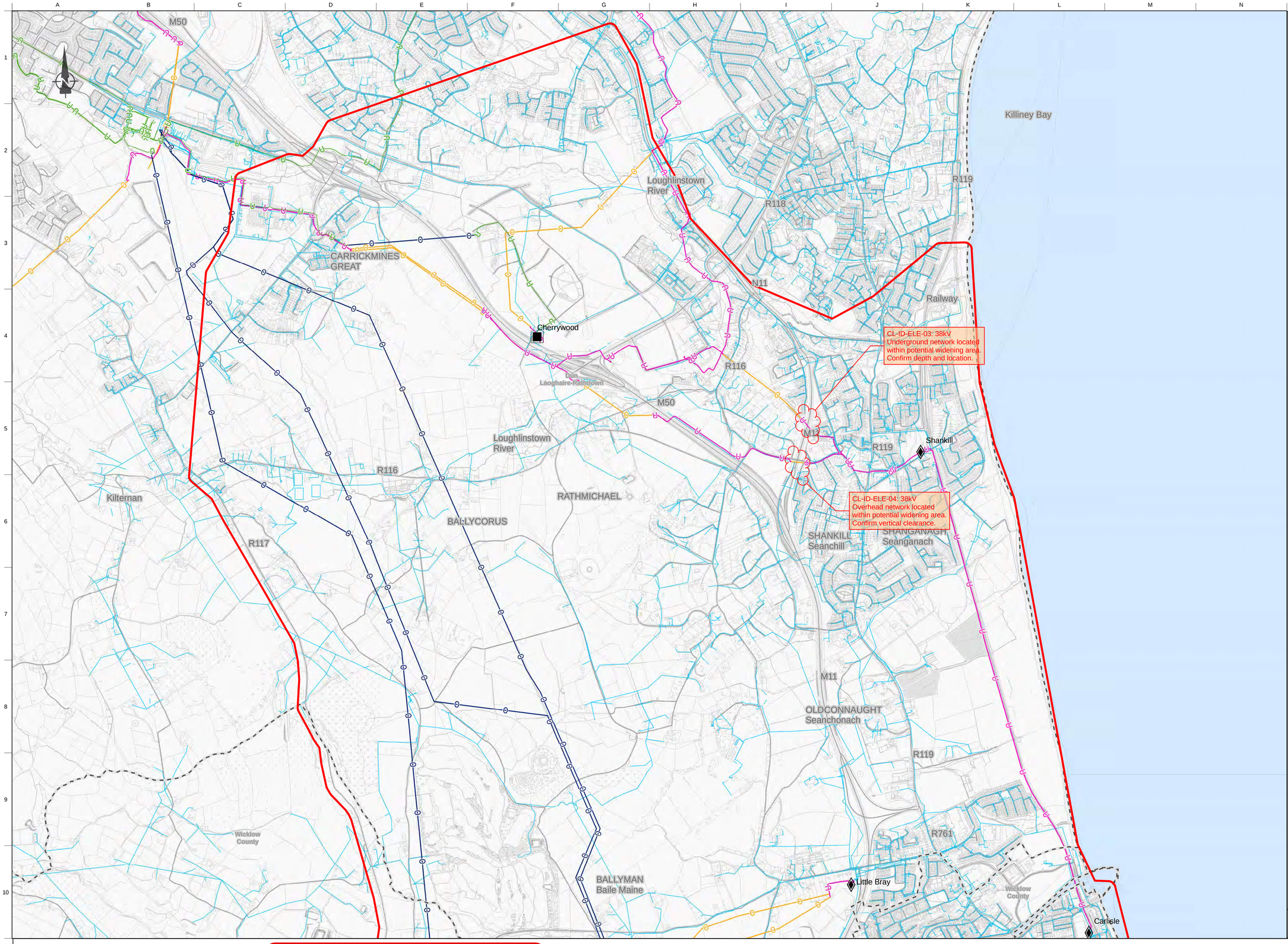
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Drawing No Figure 8.16

Issue P02

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OPTIONS SELECTION

Legend:

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- Local Authority Boundary

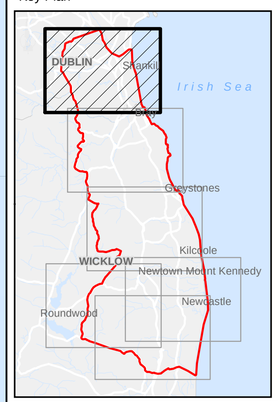
HV Substations

- 110kV
- 38kV

ESB Networks

- 110kV Underground Network
- 110kV Overhead Network
- 38kV Underground Network
- 38kV Overhead Network
- LV and MV Network

Key Plan



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Date October 2019

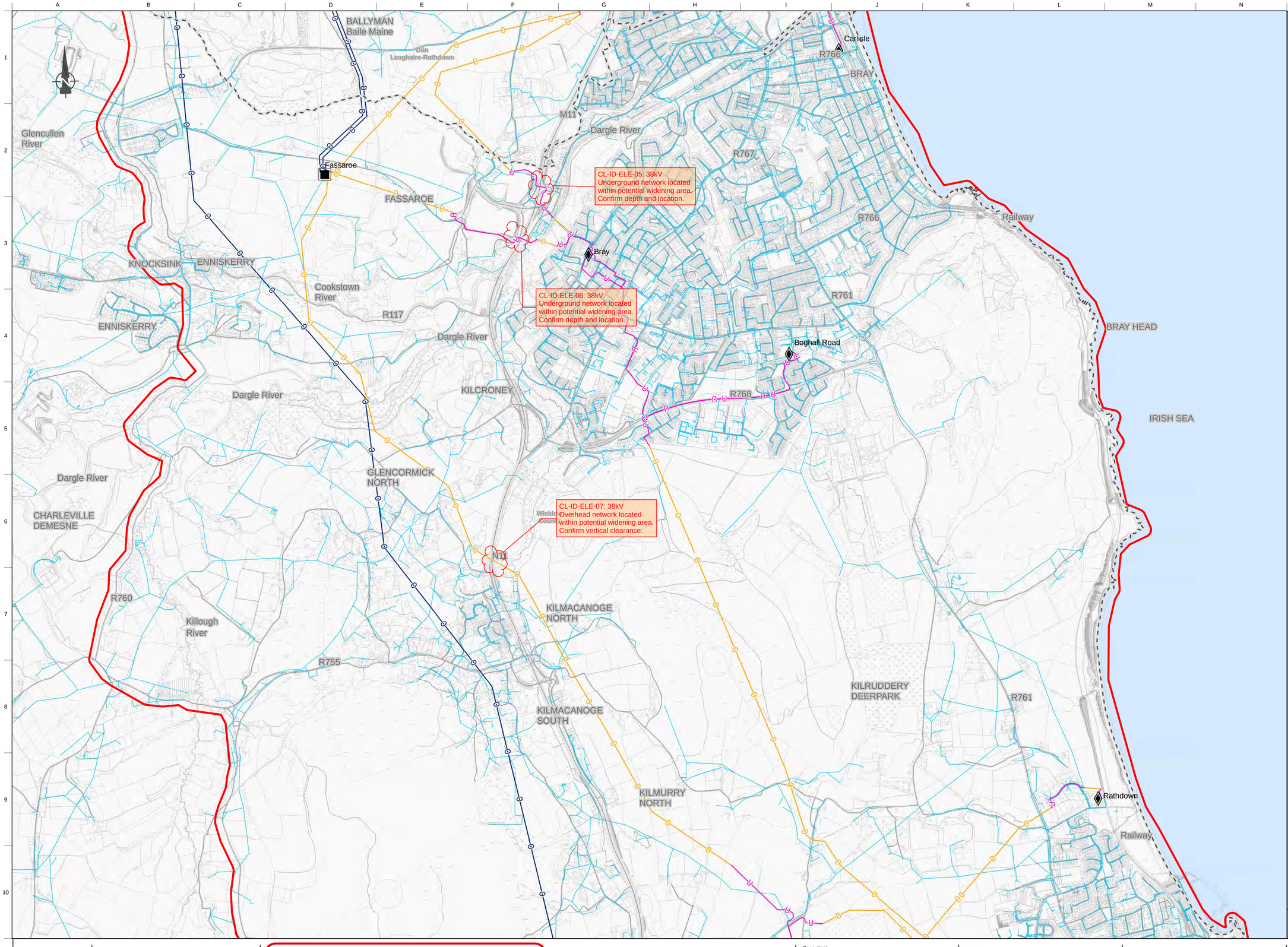
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P02	28/05/2020	VB	MA	MA

Drawing Title
ESB Networks Electricity Supply

Sheet 1 of 6
Drawing Status
Options Selection
Drawing No Figure 8.27
Issue P02

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OPTIONS SELECTION

Legend:

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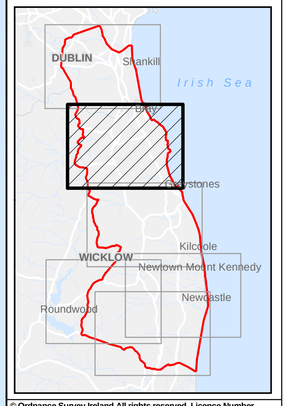
HV Substations

- 110kV
- 38kV

ESB Networks

- 110kV Overhead Network
- 38kV Underground Network
- 38kV Overhead Network
- LV and MV Network

Key Plan



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Job Title
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Scale 1:25000 @ A3
Date October 2019

Issue	Date	By	Chkd	Appd
P02	28/05/2020	VB	MA	MA

Drawing Title
ESB Networks Electricity Supply

Sheet 2 of 6
Drawing Status
Options Selection
Drawing No Figure 8.28
Issue P02

Do not scale

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Appendix E

Extent of Bus Priority

A1

FEASIBILITY

Section 1

MISSING SURVEY

LOUGHLINSTOWN ROUNDABOUT

DR-M11-004.30 STONEBRIDGE ROAD BRIDGE

Section 1

Section 2

DR-M11-003.00 CRINKEN LANE BRIDGE

JN4 - M50/M11

DR-M11-004.40 M11/M50 OVERBRIDGE

DR-M11-004.00 LORDELLO FOOTBRIDGE (BALLYBRIDE ROAD FOOTBRIDGE)

JN5 - BRAY NORTH WILFORD

Section 2

Section 3

DR-M11-001.00 OLD CONNAUGHT AVENUE BRIDGE

DR-M11-002.00 JUNCTION 5 OVERBRIDGE (COIS CARN M11 ON RAMP)

Section 3

Section 4

WW-N11-063.00 JUNCTION 6 OVERBRIDGE (DARGLE ROAD INTERCHANGE BRIDGE)

JN6 - BRAY CENTRAL

WW-N11-062.00 SAINT VALERY BRIDGE (VALERIE BRIDGE)

WW-N11-061.70 JUNCTION 6A FOOTBRIDGE (ENNISKERRY FOOTBRIDGE)

Section 4

Section 5

WW-N11-061.00 JUNCTION 7 OVERBRIDGE (WINGFIELD INTERCHANGE BRIDGE)

JN7 - BRAY SOUTH (KILCRONEY)

Section 5

WW-N11-060.00 KILMACANOGUE FOOTBRIDGE

JN8 - KILMACANOGE

LEGEND:

Extent of Bus Priority

Extent of Shared Bus Lane

DRAFT

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N11/ M11

Tionscadal Éireann Project Ireland 2040

Clients

Bonneagar Iompair Éireann Transport Infrastructure Ireland

An Roinn Iompair, Turasóireachta agus Spóirt Department of Transport, Tourism and Sport

WICKLOW ENDLESS OPPORTUNITIES CILL MHANTÁIN DEISEANNA SIORAÍ

Comhairle Contae County Council dlr

KILDARE NRO NATIONAL ROADS OFFICE NTA Údarás Náisiúnta Iompair National Transport Authority

Disclaimer Note:
The constraints shown are draft only and subject to change. More detailed assessments, on-going studies and the information received from the public may result in changes to these constraints.

Nóta Séanta:
Tá na srianta atá léirithe ina bhfoirm dréacht, d'fhéadfaí athraithe teacht orthu. Is mar thoradh ar mheasúnaithe níos mionchruinne, ar staidéar leanúnach agus ar eolas ón bpobal go ndéanfar athruithe ar na srianta seo.

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Job Title
N11 M11 Upgrade Scheme - Interim Bus Priority Measures J4 to J8

Scale 1:6250 @ A1

Date 29/09/2020

P01	29/09/2020	LH	MA	MA
Issue	Date	By	Chkd	Appd

Drawing Title
Extent of Bus Priority Achieved

Drawing Status
Feasibility

Drawing No 265455-ARP-HGN-BIS-SK-CH-0010

Issue P01

Do not scale

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Drawing File path & name: ...\\globaleurope\Dublin\Jobs\265000\265455-00\4. Interna\4-02 Drawings\4-02.13 Sketches\13.5 Bus Corridor 265455-ARP-HGN-BIS-CH-0010.dwg
User and Plot Date: ..., Liam-P Hartnett - 29.9.2020 - 4:51pm

Appendix F

Journey Time Benefits and High-Level Cost Estimate

Technical Note

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Project title	N11 / M11 Bus Priority Interim Scheme	Job number	265455-00
cc	John Bowes (WCC) Hugh Creegan (NTA) John Fitzsimons (TII)	File reference	
Prepared by	Danny Wicks / Liam Hartnett	Date	12 March 2021
Subject	Journey Time Benefits and High Level Cost Estimate		

1 Introduction

In July 2020, Arup was commissioned by the National Transport Authority (NTA) and Wicklow County Council (WCC) to develop proposals for the provision of bus priority measures on the N11/M11 national road. The scope required an engineering feasibility assessment to be undertaken on the Bus Priority Interim Scheme, which proposes priority in the form of a dedicated bus lane in the hard shoulder from Loughlinstown roundabout in the north to Kilmacanogue in the south.

Arup completed the Phase 1 Engineering Feasibility Assessment on the N11 / M11 Bus Priority Interim Scheme, submitting the feasibility assessment report on 29 September 2020. This demonstrated that the scheme was feasible from a technical perspective, however it raised some operational concerns for the scheme, including the limited extent of full bus priority and high proportion of interaction with merging and diverging traffic streams.

Considering the above, some additional assessments have been carried out as part of an initial element of the Phase 2 Option Selection process.

The focus of the investigations have been on:

- Assessing the high-level journey time benefits of the current scheme. This has included analysis on existing travel speeds and journey times along the existing corridor, as well as comparisons with other bus priority projects currently in operation; and
- Assessing the likely costs for the scheme. Using the feasibility design as a basis, an order of magnitude cost estimate has been developed which is appropriate for the level of design information currently available.

The purpose of this technical note is to present the findings of the above investigations and provide recommendations on advancing the Bus Priority Interim Scheme through Phase 2 (Option Selection).

2 Journey Time Benefits Assessment

2.1 Assumptions / methodology

The journey time benefits of the feasibility design have been assessed based on the following methodology:

- Existing speed data on the N11 / M11 corridor has been extracted from two sources - journey time data from traffic surveys and existing TII counters sited on the route. The journey time data was obtained directly from traffic surveys undertaken in May 2019 as part of the Phase 1 – 4 N11/M11 Junction 4 to Junction 14 Improvement Scheme.
- As outlined in the Feasibility Assessment Report, full bus priority is achieved on approximately 42% and 44% of the northbound and southbound carriageways of the N11 / M11 corridor respectively. In these areas, it has been assumed that the bus operates at the baseline speed of 80 km/h, or no more than 15-20 km/h above the speed of the adjacent general traffic lane, whichever is less.

  It should be noted that the original brief for the Feasibility Assessment stated that a maximum speed limit of 60 km/h should apply for the bus lane. The analysis conducted on existing speeds however suggested that a posted speed limit for buses of at least 80 km/h was required in order to achieve an advantage for buses over general traffic on the N11 / M11. This was deemed appropriate from an engineering and safety perspective as the bus lane feasibility design has been based on a design speed of 85 km/h.
- In areas where full bus priority cannot be provided, i.e. where the bus is expected to mix with general traffic in merge / diverge areas or parallel service roads, analysis has been undertaken to determine the expected congestion in these areas based on the volumes of traffic entering and exiting the N11 at the junction in question.

  Expected bus speeds in these weaving areas have been factored down from the baseline, depending on the level of congestion expected in each mixed traffic area.
- The average expected bus speeds have then been calculated along the corridor, and these yield the expected bus journey times along the entire corridor.

Further detail on the process and results is provided in the following sections.

2.2 Existing traffic speeds on N11 / M11

Existing speed data has been extracted along the existing N11/M11 between Junction 4 and Kilmacanoge from the following sources:

- Journey time surveys conducted by Tracsis on the 29th May 2019:
  - AM Period: 07:00 – 10:00
  - PM Period: 16:00 – 19:00
- TII counter data from October 2019:
  - AM Peak Hour: 08:00 – 09:00
  - PM Peak Hour: 17:00 – 18:00

It should be noted that the journey time surveys by Tracsis represent an average speed over a 3-hour period, rather than the speeds during the peak hour and therefore generally report higher speeds than the TII counter data.

Additionally, journey time surveys by Tracsis are not specific to any lane, while the TII counter data relates to the leftmost (i.e. nearside) general traffic lane. The TII counter data indicates that traffic in the leftmost lane generally travels at speeds around 5km/h lower than the average for all lanes, and this observation was used to adjust average speeds from the journey time surveys at a later point in the analysis.

The existing speed data has been collated in the key sections along the corridor and is presented in Table 1 and Table 2.

Table 1: Northbound carriageway AM peak - existing speeds

Location	Average Speed (km/h) - Survey	Average Speed (km/h) - TII
Junction 8 - Junction 7	68	48
Junction 7 - Junction 6	71	53 (interpolated)
Junction 6 - Junction 5	82	58
Junction 5 - Junction 4	91	80

During the AM Peak, speeds within the corridor are slowest at the southern extents of the proposed project near Kilmacanogue, where average speeds of 68 km/h (survey) / 48 km/h (TII counters) have been recorded. This steadily increases within each section, and average speeds increase to a maximum of 91 km/h (survey) / 80 km/h (TII counters) between Junction 5 and Junction 4.

Table 2: Southbound carriageway PM peak - existing speeds

Location	Average Speed (km/h) - Survey	Average Speed (km/h) - TII
Junction 4 - Junction 5	33	47
Junction 5 - Junction 6	56	46
Junction 6 - Junction 7	60	60 (interpolated)
Junction 7 - Junction 8	78	78

During the PM Peak, mainline traffic is generally slowest around Junction 4 as the M11 merges with southbound traffic from the M50. Average speeds of 33 km/h (survey) / 47 km/h (TII counters) have been recorded. This steadily increases moving south along the corridor, and average speeds increase to a maximum of 78 km/h (survey) / 78 km/h (TII counters) on approach to Kilmacanogue junction.

2.3 Expected congestion of auxiliary lanes

Analysis of flows has been undertaken at each junction merge and diverge to determine the likely level of congestion, and ultimately the likely reduction in bus speeds within these areas.

Analysis has been conducted as follows:

- Junction turning count and ANPR origin-destination data from surveys conducted by Tracsis on the 28th and 29th May 2019 was used to establish the flows of traffic on the N11 mainline and entering and exiting the N11 at each junction.
- Each mixed zone where the proposed bus lane would be shared with general traffic has been classified as having a heavy, medium, or light volume of general traffic.
- Likely bus speeds for the proposed scheme have been determined as a range (upper and lower bound) based on the existing traffic speeds, which have been adjusted to account for the traffic congestion classification as follows:
    - Where entering / exiting traffic is heavier (heavy / medium classification), the range of bus speeds have been reduced to substantially lower than the nearside general traffic lane (i.e. the speed ranges lower than the average nearside lane speed).
    - Where entering / exiting traffic is lighter (medium / light classification), the range of bus speeds have been reduced to slightly lower than the nearside general traffic lane (i.e. the speed ranges closer to the average nearside lane speed).

While this approach contains some limitations relative to detailed traffic modelling, it is considered appropriate at this stage for determining the high-level journey time benefits based on the level of information currently available. It is recommended that this is supported with additional analysis and detailed traffic modelling in future stages.

The congestion analysis and flows are provided in **Appendix A,** and the derived bus speeds are presented in the following sections.

2.4 Expected bus speeds – proposed case

The expected bus speeds within the mixed traffic areas have been derived based on the congestion analysis as outlined in Section 2.3. This approach yields an upper and lower bound for proposed bus speeds within the mixed areas of the corridor and can be compared with the existing traffic speeds in adjacent lanes (TII counter and survey data). This is presented in the purple sections along the corridor in Figure 1 and Figure 2. The red sections in the figures represent areas where full bus priority has been provided, and the bus is assumed to be operating at 80 km/h, or no more than 15-20 km/h above the speed of the adjacent general traffic lane.

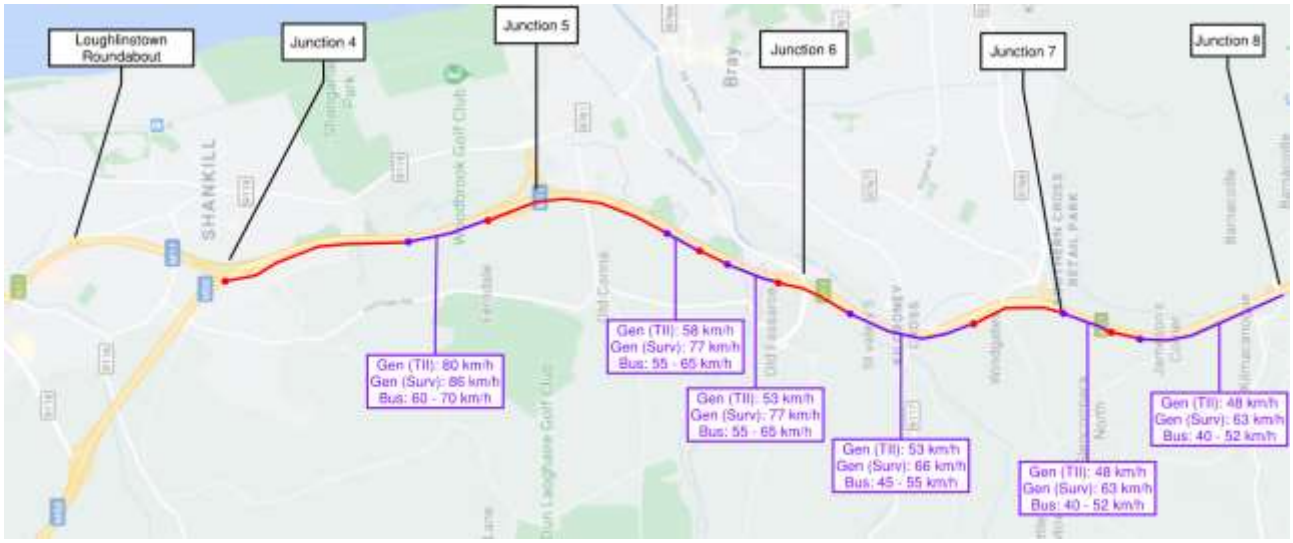


Figure 1: Expected bus speeds vs. general traffic speeds (TII counter data) - AM Peak Northbound



Figure 2: Expected bus speeds vs. general traffic speeds (TII counter data) - PM Peak Southbound

As illustrated above, the lower bound bus speeds are generally expected to be somewhat lower than general traffic speeds. The upper bound bus speeds are generally expected to be equivalent to or somewhat above the general traffic speeds.

A review has been undertaken of speeds on currently operating hard shoulder bus lane schemes on the Dublin road network, including the N3, N4 and N7. The table below presents the speed differential between the bus lane and general traffic lanes. These have been extracted from TII counter data.

Table 3 - Bus vs mainline speeds on other schemes

Location	Peak Period	Bus Speed (km/h)	Traffic Speed (km/h)	Differential (km/h)
N3 – Southbound (South of JN 3)	AM Peak	50.69	43.91	6.78
N4 – Eastbound (Between JN 2 and JN 1)	AM Peak	40.37	40.11	0.26

Location	Peak Period	Bus Speed (km/h)	Traffic Speed (km/h)	Differential (km/h)
N4 – Eastbound (Between JN 4 and JN 3)	AM Peak	61.29	68.74	-7.45
N4 – Westbound (Between JN 2 and JN 1)	PM Peak	58.2	61.77	-3.57
N4 – Westbound – (Between JN 4 and JN 3)	PM Peak	66.26	63.04	3.22
N7 – Westbound (West of JN 1)	PM Peak	51.5	45.86	5.64

The effect of bus lanes on speeds relative to general traffic generally tends to be mixed. While there are some positive differentials on the sections of the N3, N4 and N7 these are not substantial improvements to bus speeds relative to general traffic. Additionally, on sections of the N4, bus speeds are in some cases lower than general traffic speeds.

2.5 Expected bus journey times

Based on applying average speeds along sections of the N11/M11 corridor as outlined previously, expected upper and lower bound bus journey times have been calculated. These are presented in Table 4, and have been compared with lower and upper bound general traffic journey times. An expected range of journey time benefits (and disbenefits) for buses, relative to general traffic, can then be derived.

Table 4 - Expected Bus vs General Traffic Journey Times

Peak Period / Direction	Journey Time – General Traffic (Lower)	Journey Time – General Traffic (Upper)	Journey Time – Bus (Lower)	Journey Time – Bus (Upper)
AM Peak – Northbound	5 min 56 sec	7 min 44 sec	6 mins 40 sec	8 mins 15 sec
PM Peak – Southbound	8 min 12 sec	9 min 38 sec	7 mins 30 sec	10 mins 12 sec

- During the AM Peak in the northbound direction, expected journey time savings for a bus range from a benefit of 1 minute and 5 seconds to a disbenefit of 2 minutes and 20 seconds.
- During the PM Peak in the southbound direction, expected journey times savings for a bus range from a benefit of up to 2 minutes and 7 seconds to a disbenefit of up to 1 minute and 56 seconds.

The analysis suggests journey time savings for buses over general traffic are moderate in nature. In some instances, it is also possible that bus journey times may be slower than general traffic.

This can be attributed to the limited extent of full bus priority provided along the N11 / M11 corridor. With the proposed feasibility design, buses are required to mix with general traffic for over 50% of the corridor length. With the expected high levels of congestion in these areas, significant journey time savings for a bus are unlikely to be achieved in the absence of additional measures to provide increased bus priority (e.g. ramp metering, junction closures, parallel service roads etc.).

The M1 and M2 Bus Lane schemes in Belfast are two recent examples of hard shoulder bus lane implementation on motorways in Ireland. Both of these schemes have been viewed as successful, with post-implementation journey time savings recorded on the schemes as follows:

- On the M1, bus lanes run inbound and outbound, for approximately 7 km, from Junction 8 to the city centre. Journey time savings of up to 7 minutes have been recorded post-implementation.
- On the M2, bus lanes run inbound and outbound, for 4 km, from Junction 4 to the city centre. Through junction running is not a feature of the bus lanes on the M2. Instead, the bus lanes diverge at junctions and re-enter the mainline along the same junction merge. Journey time savings of up to 4 minutes have been recorded post-implementation.

It should be noted the above journey time savings represent a comparison between pre and post implementation journey time savings for a bus, rather than a comparison with general traffic. Additionally, the M1 and M2 have a far lower number of junctions and accesses within these sections and therefore are able to provide much higher proportions of full bus priority.

From a journey time perspective, it can still be acknowledged that these outcomes for the M1 and M2 provide impressive time savings. However, journey time savings alone may not be the best factor for determining the success of these bus priority schemes. There are other factors and wider benefits of the M1 and M2 schemes which have contributed to their success.

2.6 Wider benefits of bus priority schemes

Park and Ride facilities have been provided in numerous locations along the M1 and M2 corridors, including Ballygawley, Tamnamore, Loughview, and Sprucefield along the M1 and Toomebridge, Castledawson, and Ballee on the M2 corridor. The major bus routes to Belfast along the M1 and M2 corridors have been adjusted to include stops at these locations, enabling a dispersed rural population to conveniently access frequent bus services to Belfast.

It could be expected that these facilities have contributed to the end to end journey convenience for users. Figure 5 illustrates the extent of the M1 and M2 Belfast schemes, and provision of such facilities along the corridors.



Figure 5: Schematic of M1 and M2 - Belfast bus lane schemes

The provision of Park and Ride facilities alongside bus priority measures is in line with sustainable transport policy to encourage modal shift to public transport and away from private cars. It is understood that the National Transport Authority (NTA) is in the process of developing and Park and Ride Strategy for the N11/M11 corridor, and recommended that such facilities are considered as a component of the bus priority measures during the option selection phase.

In the case of the N11/M11 corridor, the time spent travelling on the actual N11/M11 road is likely to represent only a small component of the user's total end-to-end trip time. People spend time travelling from their homes to access the N11 and spend further time completing their trip to locations within the Greater Dublin Area (GDA) off the N11/M11 corridor. The relative attractiveness of the bus priority interim scheme proposed, may ultimately depend on the provision of bus services which more conveniently and reliably serve the end-to-end trip than the private car, as distinct from any (short) journey saving on the N11/M11 alone. It is recommended that further investigations into the type, frequency and reliability of bus services be undertaken during the option selection phase.

3 High Level Cost Estimate

3.1 Assumptions / methodology

This section details the assumptions and methodology applied in developing the High-Level Cost Estimate for the Bus Priority Interim Scheme. The schedule of rates and High-Level cost estimate is presented in full within **Appendix B**. It should be noted that the estimate is for Main Construction Cost only, and does not include costs for items such as Planning and Design, Land and Property, Archaeology etc.

Rates have been sourced and benchmarked against the following:

- Estimate costs for the M7 Naas to Newbridge Bypass Upgrade Scheme, using cost information supplied by Kildare National Roads Office (KNRO);
- Estimate costs prepared for other TII schemes, including the N11/M11 Main Scheme and N40;
- TII Schedule of Rates (2019)[1]

The methodology of developing the quantities and rates for each discipline are outlined in the following sections.

3.1.1 Site Clearance

A site clearance area was determined using the following approach:

- For section 1, the site clearance perimeter was determined by taking an 8m offset from the edge of existing pavement. The larger offset applied in Section 1 takes account of the lack of survey available, and therefore a lack of information on existing conditions in this area. Thus, a more conservative boundary has been assumed.
- Survey was available for the remaining sections; Section 2, Section 3, Section 4 and Section 5 and therefore a smaller offset of 5m was assumed. This offset was taken from the design edge of pavement or, where applicable, the design earthworks ground interface.
- A rate of 4,000 €/ha has been applied for site clearance. This is a more conservative rate in comparison to the TII Schedule of Rates which is more appropriate due to the constrained nature of the corridor.

3.1.2 Fencing

- It has been assumed that new timber and rail boundary fencing would be required where the site clearance perimeter extended beyond the existing fence line/boundary or where there were gaps in the existing fencing. An example of the fencing extents around Junction 7 is illustrated in Figure 6.
- A rate of 30 €/m has been applied for fencing within the cost estimate which is consistent with the TII Schedule of Rates 2019.

[1] Transport Infrastructure Ireland, TII Schedule of Rates (CC-GMP-00054), October 2019



Figure 6: Proposed fencing at Junction 7

3.1.3 Safety Barriers

As noted in the Feasibility Report, existing Vehicle Restraint Systems (VRS) along the N11/M11 do not conform to modern TII standards. Due to the proposed widening works, new safety barriers are required on the Bus Priority Interim Scheme on both the median and the verge side.

The following assumptions were made for safety barrier provision in compliance with the design of safety barriers as set out in *DN-REQ-03034 The Design of Road Restraint Systems (Vehicle and* Pedestrian*) for Roads and Bridges*:

- On the median side, a Vertical Concrete Barrier (VCB) is required along the full length of the median. This would achieve a minimum H2 level of containment. At Overbridges and structures along the median it is assumed the VCB will split in two and pass around a structure pier, providing a working width of W2.
- On the verge side, a VCB is required at locations where hazards such as bridge piers / gantry supports require protection. A length of 65m with containment level H2 has been assumed for each such major hazard within the verge along the corridor. This allows for an approach length of 30m, departure length of 15m, assumed hazard length of 10m and terminal lengths of 5m each.
- A rate of 85 €/m was applied for VCBs in the verge and median within the cost estimate. This rate is consistent with the TII Schedule of Rates 2019 and also reflects costs accrued on previous schemes such as the M7 Naas to Newbridge Bypass Upgrade

3.1.4 Drainage and Service Ducts

- The extent and state of existing drainage infrastructure along the N11/M11 is largely unknown. As discussed in the Feasibility Report, it has been assumed that the existing drainage infrastructure would be removed and replaced with new drainage infrastructure along the full length of the Interim Bus Lane Scheme.
- A rate of 460,000 €/km has been applied for the provision of new drainage along the length of the scheme. This is a per km rate which has been derived from the drainage costs for the M7 Naas to Newbridge Bypass Upgrade, a widening scheme located in a similarly constrained environment.

3.1.5 Earthworks

Cut and fill earthworks quantities have been extracted from the feasibility design 3d model. Given this is an online widening scheme, the extent of earthworks on the project is limited and predominantly involves cutting into existing cut slopes to allow for the widened cross section.

The following rates have been applied for the various earthworks elements:

- Excavation of acceptable material – 4.30 €/m^3
- Disposal of acceptable material – 4.50 €/m^3
- Deposition of acceptable material in embankments (Cut to Fill) - €5.30

These are extracted from the upper band rates of the TII Schedule of Rates (2019).

3.1.6 Pavement

The following approach has been assumed for pavement works:

- All pavement widening areas require new full depth pavement construction (sub-base, base, binder and surface course). Pavement widening areas have been defined as areas where the proposed pavement edge extends beyond the existing pavement edge. No additional allowance has been made to extend the proposed pavement edge on the inside to a lane line / centre of lane. An example of pavement widening area is shown in Figure 7.
- In addition to areas of new pavement construction in widening areas, it has been assumed that the Bus Priority Interim Scheme will rehabilitate existing pavement in non-widening areas. This has been defined as removal and replacement of the surface and binder courses. An example of the existing pavement extents is Figure 8.
- The extent of regulating course required is currently unknown and a separate allowance for this has not been made at this stage.

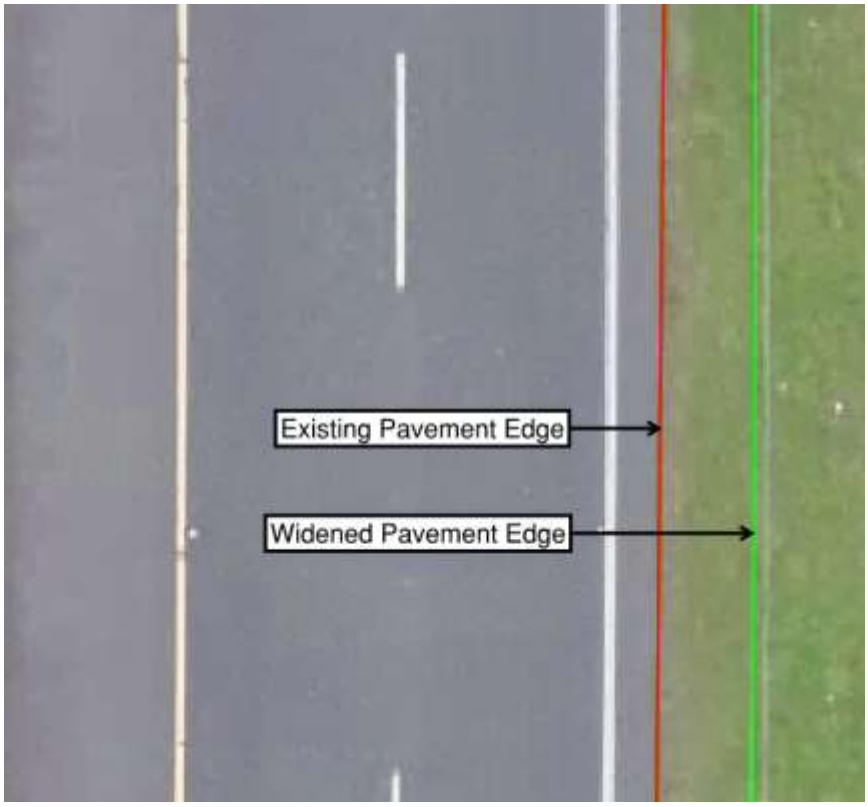


Figure 7: Example of pavement widening to the median



Figure 8: Existing pavement extents

The following rates have been applied for the various elements of pavement construction:

- Sub-base, Granular Type B to Clause 804, 150mm thick – 25 €/m^3
- Base Course (AC 32 Dense base 40/60) – 18 €/m^3

- Binder Course (AC 20 Dense bin 55mm) – 15 €/m^3
- Surface Course (SMA 40mm) – 12 €/m^3

These are extracted from the TII Schedule of Rates (2019) and sit between the lower and upper bands of the rates.

3.1.7 Kerbs, Footways and Paved Areas

- An allowance of 7,356 €/km has been applied for the provision of kerbs, footways and paved areas along the length of the scheme. This is a per km rate which has been derived from the costs for the M7 Naas to Newbridge Bypass Upgrade.

3.1.8 Traffic Signs & Road Markings

- An allowance of 45,753 €/km has been applied for the provision of general traffic signs and road markings along the length of the scheme. This is a per km rate which has been derived from the costs for the M7 Naas to Newbridge Bypass Upgrade and is expected to cover the relocation of impacted signage, and re-application of line markings to suit the revised alignment for the scheme.
- Additional signage associated with the bus lane scheme has been allocated based on guidance outlined in the emerging TII standard for the implementation of bus lanes on motorways and dual carriageways. The standard calls for signage at entry points – including all merges, exit points – including all diverges and at 1km intervals. Signage should be positioned in the nearside verge and display full operational speeds.
- A rate of €5000/sign has been allocated for the specific bus lane signage based on a desktop review of the sign sizes adopted on the M1 Belfast scheme. The rate represents the upper bound of the TII Schedule of Rates for a sign approximately $10m^2$ supported by three tubular posts. It is noted that this is based on limited availability of information and is subject to change in future stages.

3.1.9 Lighting and Electrical

- An allowance for lighting and electrical has been made based on scheme scope and costs accrued on previous schemes. A rate of 27,613 €/km has been applied for the provision of lighting along the length of the scheme. This is a per km rate which has been derived from the costs for the M7 Naas to Newbridge Bypass Upgrade, and is also expected to cover the relocation of impacted light poles.

3.1.10 Landscaping and Environmental

- An allowance of 23,334 €/km has been applied for landscaping works along the length of the scheme. This is a per km rate which has been derived from the costs for the M7 Naas to Newbridge Bypass Upgrade.

3.1.11 Structures

- Allowances for remedial works to the M11/M50 Overbridge and St. Valery's bridges have been made based on the extent of works on the bridges.
- A rate of 210 €/sq.m has been applied, which is expected to cover remedial works including removal existing concrete verges, widening of trafficable areas, replacement of parapets etc.
- It should be noted that for the purpose of the high level cost estimate, this rate has been developed by discounting rates for new bridge works and the ultimate costs for bridge remedial works are subject to a higher degree of change with further information becoming available in future stages.

3.1.12 Accommodation Works

At this stage, it is not envisaged that any accommodation works are required to deliver the scheme. It is expected that any widening spilling beyond the road boundary would be prevented by employing retaining walls and / or steepened slope treatments.

3.1.13 Statutory Authorities & Utilities

The high-level cost estimate has been developed prior to the undertaking of site investigation works, therefore the impacts on utilities and utility diversions are currently not known. Considering the above, the following approach has been taken:

- A general allowance of €1,250,000 has been made for costs associated with statutory authorities and utilities. This allowance has been made based on an estimated proportion of total contract cost only, and these costs are subject to a high degree of change.
- Separately, a specific allowance of €4,000,000 has been made for potential impacts to the gas transmission line which is located beneath the median of the N11 between Junction 6 and Junction 7, extending to Kilmacanogue. At this stage, a conservative assumption that the Above Ground Installation (AGI) requires removal and relocation has also been made. The cost is based on similar lengths of gas transmission main relocations (including AGI) on the N7 Newlands Cross Upgrade.

  It should be noted that the impacts to the gas main require further investigation and stakeholder discussions in future stages. Solutions to retain the gas main in place and protect it in areas of reduced cover should also be investigated in future stages.

3.1.14 Preliminaries

- A 20% rate has been applied for Preliminaries.
- A separate allowance has been made for traffic management at €127,500 / km / carriageway. This rate is considered to be on the higher end for traffic management, and appropriate for the constrained nature and multiple accesses on the N11 / M11, which can be expected to reduce construction staging efficiency. The development of this rate has considered per kilometre rates on recent schemes including the M7 Naas to Newbridge Bypass Upgrade.

3.1.15 Risk Contingency

- A 30% risk contingency has been allowed which is considered to be appropriate for this stage of design development.

3.2 Main Construction Contract Cost

The Main Construction Contract (MCC) cost and breakdown by discipline is presented in Table 5.

Table 5: Total Main Construction Contract (MCC) cost

Discipline	**Cost**
Site Clearance	€183,264
Fencing	€260,100
Safety Barriers	€1,005,152
Drainage and Service Ducts	€3,978,862
Earthworks	€189,724
Pavement	€10,726,260
Kerbs, Footways and Paved Areas	€63,626
Traffic Signs & Road Markings	€525,748
Lighting and Electrical	€238,844
Landscaping & Environmental	€201,835
Structures	€607,824
Statutory Authorities and Utilities	€5,250,000
Preliminaries	€6,851,921
Project Specific Risk Contingency @ 30%	€8,978,148
MCC Base Cost Total (excl. VAT)	**€39,108,108**
Add VAT @ 13.5%	€5,252,217
MCC Base Cost Total	**€44,387,703**

The total MCC cost of the scheme has been determined as approximately **€39,108,108** excluding VAT, and approximately **€44,387,703** including VAT. As outlined previously, this has been developed based on the limited information available at the current stage of design, and is subject to change in future stages. The cost estimate is provided in further detail within **Appendix B**.

4 Further investigations / Alternatives

As outlined in Section 2.5, the expected journey time savings of the feasibility design are limited. This can largely be attributed to the limited extent of full bus priority on the corridor, and the high levels of congestion in shared bus / general traffic areas. Considering the above, alternatives to improving these journey time savings have been initially investigated. These are discussed in the following section and may be further investigated in Phase 2 (Option Selection) of the Bus Priority Interim Scheme.

4.1.1 Ramp metering

The implementation of ramp metering on the N11 / M11 would provide improved bus priority in the merge areas along the scheme. The reduced interaction between buses and general traffic would provide opportunities for the bus to operate closer to 80 km/h within these areas. This can be expected to have a relative improvement to the journey times savings estimated in Section 2.5, and also improve the journey time reliability along the corridor.

Notwithstanding the above, the wider network impacts of implementing ramp metering need to be understood. Ramp metering could potentially cause a build-up of congestion on the roads feeding the N11 / M11, leading to adverse impacts on the arterial and local road networks. This additional congestion on connector roads could also cause additional queuing on the diverge slip roads, negating the improvements to bus priority achieved on the merges.

It should be noted that along the N11 / M11 corridor, the existing slip road geometry is generally sub-standard. The geometry may not be suitable for retrofitting ramp metering and further modifications to the slip road geometry may be required. It is also likely that the slip roads may not have adequate storage for ramp metering to operate successfully. This requires further consideration and investigation in future design stages.

4.1.2 Contraflow bus lane – median side

An alternative to the nearside hard shoulder bus lanes, as presented in the feasibility design, involves providing a fully segregated contraflow bus lane along the median. The contraflow bus lane would run northbound during the AM Peak and southbound during the PM peak, terminating between Crinken Lane bridge and Junction 5 at the northern end, and south of Junction 8 at the southern end.

This type of facility essentially eliminates bus interaction with general traffic for a large proportion of the corridor. A bus can therefore operate at 80 km/h along the route from Junction 8 to Junction 4 and vice versa, only interacting with general traffic upstream / downstream of the entry / exit points. This can be expected to improve journey time reliability and optimise the journey time savings along the corridor. Based on the methodology applied in Section 2.5, the following savings can be expected:

- During the AM Peak in the northbound direction, expected journey time savings for a bus ranging from between a benefit of 2 minute and 3 seconds and a benefit of 15 seconds.

- During the PM Peak in the southbound direction, expected journey times savings for a bus ranging from between a benefit of 3 minutes and 32 seconds and a benefit of 2 minutes and 7 seconds.

It should be noted that this option would have significant impacts to the overbridges along the corridor. The median alignment impacts on existing piers located within the central median, as illustrated in Figure 10 at Old Connaught Avenue Bridge.

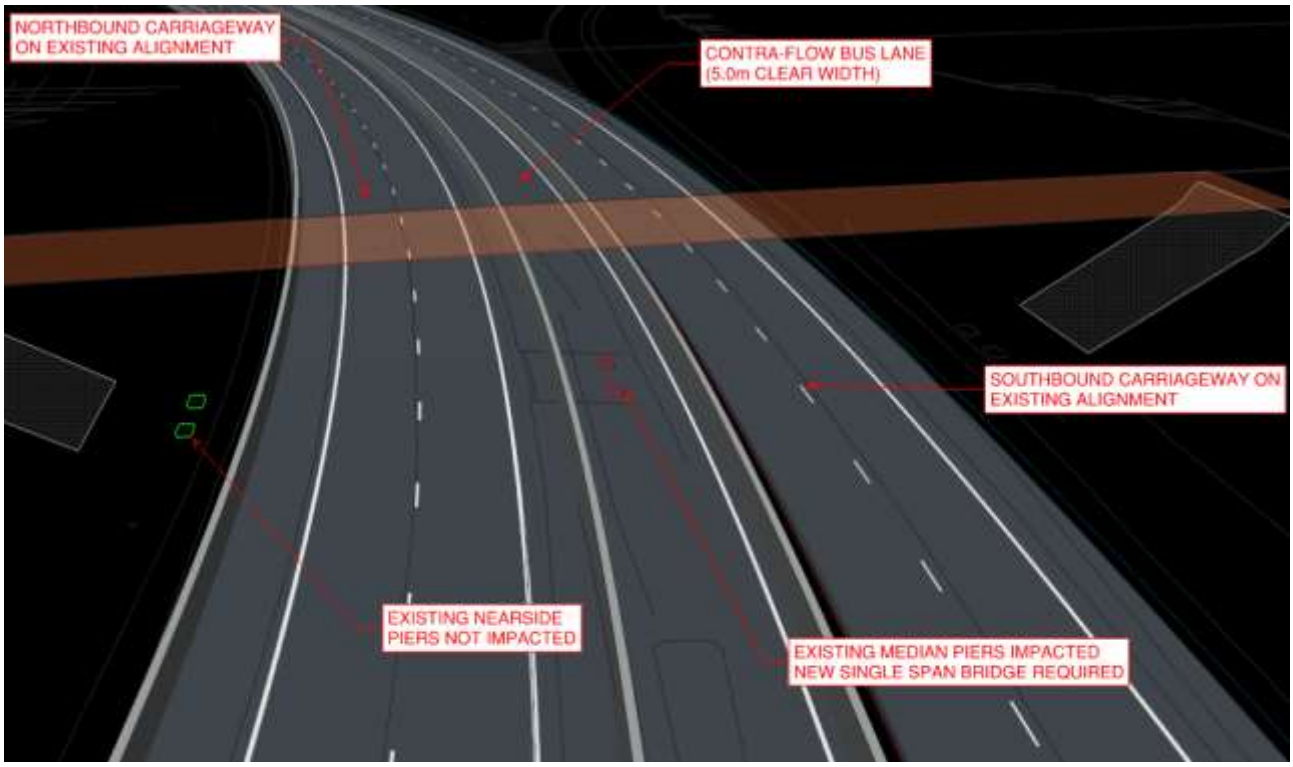


Figure 10: median contra-flow bus lane (no re-alignment)

Demolition and reconstruction to single-span bridges would be required for the following overbridges:

- Junction 5 overbridge
- Old Connaught Avenue bridge
- Junction 6 overbridge
- Junction 7 overbridge
- Junction 8 overbridge

While a cost estimate has not been developed at this stage, it can be expected that there would be significant costs associated with the demolition and reconstruction of these bridges.

In addition, a new overbridge would be required in the median at St Valery's crossing. Due to the insufficient space between the existing bridges, it can be expected that this would require re-alignment and reconstruction of at least one of the mainline bridges. This could have significant costs and construction challenges associated, which require further investigation in future stages.

A sub-alternative for the contraflow bus lane within the median is to re-align at the overbridges to avoid impact on the central piers. It should be noted however, that this requires the adjacent mainline carriageway to be re-aligned. The mainline carriageway re-alignment must achieve a design speed of 120 km/h in the motorway sections and 100 km/h in the dual carriageway sections of the N11 / M11.

A preliminary investigation of this suggests that piers / abutment slopes within the nearside hard shoulder may be impacted when a consistent cross section is adopted. This is illustrated in Figure 11 at Old Connaught Avenue Bridge.

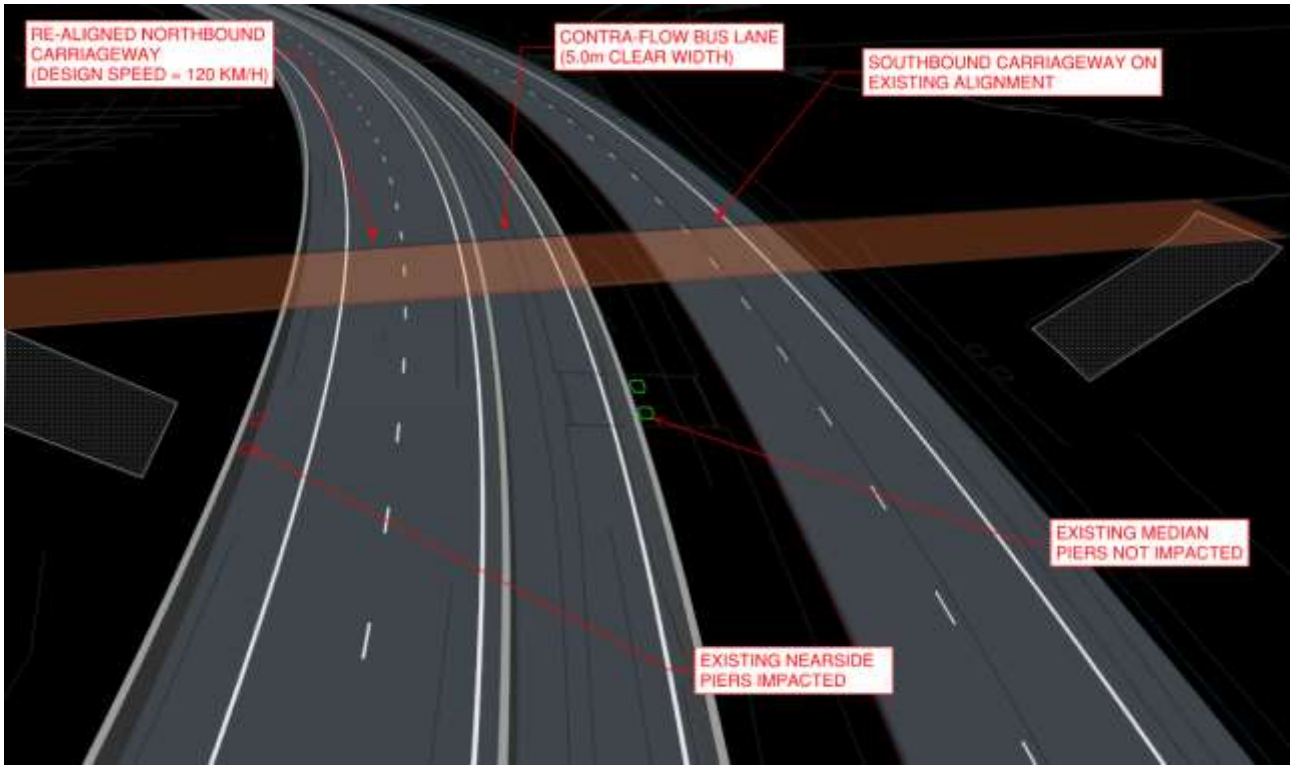


Figure 11: median contra-flow bus lane (with re-alignment)

Considering the above, departures may be required for a reduced mainline cross section and stopping sight distance (SSD) at these structures. This would require further investigation in future design stages.

4.1.3 Parallel Service Roads

The provision of parallel service roads between Junction 6 - Bray North and Junction 7 – Bray South, is one option being investigated as part of the main N11/M11 scheme. The aim of parallel service roads is to take local traffic off the N11/M11 mainline, reducing the extent of weaving traffic in the most congested area of the scheme.

This would provide improved priority for buses operating within the hard shoulder of the mainline due to the reduced interaction with weaving traffic. The construction of the parallel service roads between Junction 6 and 7 could be undertaken as early works for the main scheme, or as part of the Bus Priority Interim Scheme. The early construction and opening of this section of parallel service roads would allow for improved operation of the Bus Priority Interim Scheme on opening.

It should be noted that the parallel service roads proposed for the ultimate scheme involve closures to some of the slip roads at Junction 6 and Junction 7, as well as modifications to junction and slip road geometry. Modifications would also be required to local junctions at:

- Silverbridge Halting Site;
- Dargle Lane;
- Herbert Road;
- R117 Enniskerry Road left-in left-out Junction; and
- Local property accesses.

In addition, two new bridges would be required for the parallel service roads to cross Bray River at St Valery's. A schematic of the proposal is provided in Figure 12.



Figure 12: Parallel service road option for the N11 / M11 ultimate scheme

5 Conclusions / Recommendations

The feasibility assessment completed in September 2020 demonstrated that the delivery of the Bus Priority Interim Scheme is technically feasible, with substantial civil infrastructure works required along the majority of the corridor. It also highlighted that despite the substantive works required, continuous bus priority could not be achieved for more than 50% of the scheme on both the northbound and southbound carriageways.

Considering the above, further assessments have been undertaken on the expected journey time benefits, and high-level costs of the scheme to better define the next steps for the option selection phase.

The high-level MCC cost of the scheme has been determined as approximately **€39,108,108** excluding VAT, and approximately **€44,387,703** including VAT. This has been developed based on the limited information available at the current stage of design, and is subject to change in future stages.

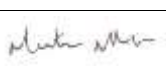
The journey time benefits assessment has highlighted that the expected journey time savings of the feasibility design are somewhat limited. This can largely be attributed to the limited extent of full bus priority on the corridor, and the high levels of congestion in shared bus / general traffic areas.

It should be noted however, bus speed differentials are comparable with other operational bus schemes on the Dublin Road network.

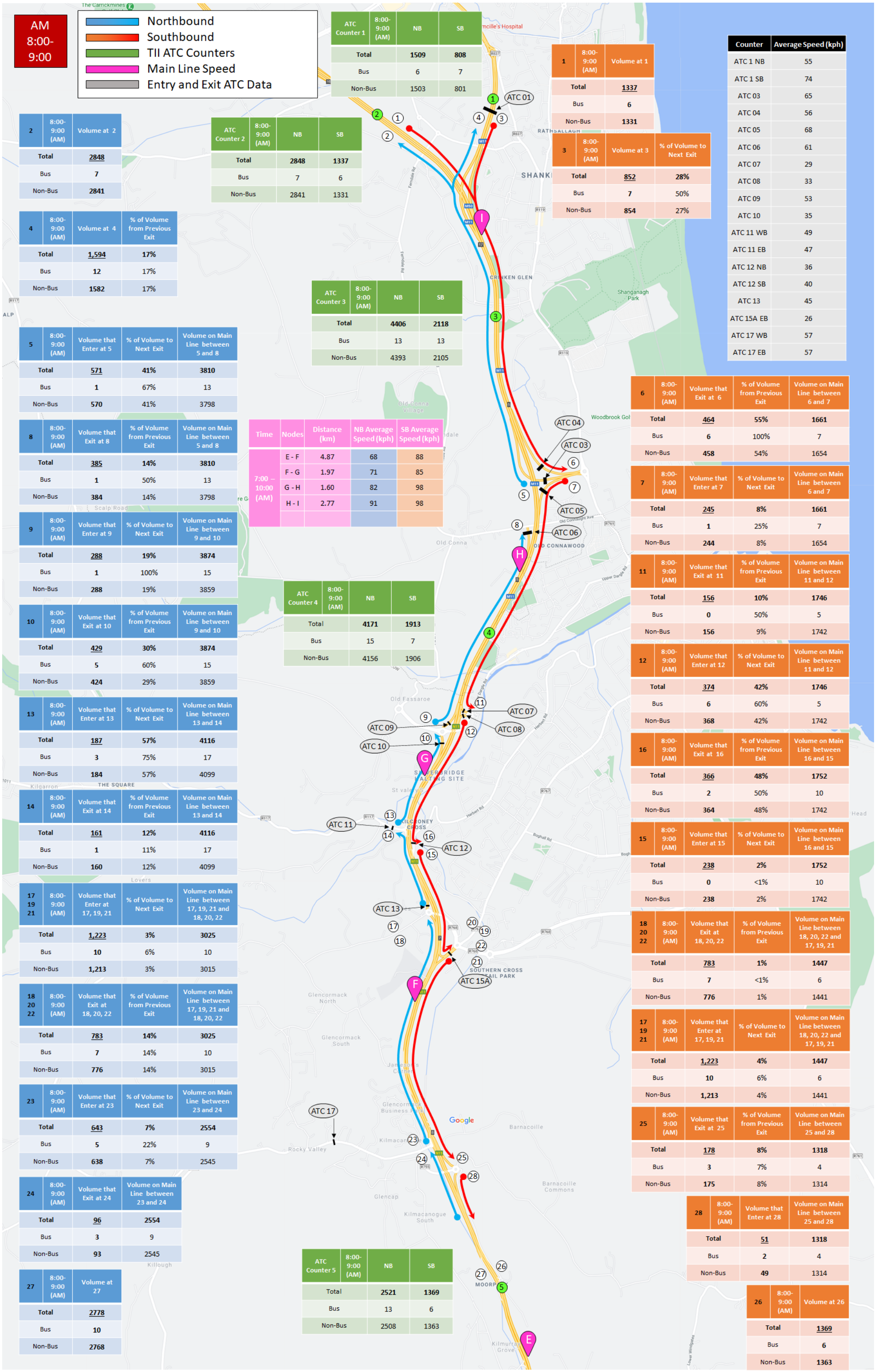
Investigations of successful bus priority schemes such as the M1 and M2 in Belfast, has also identified that journey time savings are not the only factor in encouraging modal shift away from private cars. These schemes employ park and ride facilities in strategic locations, to ensure improved end-to-end journey convenience for the public. Convenience, cost of service and journey time reliability are seen as significant factors in the success of these schemes.

It is recommended that further investigation is undertaken on the provision of such facilities on the N11 / M11. This requires more information on the likely operational services proposed for the Bus Priority Interim Scheme. Park and ride facilities could be provided both within and outside the extents of the Bus Priority Interim Scheme, to improve the end-to-end convenience of the journey and encourage modal shift. It is recommended that this is supported with traffic modelling, considers the alternatives outlined in Section 4, and is taken through a robust option selection process as part of the Phase 2 development of the scheme.

DOCUMENT CHECKING (not mandatory for File Note)

	Prepared by	Checked by	Approved by
Name	Danny Wicks / Liam Hartnett	Martin Allen	Aidan Cleary
Signature			

APPENDIX A
TRAFFIC CONGESTION ANALYSIS



ATC Counter 1	8:00-9:00 (AM)	NB	SB
Total		1509	808
Bus		6	7
Non-Bus		1503	801

1	8:00-9:00 (AM)	Volume at 1
Total		1337
Bus		6
Non-Bus		1331

2	8:00-9:00 (AM)	Volume at 2
Total		2848
Bus		7
Non-Bus		2841

ATC Counter 2	8:00-9:00 (AM)	NB	SB
Total		2848	1337
Bus		7	6
Non-Bus		2841	1331

3	8:00-9:00 (AM)	Volume at 3	% of Volume to Next Exit
Total		852	28%
Bus		7	50%
Non-Bus		854	27%

Counter	Average Speed (kph)
ATC 1 NB	55
ATC 1 SB	74
ATC 03	65
ATC 04	56
ATC 05	68
ATC 06	61
ATC 07	29
ATC 08	33
ATC 09	53
ATC 10	35
ATC 11 WB	49
ATC 11 EB	47
ATC 12 NB	36
ATC 12 SB	40
ATC 13	45
ATC 15A EB	26
ATC 17 WB	57
ATC 17 EB	57

4	8:00-9:00 (AM)	Volume at 4	% of Volume from Previous Exit
Total		1,594	17%
Bus		12	17%
Non-Bus		1582	17%

ATC Counter 3	8:00-9:00 (AM)	NB	SB
Total		4406	2118
Bus		13	13
Non-Bus		4393	2105

5	8:00-9:00 (AM)	Volume that Enter at 5	% of Volume to Next Exit	Volume on Main Line between 5 and 8
Total		571	41%	3810
Bus		1	67%	13
Non-Bus		570	41%	3798

6	8:00-9:00 (AM)	Volume that Exit at 6	% of Volume from Previous Exit	Volume on Main Line between 6 and 7
Total		464	55%	1661
Bus		6	100%	7
Non-Bus		458	54%	1654

7	8:00-9:00 (AM)	Volume that Enter at 7	% of Volume to Next Exit	Volume on Main Line between 6 and 7
Total		245	8%	1661
Bus		1	25%	7
Non-Bus		244	8%	1654

8	8:00-9:00 (AM)	Volume that Exit at 8	% of Volume from Previous Exit	Volume on Main Line between 5 and 8
Total		385	14%	3810
Bus		1	50%	13
Non-Bus		384	14%	3798

Time	Nodes	Distance (km)	NB Average Speed (kph)	SB Average Speed (kph)
7:00 – 10:00 (AM)	E - F	4.87	68	88
	F - G	1.97	71	85
	G - H	1.60	82	98
	H - I	2.77	91	98

9	8:00-9:00 (AM)	Volume that Enter at 9	% of Volume to Next Exit	Volume on Main Line between 9 and 10
Total		288	19%	3874
Bus		1	100%	15
Non-Bus		288	19%	3859

10	8:00-9:00 (AM)	Volume that Exit at 10	% of Volume from Previous Exit	Volume on Main Line between 9 and 10
Total		429	30%	3874
Bus		5	60%	15
Non-Bus		424	29%	3859

ATC Counter 4	8:00-9:00 (AM)	NB	SB
Total		4171	1913
Bus		15	7
Non-Bus		4156	1906

11	8:00-9:00 (AM)	Volume that Exit at 11	% of Volume from Previous Exit	Volume on Main Line between 11 and 12
Total		156	10%	1746
Bus		0	50%	5
Non-Bus		156	9%	1742

12	8:00-9:00 (AM)	Volume that Enter at 12	% of Volume to Next Exit	Volume on Main Line between 11 and 12
Total		374	42%	1746
Bus		6	60%	5
Non-Bus		368	42%	1742

13	8:00-9:00 (AM)	Volume that Enter at 13	% of Volume to Next Exit	Volume on Main Line between 13 and 14
Total		187	57%	4116
Bus		3	75%	17
Non-Bus		184	57%	4099

16	8:00-9:00 (AM)	Volume that Exit at 16	% of Volume from Previous Exit	Volume on Main Line between 16 and 15
Total		366	48%	1752
Bus		2	50%	10
Non-Bus		364	48%	1742

14	8:00-9:00 (AM)	Volume that Exit at 14	% of Volume from Previous Exit	Volume on Main Line between 13 and 14
Total		161	12%	4116
Bus		1	11%	17
Non-Bus		160	12%	4099

15	8:00-9:00 (AM)	Volume that Enter at 15	% of Volume to Next Exit	Volume on Main Line between 16 and 15
Total		238	2%	1752
Bus		0	<1%	10
Non-Bus		238	2%	1742

17 19 21	8:00-9:00 (AM)	Volume that Enter at 17, 19, 21	% of Volume to Next Exit	Volume on Main Line between 17, 19, 21 and 18, 20, 22
Total		1,223	3%	3025
Bus		10	6%	10
Non-Bus		1,213	3%	3015

18 20 22	8:00-9:00 (AM)	Volume that Exit at 18, 20, 22	% of Volume from Previous Exit	Volume on Main Line between 17, 19, 21 and 18, 20, 22
Total		783	14%	3025
Bus		7	14%	10
Non-Bus		776	14%	3015

18 20 22	8:00-9:00 (AM)	Volume that Exit at 18, 20, 22	% of Volume from Previous Exit	Volume on Main Line Between 18, 20, 22 and 17, 19, 21
Total		783	1%	1447
Bus		7	<1%	6
Non-Bus		776	1%	1441

17 19 21	8:00-9:00 (AM)	Volume that Enter at 17, 19, 21	% of Volume to Next Exit	Volume on Main Line between 18, 20, 22 and 17, 19, 21
Total		1,223	4%	1447
Bus		10	6%	6
Non-Bus		1,213	4%	1441

23	8:00-9:00 (AM)	Volume that Enter at 23	% of Volume to Next Exit	Volume on Main Line between 23 and 24
Total		643	7%	2554
Bus		5	22%	9
Non-Bus		638	7%	2545

24	8:00-9:00 (AM)	Volume that Exit at 24	Volume on Main Line between 23 and 24
Total		96	2554
Bus		3	9
Non-Bus		93	2545

25	8:00-9:00 (AM)	Volume that Exit at 25	% of Volume from Previous Exit	Volume on Main Line between 25 and 28
Total		178	8%	1318
Bus		3	7%	4
Non-Bus		175	8%	1314

28	8:00-9:00 (AM)	Volume that Enter at 28	Volume on Main Line between 25 and 28
Total		51	1318
Bus		2	4
Non-Bus		49	1314

27	8:00-9:00 (AM)	Volume at 27
Total		2778
Bus		10
Non-Bus		2768

ATC Counter 5	8:00-9:00 (AM)	NB	SB
Total		2521	1369
Bus		13	6
Non-Bus		2508	1363

26	8:00-9:00 (AM)	Volume at 26
Total		1369
Bus		6
Non-Bus		1363

PM 17:00-18:00

- Northbound
- Southbound
- TII ATC Counters
- Main Line Speed
- Entry and Exit ATC Data

ATC Counter 1	17:00-18:00 (PM)	NB	SB
Total		973	1599
Bus		8	15
Non-Bus		965	1584

1	17:00-18:00 (PM)	Volume at 1
Total		1407
Bus		3
Non-Bus		1404

Counter	Average Speed (kph)
ATC 1 NB	72
ATC 1 SB	74
ATC 03	64
ATC 04	53
ATC 05	66
ATC 06	64
ATC 07	29
ATC 08	31
ATC 09	54
ATC 10	35
ATC 11 WB	49
ATC 11 EB	45
ATC 12 NB	36
ATC 12 SB	40
ATC 13	48
ATC 15A EB	24
ATC 17 WB	57
ATC 17 EB	53

2	17:00-18:00 (PM)	Volume at 2
Total		1377
Bus		6
Non-Bus		1371

ATC Counter 2	17:00-18:00 (PM)	NB	SB
Total		1377	1407
Bus		6	3
Non-Bus		1371	1404

3	17:00-18:00 (PM)	Volume at 3	% of Volume to Next Exit
Total		1723	24%
Bus		14	8%
Non-Bus		1723	24%

4	17:00-18:00 (PM)	Volume at 4	% of Volume from Previous Exit
Total		1014	21%
Bus		13	30%
Non-Bus		1001	20%

ATC Counter 3	17:00-18:00 (PM)	NB	SB
Total		2326	3023
Bus		14	18
Non-Bus		2312	3005

5	17:00-18:00 (PM)	Volume that Enter at 5	% of Volume to Next Exit	Volume on Main Line between 5 and 8
Total		636	54%	1823
Bus		4	50%	10
Non-Bus		632	54%	1813

6	17:00-18:00 (PM)	Volume that Exit at 6	% of Volume from Previous Exit	Volume on Main Line between 6 and 7
Total		555	63%	2641
Bus		0	50%	17
Non-Bus		555	63%	2641

7	17:00-18:00 (PM)	Volume that Enter at 7	% of Volume to Next Exit	Volume on Main Line between 6 and 7
Total		272	10%	2641
Bus		2	<1%	17
Non-Bus		270	10%	2641

8	17:00-18:00 (PM)	Volume that Exit at 8	% of Volume from Previous Exit	Volume on Main Line between 5 and 8
Total		132	13%	1823
Bus		0	<1%	10
Non-Bus		132	13%	1813

Time	Nodes	Distance (km)	NB Average Speed (kph)	SB Average Speed (kph)
16:00 – 19:00 (PM)	E - F	4.87	88	78
	F - G	1.97	96	60
	G - H	1.60	94	56
	H - I	2.77	93	33

9	17:00-18:00 (PM)	Volume that Enter at 9	% of Volume to Next Exit	Volume on Main Line between 9 and 10
Total		126	17%	1955
Bus		0	<1%	12
Non-Bus		126	17%	1943

ATC Counter 4	17:00-18:00 (PM)	NB	SB
Total		2088	3086
Bus		11	17
Non-Bus		2077	3069

10	17:00-18:00 (PM)	Volume that Exit at 10	% of Volume from Previous Exit	Volume on Main Line between 9 and 10
Total		426	62%	1955
Bus		3	60%	12
Non-Bus		423	63%	1943

11	17:00-18:00 (PM)	Volume that Exit at 11	% of Volume from Previous Exit	Volume on Main Line between 11 and 12
Total		134	22%	2976
Bus		0	<1%	15
Non-Bus		134	22%	2961

12	17:00-18:00 (PM)	Volume that Enter at 12	% of Volume to Next Exit	Volume on Main Line between 11 and 12
Total		671	25%	2976
Bus		1	33%	15
Non-Bus		670	25%	2961

13	17:00-18:00 (PM)	Volume that Enter at 13	% of Volume to Next Exit	Volume on Main Line between 13 and 14
Total		336	72%	2045
Bus		3	60%	12
Non-Bus		333	72%	2033

14	17:00-18:00 (PM)	Volume that Exit at 14	% of Volume from Previous Exit	Volume on Main Line between 13 and 14
Total		144	17%	2045
Bus		0	<1%	12
Non-Bus		144	17%	2033

16	17:00-18:00 (PM)	Volume that Exit at 16	% of Volume from Previous Exit	Volume on Main Line between 16 and 15
Total		344	36%	3326
Bus		0	100%	16
Non-Bus		344	35%	3310

15	17:00-18:00 (PM)	Volume that Enter at 15	% of Volume to Next Exit	Volume on Main Line between 16 and 15
Total		124	3%	3326
Bus		0	<1%	16
Non-Bus		124	3%	3310

17 19 21	17:00-18:00 (PM)	Volume that Enter at 17, 19, 21	% of Volume to Next Exit	Volume on Main Line between 17, 19, 21 and 18, 20, 22
Total		1293	4%	1404
Bus		4	<1%	13
Non-Bus		1289	4%	1389

18 20 22	17:00-18:00 (PM)	Volume that Exit at 18, 20, 22	% of Volume from Previous Exit	Volume on Main Line between 17, 19, 21 and 18, 20, 22
Total		1072	6%	1404
Bus		8	21%	13
Non-Bus		1064	6%	1389

18 20 22	17:00-18:00 (PM)	Volume that Exit at 18, 20, 22	% of Volume from Previous Exit	Volume on Main Line between 18, 20, 22 and 17, 19, 21
Total		1072	<1%	2666
Bus		8	<1%	6
Non-Bus		1064	<1%	2660

17 19 21	17:00-18:00 (PM)	Volume that Enter at 17, 19, 21	% of Volume to Next Exit	Volume on Main Line between 18, 20, 22 and 17, 19, 21
Total		1293	11%	2666
Bus		4	33%	6
Non-Bus		1289	11%	2660

23	17:00-18:00 (PM)	Volume that Enter at 23	% of Volume to Next Exit	Volume on Main Line between 23 and 24
Total		260	11%	1365
Bus		7	14%	9
Non-Bus		253	11%	1357

25	17:00-18:00 (PM)	Volume that Exit at 25	% of Volume from Previous Exit	Volume on Main Line between 25 and 28
Total		302	12%	2948
Bus		3	29%	5
Non-Bus		299	12%	2943

24	17:00-18:00 (PM)	Volume that Exit at 24	Volume on Main Line between 23 and 24
Total		93	1365
Bus		0	9
Non-Bus		93	1357

28	17:00-18:00 (PM)	Volume that Enter at 28	Volume on Main Line between 25 and 28
Total		166	2948
Bus		1	5
Non-Bus		165	2943

ATC Counter 5	17:00-18:00 (PM)	NB	SB
Total		1465	3114
Bus		10	6
Non-Bus		1455	3108

26	17:00-18:00 (PM)	Volume at 26
Total		3114
Bus		6
Non-Bus		3108

27	17:00-18:00 (PM)	Volume at 27
Total		1451
Bus		7
Non-Bus		1444

APPENDIX B
HIGH LEVEL COST ESTIMATE

N11/M11 Bus Priority Interim Scheme	**05/03/2021**
Phase 1: Feasibility Assessment	**05/03/2021**
Arup	INSERT NAME OF ESTIMATOR

Main Construction Cost - Base Cost Estimate

Summary

A	Site Clearance		€	183,264
B	Fencing		€	260,100
C	Safety Barriers and Pedestrian Guardrails		€	1,005,152
D	Drainage and Service Ducts		€	3,978,862
E	Earthworks		€	189,724
F	Pavement		€	10,726,260
G	Kerbs, Footways and Paved Areas		€	63,626
H	Traffic Signs and Roadmarkings		€	525,748
K	Lighting and Electrical		€	238,844
L	Landscaping and Environmental		€	201,835
M	Structures (Including Tunnels to be seperately identified)		€	607,824
N	Accommodation Works		€	-
P	Statutory Authorities & Utilities		€	5,250,000
Q	Any Other Obligations and Liabilities of the Contractor		€	-
	Sub-Total		€	23,231,239
S	Preliminaries		€	6,851,921
	MCC Base Cost Total excluding Project Specific Risk Contingency		€	30,083,160
	Add Project Specific Risk Contingency	30 %	€	9,024,948
	MCC Base Cost Total including Project Specific Risk Contingency		**€**	**39,108,108**
	Add VAT at	13.5 %	€	5,279,595
	MCC Base Cost Total including Project Specific Risk Contingency and VAT		**€**	**44,387,703**

Mainline Length	8.65	km
MCC Cost per km based on Mainline Length Only	**€ 5,131,704.29**	
Mainline plus Link Road Length	13.85	km
MCC Cost per km based on Mainline plus Link Road Length	€ 3,204,888.27	

Schedule of Works		**Quantity**	**Unit**	**Rate/Prices**		**Totals**
A	**Site Clearance**					
A.1a	General Site Clearance (Existing Road) - Section 1	5.0	Ha	€ 4,000.00	€	19,859.60
A.1b	General Site Clearance (Existing Road) - Section 2	13.3	Ha	€ 4,000.00	€	53,274.80
A.1c	General Site Clearance (Existing Road) - Section 3	9.7	Ha	€ 4,000.00	€	38,784.80
A.1d	General Site Clearance (Existing Road) - Section 4	9.3	Ha	€ 4,000.00	€	37,099.20
A.1e	General Site Clearance (Existing Road) - Section 5	8.6	Ha	€ 4,000.00	€	34,245.60
	Site Clearance Total to Summary				**€**	**183,264.00**
B	**Fencing**					
B.1a	Permanent Boundary Fencing - Section 1	1855	m	€ 30.00	€	55,650.00
B.1b	Permanent Boundary Fencing - Section 2	1262	m	€ 30.00	€	37,860.00
B.1c	Permanent Boundary Fencing - Section 3	2068	m	€ 30.00	€	62,040.00
B.1d	Permanent Boundary Fencing - Section 4	1854	m	€ 30.00	€	55,620.00
B.1e	Permanent Boundary Fencing - Section 5	1631	m	€ 30.00	€	48,930.00
	Fencing Total to Summary				**€**	**260,100.00**
C	**Safety Barrier and Pedestrian Guardrails**					

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C.1a	Nearside Safety Barrier (H2 Concrete) - Section 1	260	m	€	85.00	€	22,100.00
C.1b	Nearside Safety Barrier (H2 Concrete) - Section 2	1145	m	€	85.00	€	97,282.50
C.1c	Nearside Safety Barrier (H2 Concrete) - Section 3	585	m	€	85.00	€	49,725.00
C.1d	Nearside Safety Barrier (H2 Concrete) - Section 4	455	m	€	85.00	€	38,675.00
C.1e	Nearside Safety Barrier (H2 Concrete) - Section 5	650	m	€	85.00	€	55,250.00
C.2a	Median Barrier (H2 Concrete) - Section 1	1131	m	€	85.00	€	96,092.50
C.2b	Median Barrier (H2 Concrete) - Section 2	2518	m	€	85.00	€	214,038.50
C.2c	Median Barrier (H2 Concrete) - Section 3	2603	m	€	85.00	€	221,265.20
C.2d	Median Barrier (H2 Concrete) - Section 4	2060	m	€	85.00	€	175,108.50
C.2e	Median Barrier (H2 Concrete) - Section 5	419	m	€	85.00	€	35,615.00
	Safety Barrier and Pedestrian Guardrails Total to Summary					**€**	**1,005,152.20**
D	**Drainage and Service Ducts**						
D.1a	Drainage and Service Ducts per km (Mainline) - Section 1	0.99	km	€	460,000.00	€	454,480.00
D.1b	Drainage and Service Ducts per km (Mainline) - Section 2	2.31	km	€	460,000.00	€	1,062,830.00
D.1c	Drainage and Service Ducts per km (Mainline) - Section 3	1.83	km	€	460,000.00	€	841,938.00
D.1d	Drainage and Service Ducts per km (Mainline) - Section 4	1.58	km	€	460,000.00	€	725,558.00
D.1e	Drainage and Service Ducts per km (Mainline) - Section 5	1.94	km	€	460,000.00	€	894,056.00
	Drainage and Service Ducts Total to Summary					**€**	**3,978,862.00**
E	**Earthworks**						
	Mainline & Link Roads						
E.1a	Excavation - Acceptable - Section 1	1614	m3	€	4.30	€	6,939.55
E.1b	Excavation - Acceptable - Section 2	3774.086	m3	€	4.30	€	16,228.57
E.1c	Excavation - Acceptable - Section 3	8564.726	m3	€	4.30	€	36,828.32
E.1d	Excavation - Acceptable - Section 4	7006.929	m3	€	4.30	€	30,129.79
E.1e	Excavation - Acceptable - Section 5	391.508	m3	€	4.30	€	1,683.48
E.7a	Disposal - U1 - Section 1	1608.4076	m3	€	4.50	€	7,237.83
E.7b	Disposal - U1 - Section 2	3761.362	m3	€	4.50	€	16,926.13
E.7c	Disposal - U1 - Section 3	7709.893	m3	€	4.50	€	34,694.52
E.7d	Disposal - U1 - Section 4	5587.282	m3	€	4.50	€	25,142.77
E.7e	Disposal - U1 - Section 5	391.508	m3	€	4.50	€	1,761.79
E.8a	Earthworks Cut to Fill - Section 1	5	m3	€	5.30	€	28.84
E.8b	Earthworks Cut to Fill - Section 2	12.724	m3	€	5.30	€	67.44
E.8c	Earthworks Cut to Fill - Section 3	854.833	m3	€	5.30	€	4,530.61
E.8d	Earthworks Cut to Fill - Section 4	1419.647	m3	€	5.30	€	7,524.13
E.8e	Earthworks Cut to Fill - Section 5	0	m3	€	5.30	€	-
	Earthworks Sub-Total					**€**	**189,723.77**
F	**Pavement**						
	Mainline						
F.1a	Sub-Base (Cl. 804, 150mm) - Section 1	707	m3	€	25.00	€	17,678.81
F.1b	Sub-Base (Cl. 804, 150mm) - Section 2	2032	m3	€	25.00	€	50,801.25
F.1c	Sub-Base (Cl. 804, 150mm) - Section 3	2254	m3	€	25.00	€	56,352.00
F.1d	Sub-Base (Cl. 804, 150mm) - Section 4	1654	m3	€	25.00	€	41,343.00
F.1e	Sub-Base (Cl. 804, 150mm) - Section 5	2152	m3	€	25.00	€	53,796.00
F.2a	Base Course (AC 32 Dense base 40/60 100mm 2 layers) - Section 1	18857	m2	€	18.00	€	339,433.10
F.2b	Base Course (AC 32 Dense base 40/60 100mm 2 layers) - Section 2	27094	m2	€	18.00	€	487,692.00
F.2c	Base Course (AC 32 Dense base 40/60 100mm 2 layers) - Section 3	30054	m2	€	18.00	€	540,979.20
F.2d	Base Course (AC 32 Dense base 40/60 100mm 2 layers) - Section 4	22050	m2	€	18.00	€	396,892.80
F.2e	Base Course (AC 32 Dense base 40/60 100mm 2 layers) - Section 5	28691	m2	€	18.00	€	516,441.60
F.3a	Binder Course (AC 20 Dense bin 55mm) - Section 1	20359	m2	€	15.00	€	305,391.42
F.3b	Binder Course (AC 20 Dense bin 55mm) - Section 2	81689	m2	€	15.00	€	1,225,335.00
F.3c	Binder Course (AC 20 Dense bin 55mm) - Section 3	56831	m2	€	15.00	€	852,468.00
F.3d	Binder Course (AC 20 Dense bin 55mm) - Section 4	47612	m2	€	15.00	€	714,177.00
F.3e	Binder Course (AC 20 Dense bin 55mm) - Section 5	59701	m2	€	15.00	€	895,509.00
F.4a	Surface Course (SMA 40mm) - Section 1	20359	m2	€	12.00	€	244,313.14
F.4b	Surface Course (SMA 40mm) - Section 2	81689	m2	€	12.00	€	980,268.00
F.4c	Surface Course (SMA 40mm) - Section 3	56831	m2	€	12.00	€	681,974.40
F.4d	Surface Course (SMA 40mm) - Section 4	47612	m2	€	12.00	€	571,341.60
F.4e	Surface Course (SMA 40mm) - Section 5	59701	m2	€	12.00	€	716,407.20
F.5a	Milling Existing Pavement (100mm including disposal) - Section 1	15645	m2	€	5.00	€	78,225.40
F.5b	Milling Existing Pavement (100mm including disposal) - Section 2	68142	m2	€	5.00	€	340,710.00
F.5c	Milling Existing Pavement (100mm including disposal) - Section 3	41804	m2	€	5.00	€	209,020.00
F.5d	Milling Existing Pavement (100mm including disposal) - Section 4	36587	m2	€	5.00	€	182,935.00
F.5e	Milling Existing Pavement (100mm including disposal) - Section 5	45355	m2	€	5.00	€	226,775.00
	Pavement Sub-Total					**€**	**10,726,259.91**
G	**Kerbs Footways and Paved Areas**						
	Allowance based on scheme scope and historical costs - Section 1	0.99	km	€	7,355.89	€	7,267.62
	Allowance based on scheme scope and historical costs - Section 2	2.31	km	€	7,355.89	€	16,995.79
	Allowance based on scheme scope and historical costs - Section 3	1.83	km	€	7,355.89	€	13,463.49
	Allowance based on scheme scope and historical costs - Section 4	1.58	km	€	7,355.89	€	11,602.45
	Allowance based on scheme scope and historical costs - Section 5	1.94	km	€	7,355.89	€	14,296.91
	KFPA Sub-Total					**€**	**63,626.26**
H	**Traffic Signs & Road Markings**						

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H.1a	General allowance relocation of existing signage, and re-linemarking - Section 1	0.99	km	€	45,752.75	€	45,203.71
H.1b	General allowance relocation of existing signage, and re-linemarking - Section 2	2.31	km	€	45,752.75	€	105,711.72
H.1c	General allowance relocation of existing signage, and re-linemarking - Section 3	1.83	km	€	45,752.75	€	83,741.25
H.1d	General allowance relocation of existing signage, and re-linemarking - Section 4	1.58	km	€	45,752.75	€	72,165.81
H.1e	General allowance relocation of existing signage, and re-linemarking - Section 5	1.94	km	€	45,752.75	€	88,925.04
H.2a	Bus Lane Signage - Section 1	2	No.	€	5,000.00	€	10,000.00
H.2b	Bus Lane Signage - Section 2	6	No.	€	5,000.00	€	30,000.00
H.2c	Bus Lane Signage - Section 3	5	No.	€	5,000.00	€	25,000.00
H.2d	Bus Lane Signage - Section 4	6	No.	€	5,000.00	€	30,000.00
H.2e	Bus Lane Signage - Section 5	7	No.	€	5,000.00	€	35,000.00
	Traffic Signs Sub-Total		**sum**			**€**	**525,747.53**
K	**Lighting and Electrical**						
	Allowance based on scheme scope and historical costs - Section 1	0.99	km	€	27,613.04	€	27,281.68
	Allowance based on scheme scope and historical costs - Section 2	2.31	km	€	27,613.04	€	63,799.92
	Allowance based on scheme scope and historical costs - Section 3	1.83	km	€	27,613.04	€	50,540.14
	Allowance based on scheme scope and historical costs - Section 4	1.58	km	€	27,613.04	€	43,554.04
	Allowance based on scheme scope and historical costs - Section 5	1.94	km	€	27,613.04	€	53,668.70
	Lighitng and Electrical Sub-Total		**sum**			**€**	**238,844.47**
L	**Landscaping and Environmental**						
	Allowance based on scheme scope and historical costs - Section 1	0.99	km	€	23,334.29	€	23,054.28
	Allowance based on scheme scope and historical costs - Section 2	2.31	km	€	23,334.29	€	53,913.87
	Allowance based on scheme scope and historical costs - Section 3	1.83	km	€	23,334.29	€	42,708.75
	Allowance based on scheme scope and historical costs - Section 4	1.58	km	€	23,334.29	€	36,805.17
	Allowance based on scheme scope and historical costs - Section 5	1.94	km	€	23,334.29	€	45,352.52
	Landscaping and Environmental Sub-Total		**sum**			**€**	**201,834.59**
M	**Structures (Including Tunnels to be seperately identified)**						
Structure A (M11 / M50 Overbridge - Remedial Works)							
M.1	Deck Area (Specify)	2202	m2	€	210.00	€	462,420.00
	Structure A Total					€	462,420.00
Structure B St Valery's Bridge - Remedial Works							
M.1	Deck Area	692.4	m2	€	210.00	€	145,404.00
	Structure B Total					€	145,404.00
	Structure C Total					€	-
	Structures Total to Summary					**€**	**607,824.00**
INSERT FURTHER STRUCTURES AS NECESSARY - CLEARLY IDENTIFY SIGNATURE STRUCTURES							
N	**Accommodation Works**						
	Allowance based on scheme scope and historical costs - Section 1		sum			€	-
	Allowance based on scheme scope and historical costs - Section 2		sum			€	-
	Allowance based on scheme scope and historical costs - Section 3		sum			€	-
	Allowance based on scheme scope and historical costs - Section 4		sum			€	-
	Allowance based on scheme scope and historical costs - Section 5		sum			€	-
	Accomodation Works Sub-Total		**sum**			**€**	**-**
P	**Statutory Authorities & Utilities**						
	Allowance based on scheme scope and historical costs - Section 1		sum	€	250,000.00	€	250,000.00
	Allowance based on scheme scope and historical costs - Section 2		sum	€	250,000.00	€	250,000.00
	Allowance based on scheme scope and historical costs - Section 3		sum	€	250,000.00	€	250,000.00
	Allowance based on scheme scope and historical costs - Section 4		sum	€	250,000.00	€	250,000.00
	Allowance based on scheme scope and historical costs - Section 5		sum	€	250,000.00	€	250,000.00
	Gas Main Relocation (including API)			€	4,000,000.00	€	4,000,000.00
	Statutory Authorities & Utilities Sub-Total		sum			**€**	**5,250,000.00**
Q	**Any Other Obligations and Liabilities of the Contractor**						
	Allowance based on scheme scope and historical costs - Section 1	0	sum			€	-
	Allowance based on scheme scope and historical costs - Section 2	0	sum			€	-
	Allowance based on scheme scope and historical costs - Section 3	0	sum			€	-
	Allowance based on scheme scope and historical costs - Section 4	0	sum			€	-
	Allowance based on scheme scope and historical costs - Section 5	0	sum			€	-
	Any Other Obligations and Liabilities of the Contractor		sum			**€**	**-**
S	**Preliminaries**						
R.1	Temporary Works including Traffic Management (Specify)-	17.3	km	€	127,500.00	€	2,205,673.50
R.2	All other Preliminary Items	20%	%	€	4,646,247.75	€	4,646,247.75
	Preliminaries Total to Summary					€	6,851,921.25

N.B. Figures are exclusive of VAT except where expressly stated above.
Figures above are EXCLUSIVE of provision for Inflation - base date to be stated if different from date of estimate.
Total base costs to include for ALL qualifying costs under each cost heading.
Refer to the NRA Cost Management Manual for information on coverage and format of back-up.
See attached Budget Assumptions Sheet for Further Scheme Information.