LIVING STREETS - DÚN LAOGHAIRE
TRAFFIC MODELLING REPORT

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TABLE OF CONTENTS

EXECUTIVE SUMMARY		5
1.	INTRODUCTION	9
1.1	Background & Purpose of Report	9
1.2	Methodology Summary	11
1.3	Report Structure	15
2.	EXISTING SITUATION	16
2.1	Local Area Characteristics	16
2.2	Existing Transport Demand	16
2.3	Existing Transport Network	17
3.	EAST REGIONAL MODEL	21
3.1	Overview	21
4.	ERM MODELLING	23
4.1	Overview	23
4.2	Review of Road Network	23
4.3	Application of ERM	27
4.4	Validation	29
4.5	Initial Tests and Results	30
4.6	Summary	31
5.	LAM MODEL DEVELOPMENT	32
5.1	Introduction	32
5.2	Modelling Software	32
5.3	Model Time Periods and User Classes	32
5.4	Network Development	33
5.5	Model Zone System and Prior Matrix Development	34
5.6	Prior Matrix Development	35
5.7	Calibration	35
5.8	Validation	37
6.	LAM MODELLING	38
6.1	Scenarios and Project Phasing Overview	38
6.2	Initial Testing	40

6.3	MITIGATION TESTING WITH INITIAL PREFERRED OPTION	45
6.4	REVISION OF PREFERRED OPTION	50
7.	**MODESHIFT MODELLING**	**56**
7.1	OVERVIEW	56
7.2	EXAMPLES OF SIMILAR SCHEMES	56
7.3	MODE SHARE CHANGES	58
8.	**PREFFERED OPTION MODELLING RESULTS**	**61**
8.1	OVERVIEW	61
8.2	VEHICLE FLOW LEVELS	63
8.3	JUNCTION PERFORMANCE	72
8.4	EMISSION IMPACTS	78
8.5	BUS ROUTE OPTIONS	82
8.6	SUMMARY	90
9.	**CONCLUSION**	**93**

EXECUTIVE SUMMARY

Dún Laoghaire-Rathdown County Council are developing the Living Streets Dún Laoghaire scheme. It aims to create a more liveable environment where all mode choices are catered for, and more sustainable travel choices are prioritised. It seeks to improve the local environment through improvements in noise and air quality and providing safer and more pleasant active mode friendly routes through the area.

This modelling report forms part of a wider study by Barry Transportation on behalf of Dún Laoghaire-Rathdown County Council. The modelling report was commissioned to provide guidance in decision making by exploring the various interventions required to achieve the scheme's objectives and to detail the impacts of these on the local street network. This report should be read in conjunction with the Living Streets Dún Laoghaire Options Assessment Report.

Extensive modelling of the scheme was carried out looking at 17 options using the National Transport Authority's East Regional Model, and a bespoke Local Area Model developed using data from September 2022 for the study, to help inform the identification of a preferred scheme. The Preferred Option was selected based on its capabilities in meeting the project objectives.

The preferred scheme includes the following measures:

- Pedestrianisation of Georges Street Lower;
- Modal Gates at Clarinda Park West, Cross Avenue and Tivoli Road (west of Patrick Street); and
- Reversal of the direction of one-way car traffic on Windsor Terrace between Link Road in Glasthule and Park Road. (Note: due to its location, the implementation of this measure has been included as part of the Living Streets: Coastal Mobility Route project)

The table below summarises the preferred option's performance against the study's objectives for the modelling exercise.

Objective	Preferred Option Impact
Promote inclusive, sustainable mobility and reduce car dependency by making walking, cycling and public transport more convenient, enjoyable, and safer for all.	Through the removal of motorised through traffic (traffic not originating or travelling to the Living Street neighbourhood) car movements within the area are reduced in the AM peak, by a minimum of 35%, even if there is no movement away from use of private vehicles to other modes of transport (mode shift). This reduction in motorised traffic across the areas results in the following reductions on individual roads; • 31-84% along Tivoli Road; • 33% on Patrick Street; and • 28% on Mulgrave Street. The above numbers assume no mode shift occurs, when a mode shift was applied an average reduction of 43% across the area was achieved in the sensitivity test with localised reductions of; • 37-94% along Tivoli Road; • 47% on Patrick Street; and • 34% on Mulgrave Street. These reductions will provide a safer, more walking and cycling friendly environment for residents and visitors to move about the area.
Improve the neighbourhood by reducing traffic and related noise and air pollution; and increasing climate resilience through planting and greening initiatives.	The preferred option diverts through traffic away from the neighbourhood, thereby reducing car trips within the area by 35% during the morning (AM) peak with no mode shift and 43% within the high mode shift sensitivity scenario. These reductions in through traffic lead to reductions in harmful emissions, with a predicted reduction of 26% and 37% NOx within the Living Streets Neighbourhood and George's Street Lower respectively. Some of the shortest trips can then be more easily made by walking or cycling, while the longer distance (strategic trips) will be reallocated on the network (i.e. changing routes or destinations). The addition of three modal filters also allows for new areas of tree planting and landscaping at each location.
Enhance the economic vibrancy of Dún Laoghaire as a mixed-use town and its attractiveness as a destination by facilitating the sustainable and efficient movement of people and goods, and by creating an environment that people want to linger in.	The preferred option facilitates active travel by creating a network of streets with low levels of car traffic between Glenageary Road Upper, Glenageary Road Lower, York Road and Crofton Road. This will allow residents and visitors to have safer and more pleasant journeys by active modes. Walking and cycling are more efficient ways for people to move around and do not require large areas for car parking, These changes are achieved while retaining access to the town centre and wider area for those who choose to use their car. This results in more people within the town.

Improve connections between bus, rail and active travel facilities to make it easier for people to access sites of interest in the town, the seafront and surrounding neighbourhood.	On key routes through the Living Streets Neighbourhood identified as Active Travel Corridors there is a predicted minimum 34% reduction with no mode shift, and 40% reduction in the mode shift sensitivity tests. Reduced car traffic on these routes facilitates safer and more pleasant movement by active modes. In addition, reduction in traffic along Tivoli Road, and pedestrianisation of Georges Street Lower, would allow for easier and safer movement of people via sustainable transport to key destinations (work, retail) within and outside of the town centre including the seafront and nearby villages. The preferred option achieves this while retaining car access to the town centre, including all car parks.
Promote health and wellbeing in the community by enabling safer active travel and enhancing the public realm for outdoor play, recreation, and social interaction.	Reduced traffic, including an elimination of all HGV through trips, will provide a safer and healthier environment, with a significant reduction in harmful emissions and noise pollution. Two key routes through the neighbourhood, identified as active travel corridors, see reductions in motorised vehicle numbers below 2,000 vehicles per day, which is identified as the safe design limit for unsegregated cyclists; • Western route on Tivoli Terrace E reduced from 2,200 to 1,700; and • Eastern route on Clarinda Park W reduced from 1,300 to 700. These safer routes will encourage a greater number of walking and cycling trips which would have health benefits resulting from the increased physical activity. Safer walking and cycling routes to schools will be created that will allow more children to walk and cycle to the schools in the area. Research has shown that children who use active modes to get to school are much more likely to keep up these habits later in live and this leads to significant health benefits. The streets outside of the schools will also be safer and calmer which would create an environment that is more conducive to outdoor play, recreation and social interaction.
Promote equitable travel options and urban design that creates a safe and welcoming experience for all members of society, regardless of age, gender, ability, or income.	The preferred option retains access to the area for those who choose or need to use a car, only removing through traffic. The reductions in car traffic provide safer spaces for pedestrians and cyclists, who account for over 63% of all local trips, this will help achieve the project objective of creating a place which is safer, more vibrant and pleasant for people of all ages, abilities and genders. The pedestrianised section of George's St Lower will be fully

	landscaped with high quality paving, planting and seating, creating a safe, welcoming and attractive environment for all. Several other parklets will also be created at Tivoli Road, Cross Ave and Clarinda Park with new seating and landscaping. The introduction of the modal gates will lead to a redistribution of motorised vehicle traffic with a consolidation of this traffic along the permitter roads. This will increase the daily vehicle trips along these routes. Individual junction modelling of all junctions along the perimeter roads has been done and the results show that sufficient capacity remains to accommodate these changes with a minimal increase in travel times of 2-4 mins during the peak periods. Modelling of the preferred option focused on no change in mode choice and sensitivity tests looking at mode choice changes within the study area. However, the mode choice impacts of the scheme on the wider area are not covered, though schemes that reallocated road space typically lead to “traffic evaporation” as a result of movement to alternative modes. The project will optimise the operation of all traffic lights in the wider area to suit the new traffic patterns, this will improve the efficiency of all junctions. It will also involve road safety improvements such as a new signalised pedestrian crossing on York Road and improved pedestrian crossing facilities at the Glenageary Road/Corrig Road junction.

1. INTRODUCTION

1.1 Background and Purpose of Report

1.1.1 Dún Laoghaire Town Centre and its surrounding environs is a historic port town and vibrant commercial, residential and employment area in the South East of the Dublin Metropolitan Area.

1.1.2 Dún Laoghaire-Rathdown County Council (DLRCC) proposes the development of a low traffic, active mode friendly neighbourhood encompassing the area south of the main town centre and including the primary shopping street in the town, George's Street Lower. This low traffic neighbourhood is referred to as the Living Streets Neighbourhood (LSN), reflecting the desire for the area to be safe and encouraging active mode users of all ages.

1.1.3 As part of their assessment of this scheme, DLRCC and Barry Transportation, commissioned SYSTRA Ltd. to carry out a modelling exercise to explore options to achieve the objectives of the Living Streets Area while also testing the impact on the wider network, particularly the boundary roads.

1.1.4 The proposed scheme is bordered by George's Street Lower and George's Street Upper to the North, Glenageary Road Lower to the East, Tivoli Road to the south and York Road to the West. The area, and its location within Dún Laoghaire, is shown in Figure 1.1.

Figure 1.1 Living Streets Neighbourhood within Dún Laoghaire

1.2 Methodology Summary

1.2.1 The purpose of the modelling exercise undertaken was threefold:

- To test the performance of various traffic management measures in reducing strategic traffic within the LSN and their ability to meet study objectives;
- To measure the impact on the boundary roads and identifying potential mitigation measures; and
- To test the impacts of the various options on bus journey times.

1.2.2 The options were examined using the National Transport Authority's (NTA) East Regional Model (ERM) Road Network. The ERM is a multi-modal transport model covering the east of Ireland. More details of the ERM are provided in Section 3.

1.2.3 The Road Network within the ERM is a strategic road network with a high level of detail for Dublin and its surrounding towns. The road network for the study area was updated to improve level of detail and address changes made since the network base year of 2016. To validate the ERM results, count data in the form of Automatic Traffic Counts (ATC) and Junction Turning Counts (JTC) was collected within the study area in September 2022.

1.2.4 Validation of the ERM road network and initial testing of the schemes within the ERM road network revealed low sensitivity to the modelled schemes. It was determined that this was due to the level of detail within the zone system.

1.2.5 To address this, modelling progressed to the next layer of modelling, a Local Area Model (LAM) which provided a more detailed zone system and road network. The LAM was developed to cover the study area as shown in Figure 1.2.

1.2.6 The LAM was calibrated and validated against count data collected around the Study Area in September 2022 along with Journey Time data extracted from the Tom Tom journey time database. The LAM provided a more detailed view of the area and allowed for better understanding on the impacts of the proposed scheme.

1.2.7 The LAM was applied through several iterations of testing proposed schemes and developing mitigations for problems that arose until a preferred option emerged.

Figure 1.2 Living Streets Neighbourhood Study area

1.2.8 The local area model was supported by junction specific LINSIG modelling. Figure 1.3 shows the hierarchy of the model deployment for this study.

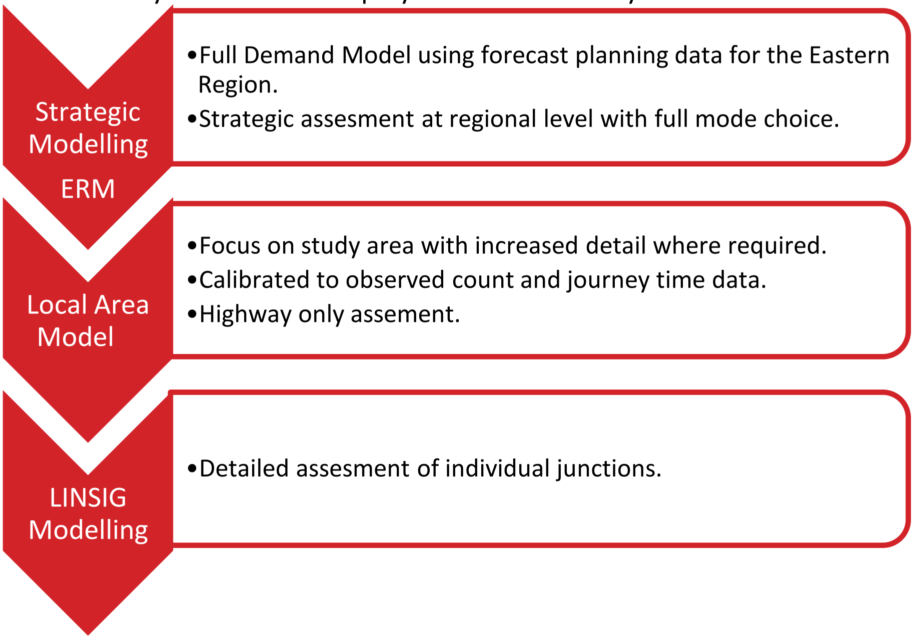

Figure 1.3 Modelling Process

1.2.9 Table 1.1 below shows the alignment of KPIs from the modelling and study's objectives for the modelling exercise.

Table 1.1 Study's Objectives for the Traffic Modelling Exercise

Objective	Method of Measurement
Promote inclusive, sustainable mobility and reduce car dependency by making walking, cycling and public transport more convenient, enjoyable, and safer for all.	Change in car trips along key active corridors. Change in traffic volumes passing through the Living Streets area.
Improve the neighbourhood by reducing traffic and related noise and air pollution; and increasing climate resilience through planting and greening initiatives.	Change in emissions levels within the Living Streets Neighbourhood. Change in traffic levels within the Living Streets Area on key routes.
Enhance the economic vibrancy of Dún Laoghaire as a mixed-use town and its attractiveness as a destination by facilitating the sustainable and efficient movement of people and goods, and by creating an environment that people want to linger in.	Review of zonal access to ensure all zones remain accessible by car, ensuring those who need to travel by car still can. Change in travel situation, delays and junction performance, on perimeter roads.
Improve connections between bus, rail and active travel facilities to make it easier for people to access sites of interest in the town, the seafront and surrounding neighbourhood.	Change in car trips along key active travel corridors. Alternative bus route catchment analysis.
Promote health and wellbeing in the community by enabling safer active travel and enhancing the public realm for outdoor play, recreation, and social interaction.	Change in traffic levels within the Living Streets Area. Change in traffic along key active corridors and outside schools. Change in air quality withing the area.
Promote equitable travel options and urban design that creates a safe and welcoming experience for all members of society, regardless of age, gender, ability, or income.	Retain access/egress routes for the Living Streets Neighbourhood for car users. Change in traffic volumes passing through the Living Streets area. Change in traffic levels within the Living Streets Area on key routes and outside schools.

	Change in delays and junction performance on perimeter roads.

1.3 Report Structure

1.3.1 The report is divided into the following sections:

- **Section 2** provides an overview of the existing situation with an introduction to the context, the local area characteristics, and the existing transport network;
- **Section 3** describes the NTA's East Regional Model;
- **Section 4**; describes the initial testing with the NTA's East Regional model;
- **Section 5**; describes the development of the Local Area Model;
- **Section 6**; describes the iterative modelling process undertaken in the Local Area Model;
- **Section 7** discusses the application of Mode Shift in the Local Area Model;
- **Section 8** details the results of the Preferred Scheme and looks at the performance of junction, including design options and route options for busses; and
- **Section 9** presents the conclusion of the assessment.

2. EXISTING SITUATION

2.1 Local Area Characteristics

2.1.1 Dún Laoghaire is located to the southeast of Dublin City Centre. Its close proximity to Dublin City Centre has led to it becoming a major retail, employment and residential area within the wider Dublin Metropolitan area.

2.1.2 The town is connected to Dublin City Centre, and the wider area, by high quality public transport services including the DART and frequent Dublin Bus services. The DART serves the harbour side and eastern residential side of Dún Laoghaire centre with a high frequency train service. The Dublin Bus services provide services along; York Road and Glenageary Road Lower and Upper. The majority of services utilise Crofton Road and complete a loop along George's Street Lower to leave the town with an interchange between DART and Dublin Bus on Crofton Road.

2.1.3 The Centre of Dún Laoghaire consist of a mix of shopping centres and high-street shopping with high density commercial and residential. The centre of the town is located along George's Street Lower and Upper, providing the primary retail space, and Marine Road, providing residential and commercial.

2.1.4 To the south of the town centre, between George's Street and Tivoli Road, is a low to mid density residential area. This area is the primary connection between the town centre and the new higher density developments of Culanor and Honeypark.

2.1.5 The Covid-19 pandemic has led to substantial improvements in active travel within the area through the introduction of the Coastal Mobility Route reported on in the DLR COVID-19 Mobility Review carried out by TU Dublin[1].

2.2 Existing Transport Demand

2.2.1 Mode share for Dún Laoghaire is shown in Figure 2.1 divided into internal and external trips. Internal trips are trips within the study area shown previously in Figure 1.2, these trips could also be classified as local trips as they remain within the town centre and adjacent residential areas. External trips are trips that originated or terminate outside the study area.

[1] https://www.tudublin.ie/media/TU_Ph2a_CovidMob_BusinessCMR_IssDLR0223FI.pdf

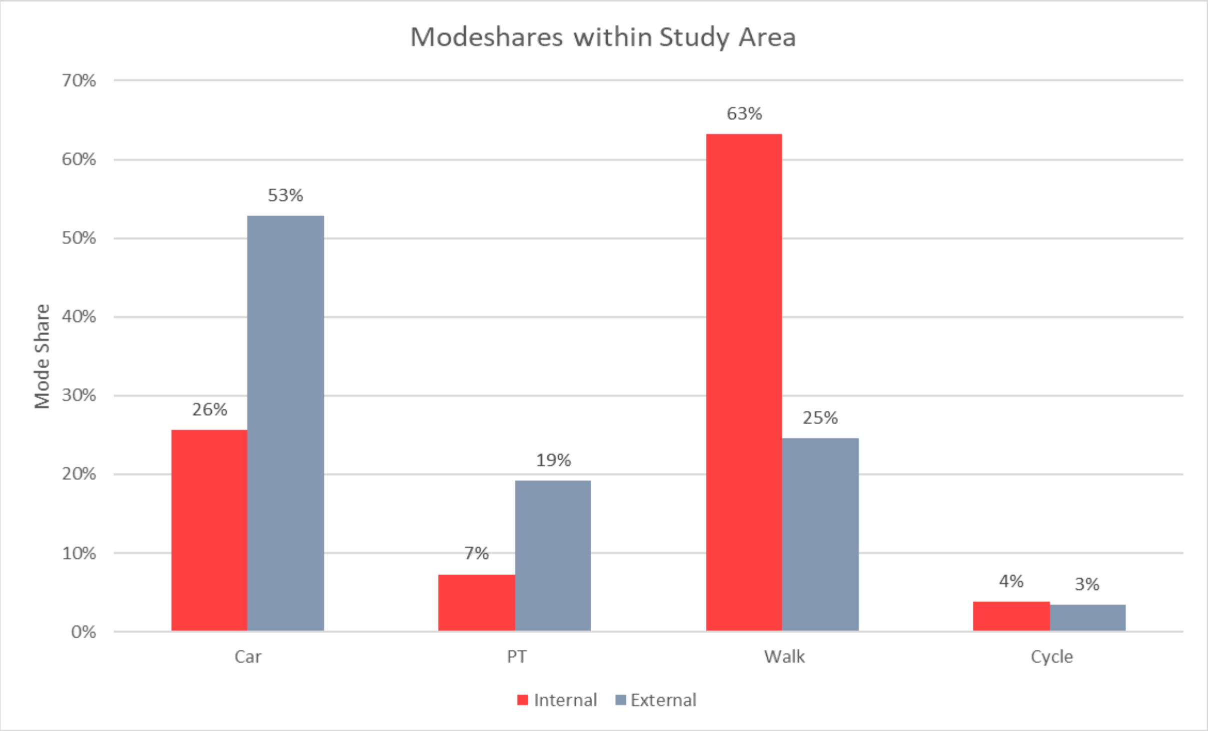

Figure 2.1 Mode shares within the study area

2.2.2 Mode shares in Figure 2.1 are extracted from the ERM for a 2022 reference case model run.

2.2.3 The mode share information indicates that internal trips are predominantly made by walking with car making up most of the remaining trips. Public Transport is relatively low within the area which is not unusual for short trips. However, cycle trips are low for the local area and show an area where improvement can be made.

2.2.4 For external trips, the majority are made by car though a large proportion of trips use public transport. The public transport trips are primarily to connect to the city centre while car is used to connect to areas of South Dublin and down to Wicklow. Mode share for external trips is consistent with the GDA average mode share of 49% Car, 20% Public Transport and 31% active mode.

2.2.5 For context, the 2030 Climate Action Plan has a forecast mode share of 53% Car, 19% PT and 28% Active Modes in the scenario that achieves Ireland’s climate goals of a 50% reduction in vehicle emissions by 2030, this mode share is an average for the whole country. To achieve this, compact areas with access to high frequency public transport, such as Dún Laoghaire, would need to achieve much higher sustainable mode shares.

2.3 Existing Transport Network

Public Transport

2.3.1 Dún Laoghaire is well served by public transport, with the DART providing high frequency connections north to Dublin City Centre and south toward Bray.

2.3.2 Multiple bus routes currently serve Dún Laoghaire, with the major routes being;

- 46A Dún Laoghaire to Phoenix Park
- 111 Brides Glen to Dún Laoghaire
- 45A Dún Laoghaire to Kilmacanogue
- 59 Dún Laoghaire to Killiney
- 63 Dún Laoghaire to Kilternan Village
- 75 Dún Laoghaire to Tallaght

2.3.3 These routes are shown in Figure 2.2 below.

Figure 2.2 Major existing bus routes in Dún Laoghaire

2.3.4 The routes shown are all due to be replaced with BusConnects services in the near future with the new routes becoming;

- B3 – Dún Laoghaire to Blanchardstown (via City Centre)
- E2 – Dún Laoghaire to Charlestown (via City Centre)
- S8 – Dún Laoghaire to Citywest
- L11 – Dún Laoghaire to Kilmacanogue
- L21 – Dún Laoghaire to Killiney
- L22 – Dún Laoghaire to Brides Glen
- L25 – Dún Laoghaire to Dúndrum
- L27 – Dún Laoghaire to Ballyogan

2.3.5 In addition to the public transport network, the aforementioned Coastal Mobility Route provides a high-quality cycle connection from the western edge of the study area to Blackrock and from Queen's Road east to Sandycove.

Road Network

2.3.6 Dún Laoghaire is not located directly on the strategic road network with the nearest strategic routes being the N11 and M50. These routes are connected by the N31 national road and a number of regional roads which operate as connections to the strategic route but also distributor roads for local traffic.

2.3.7 Within the model area there are three main routes accessing the town centre, each road offers one lane in each direction. There is little scope to expand these roads due to residential units boarding each side. The three roads are:

- York Road/Clarence Street - on the western side of the town, connects to Crofton Road and is used by the majority of bus routes;
- Glenageary Road Lower – on the eastern side of the town connecting onto George's Street Upper at the People's Park Junction; and
- Summerhill Road – on the eastern side of the town connecting to the People's Park Junction and provides a link to Dalkey.

2.3.8 Within Dún Laoghaire there are three main routes through the town and two secondary routes;

- Crofton Road – part of the N31 national road and a main route for east/west traffic as well as the termination point for many of the bus routes and location of the DART Station;
- Marine Road – provides north/south access to the centre of Dún Loaghaire as well as access to the Dún Laoghaire Shopping Centre car park;
- Georges Street Upper – a retail street running east/west and used by traffic entering the town from the People's Park Junction;
- Queen's Road – running one way from east to west with a short two way section at the western end to provide access to car parking;
- Tivoli Road – a distributor road connecting York Road to Glenageary Road Lower, used by local traffic to access the Living Street Neighbourhood area and traffic bypassing the town centre; and

- George’s Street Lower – pedestrian focused retail street currently used by bus routes leaving Dún Laoghaire.

2.3.9 The key roads that were examined in this study are shown in Figure 2.3 below.

Figure 2.3 Key study roads in Dún Laoghaire

3. EAST REGIONAL MODEL

3.1 Overview

3.1.1 The East Regional Model is part of the National Transport Authority's Regional Modelling System (RMS) for Ireland that allows for the appraisal of a wide range of potential future transport and land use alternatives. The RMS comprises the National Demand Forecasting Model (NDFM); five large-scale, detailed, multi-modal regional transport models; and, a suite of Appraisal Modules. The five regional models comprising the RMS are focussed on the travel to-work areas for Dublin (represented by the aforementioned East Regional Model (ERM)), for Cork (represented by the South-West Regional Model (SWRM)), for Limerick (represented by the Mid-West Regional Model (MWRM)), for Galway (represented by the West Regional Model (WRM)) and for Waterford (represented by the South East Regional Model (SERM)).

3.1.2 The key attributes of the five regional models include; full geographic coverage of each region, detailed representations of all major surface transport modes including active modes, road and public transport networks and services, and of travel demand for five time periods (AM, 2 Inter-Peaks, PM and Off-Peak). The RMS encompasses behavioural models calibrated to 2017 National Household Travel Survey[2] data that predict changes in trip destination and mode choice in response to changing traffic conditions, transport provision and/or policies which influence the cost of travel.

Purpose of the Regional Modelling System

3.1.3 The NTA uses the RMS to help inform decisions required during strategy development and to assess schemes and policy interventions that are undertaken as part of its remit. The RMS has been developed to provide the NTA with the means to undertake comparative appraisals of a wide range of potential future transport and land use options, and to provide evidence to assist in the decision-making process. Examples of how the RMS can assist the NTA include testing new public transport schemes by representing the scheme in the assignment networks, testing demand management measures by, for example, changing the cost of parking or number of parking spaces within the regional model or testing the impacts of new land use by changing the planning data assumptions within the NDFM.

3.1.4 The RMS includes the 2016 Census/POWSCAR and 2017 National Household Travel Survey (NHTS) data sets and the NTA has included a range of improvements to the main model components where identified and implemented. These improvements include improving and making changes to such elements as the NDFM, development of the Long-Distance Model, updated zoning, networks, and parking modules; best-practice discrete choice modelling using the NHTS and POWSCAR datasets to estimate the parameters of the behavioural models, improved model runtimes, and general model functionality improvements.

RMS Components

3.1.5 The NTA RMS comprises of the following three main components, namely:

- The National Demand Forecasting Model (NDFM);
- 5 Regional Models (including the ERM); and

- A suite of Appraisal Modules

3.1.6 The NDFM takes input attributes such as land-use data, population etc., and estimates the total quantity of daily travel demand produced by, and attracted to, each of the 18,641 Census Small Areas in Ireland.

3.1.7 The ERM is a strategic multi-modal transport model representing travel by all the primary surface modes – including, walking and cycling (active modes), and travel by car, bus, rail, tram, light goods and heavy goods vehicles, and broadly covers the Leinster province of Ireland including the counties of Dublin, Wicklow, Kildare, Meath, Louth, Wexford, Carlow, Laois, Offaly, Westmeath, and Longford, plus Cavan and Monaghan.

3.1.8 The ERM is comprised of the following key elements:

- **Trip End Integration:** The Trip End Integration module converts the 24-hour trip ends output by the NDFM into the appropriate zone system and time period disaggregation for use in the Full Demand Model (FDM);
- **The Full Demand Model (FDM):** The FDM processes travel demand, carries out mode and destination choice, and outputs origin-destination travel matrices to the assignment models. The FDM and assignment models run iteratively until an equilibrium between travel demand and the cost of travel is achieved; and
- **Assignment Models:** The Road, Public Transport, and Active Modes assignment models receive the trip matrices produced by the FDM and assign them in their respective transport networks to determine route choice and the generalised cost for each origin and destination pair.

3.1.9 Destination and mode choice parameters within the ERM have been calibrated using two main sources: Census 2016 Place of Work, School or College - Census of Anonymised Records (2016 POWSCAR), and the Irish National Household Travel Survey (2017 NHTS).

The use of the ERM for the Proposed Scheme

3.1.10 The NTA's ERM is the most sophisticated modelling tool available for assessing complex multi modal movements within an urban context. This provides a consistent framework for transport assessments.

3.1.11 The ERM provides a high quality, off the shelf solution to testing the impacts of the LSN scheme and understanding the road impacts. While the model has been calibrated to 2016 standards, the validity of results is assessed against more recently gathered count data.

3.1.12 Dún Laoghaire sits within the more detailed centre of the ERM model, and the town is well represented with all major roads and many minor roads included in the model.

4. ERM MODELLING

4.1 Overview

4.1.1 This section details the modelling process undertaken in the ERM including updates to the network, validation against count data and initial results.

4.2 Review of Road Network

4.2.1 The Base ERM road model is currently developed and calibrated against 2016 network conditions. For this study the NTA provided a 2019 reference case road network which included new schemes implemented between the development date of the model and 2019. This however, does not include schemes implemented between 2019 and 2022 and therefore additional coding was required to update the model to 2022.

4.2.2 To update the road network from 2019 to 2022 within Dún Laoghaire, a comprehensive review of the network was undertaken with three main goals:

- To update the transport network to reflect the 2022 situation;
- To add additional network detail where required for the purpose of the study; and
- To correct any issues with the network that may have been overlooked in the NTA calibration process.

4.2.3 The largest change to the road network within Dún Laoghaire is along the sea front where a system of one-way streets has been implemented to accommodate the new Coastal Mobility Route (CMR) cycle facilities shown in Figure 4.1.

Figure 4.1 New one-way roads supporting the Coastal Mobility Route

4.2.4 Further south, the developments of Cualanor and Honey Park have been completed between 2016 and 2022, as such the junction on Glenageary Road Upper connecting the two development sites to the road is operational and serves as the primary access point for the two sites. The developments sit either side of Glenageary Road Upper as shown in Figure 4.2.

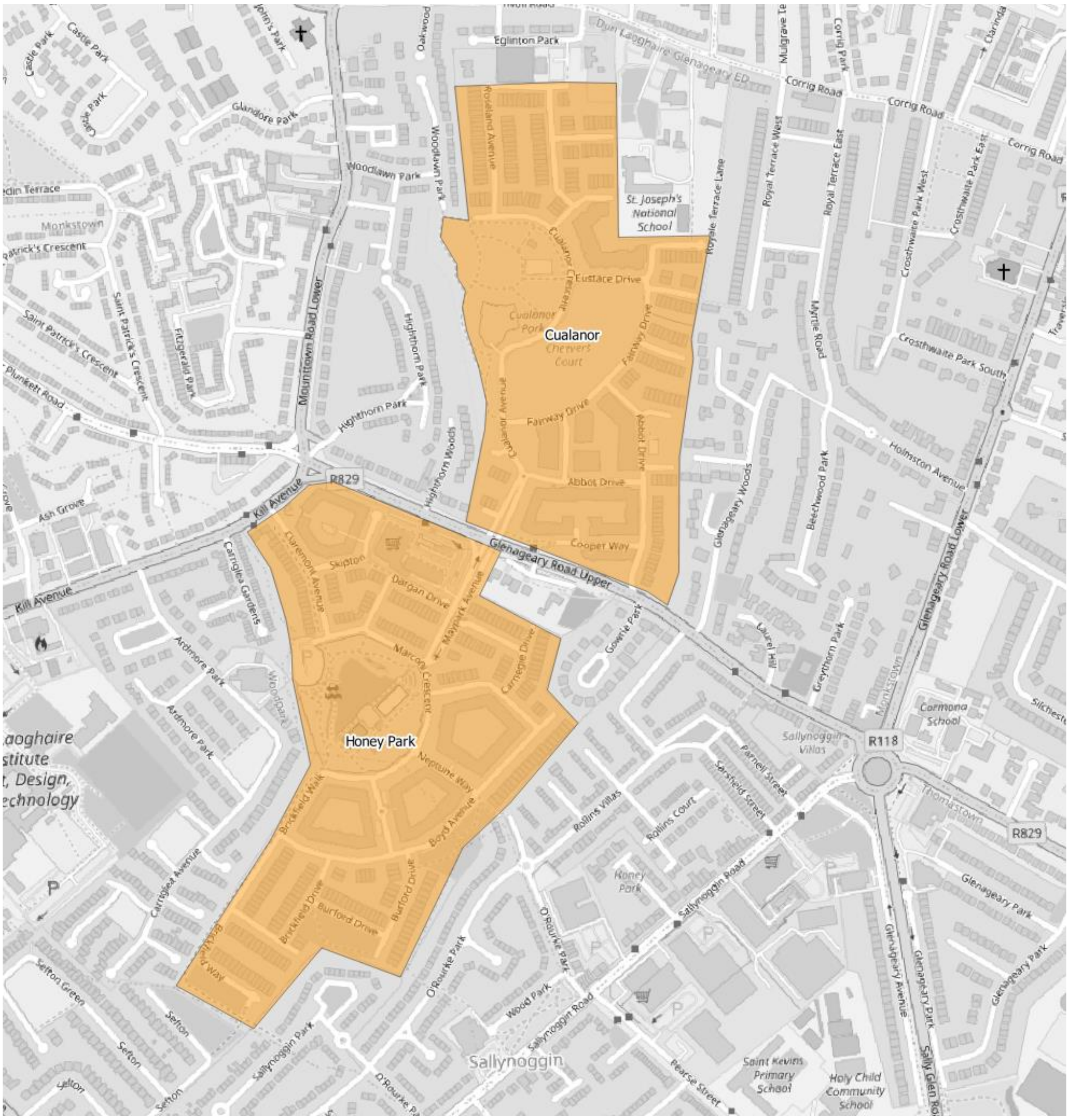

Figure 4.2 Culanor and Honey Park Esates

4.2.5 To understand the impacts of planned schemes within the area additional detail was added to the model. This additional detail was focused on the area between Tivoli Road and George's Street.

4.2.6 The following changes and additional links were added to the road network:

- Added Convent Road;

- Added Mulgrave Street;
- Added Northumberland Avenue;
- Added pedestrian signal on Tivoli Road;
- Added pedestrian signal on Harbour Road; and
- Changed zone loaders, access points for traffic to load and unload from the network, for two zones between George Street and Tivoli Road.

4.2.7 Changes to the links are shown in red in Figure 4.3 below.

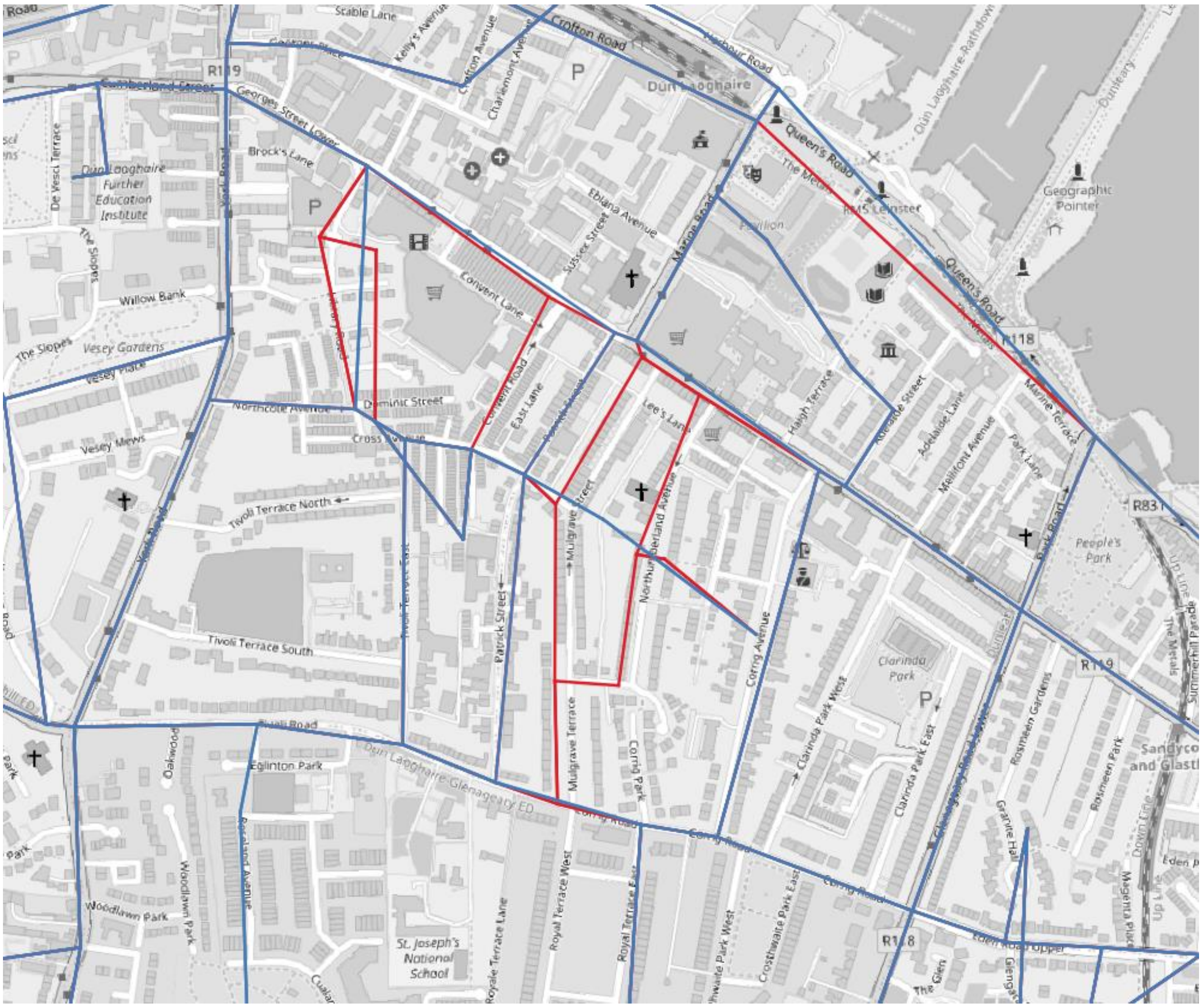

Figure 4.3 New links added to the ERM network

4.2.8 As can be seen from Figure 4.3, not all roads where represented by links within the ERM network. Within the ERM, trips enter and exit zones via zone loaders. These zone access points aggregate all origin destination points, such as homes and shops, into one or two access locations. As a result, minor roads, such as Tivoli Terrace North and South are designated as 'Internal Roads' from a modelling perspective and represented as part of the aggregate zone loader.

4.2.9 The final changes to the network took the form of corrections to the existing 2016 network. While the majority of the network matched the on the ground situation, an exception was

Queens Road, which in the 2016 model connects onto the Harbour Road roundabout. This was corrected in the 2022 model and now connects to Crofton Road.

4.3 Application of ERM

4.3.1 Following the completion of the road review and the preparation of the 2022 road network the ERM was run using the 2022 Business as Usual, or Core, demand set provided by the NTA to produce the base Do Nothing run. This demand set represents growth from the calibrated 2016 base year in line with travel patterns pre-Covid. As such, travel demand is higher as it is assumed a high proportion of employees will commute to their lace of work each day.

4.3.2 This demand set was used as the effects of Covid are still be understood and it is important to apply a worst case scenario to understand the full extent of the impact of the schemes being tested.

4.3.3 Only the Do Nothing Scenario, a scenario where no changes are made and situation tested is ‘as is’, was run in the ERM for this study, tests of the scheme measures where then carried out within a cordoned section of the road network. This process is illustrated by Figure 4.4 below.

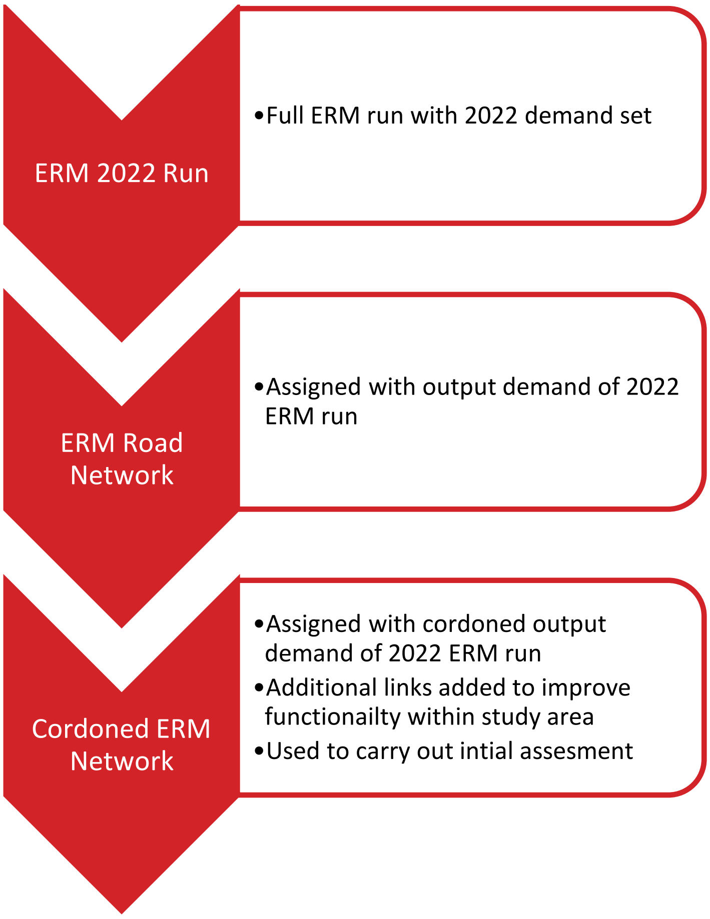

Figure 4.4 Modelling process for the ERM

4.3.4 The reasoning behind using a cordoned network over the East Regional Model is laid out in Table 4.1 below with the pros and cons of each approach detailed.

Table 4.1 Pros and Cons of different ERM modelling approaches

MODEL APPROACH	PROS	CONS
ERM Full Model Run	• Mode choice modelling • Widley used for scheme appraisal in Ireland • Full PT service modelling.	• Strategic focus would lead to limited mode choice impacts of localised schemes. • Long Runs Times of up to 72hrs • Requires access to NTA's suite of high power modelling machines.
ERM Highway Only Run	• Shorter run time than ERM while retaining benefits of the road model. • Can be run on a normal computer without need for NTA modelling machines.	• PT modelling limited to fixed flows. Not PT passenger modelling. • Run times of 3 to 4 hours.
Cordoned ERM Network	• Very short run times of around 5 minutes. • Uses demand from ERM road model, only limiting route choice at a wider regional level. • Can be run on a normal computer without need for NTA modelling machines.	• Region wide impacts not modelled. Not considered an issue for a localised scheme.

4.3.5 The cordoned network for this study is shown in Figure 4.5 below.

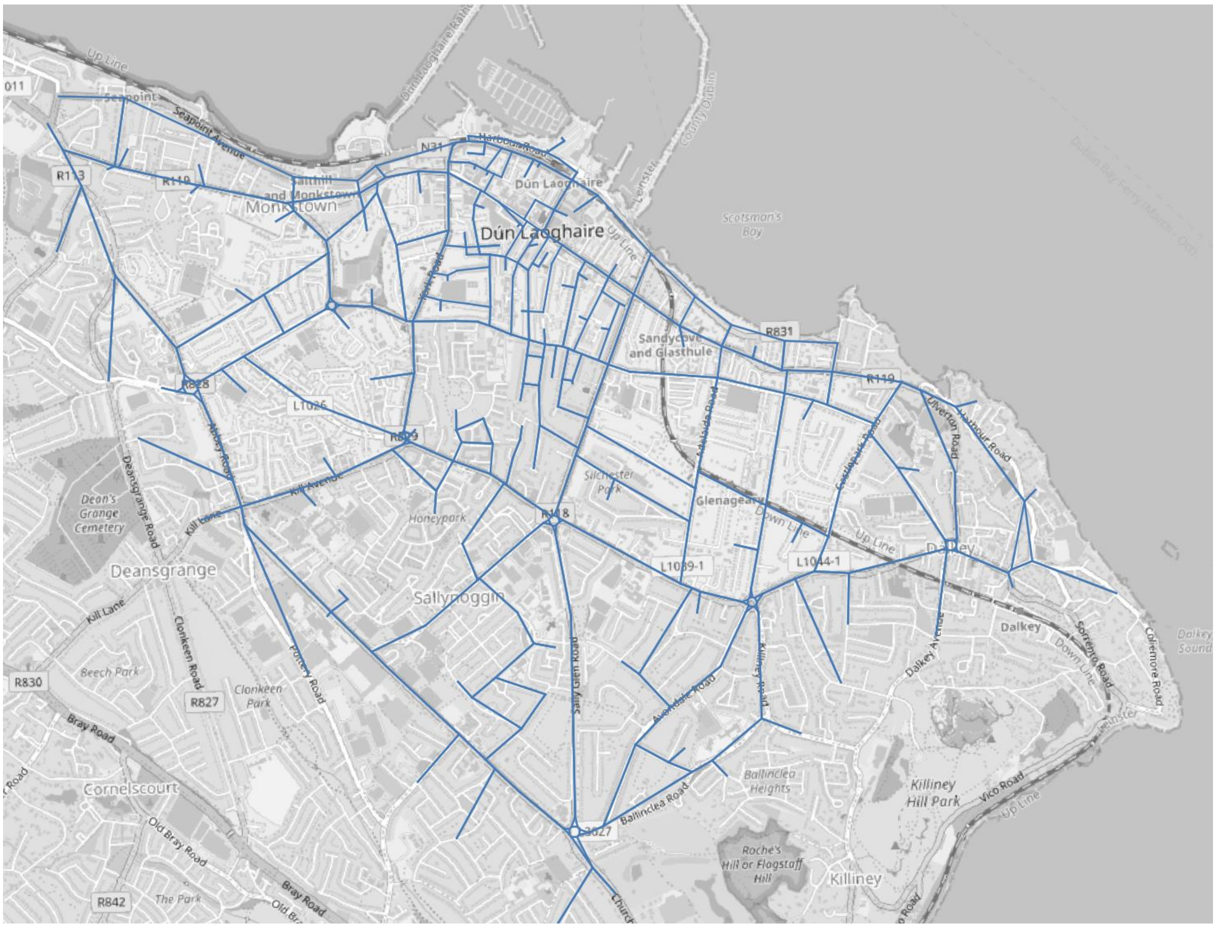

Figure 4.5 Cordoned ERM network

4.4 Validation

4.4.1 To validate the results of the ERM, counts where collected in and around the study area in September 2022. These counts were a mix of Automatic Traffic Counts (ATC) and Junction Turning Counts (JTC), with the ATC counts providing a perimeter around the study area and the JTC providing turning detail within the study area.

4.4.2 A map of the junctions surveyed is shown in Figure 4.6.

Figure 4.6 Location of traffic counts

4.4.3 Traffic flows from the ERM road network were compared against the traffic flows recorded in the observed data. The match between the ERM and observed data was considered insufficient to provide confidence in the model response for understanding some of the more localised aspects of the schemes, particularly movements within the Living Streets Neighbourhood.

4.4.4 While the ERM was able to provide strong results for movements across the wider area, the localised movements were restrained due to the aggregate zone system for the ERM which provided two zones, loading points where traffic joins or leaves the network, for the Living Streets Neighbourhood. As a result of this the movement of traffic internal to the Living Streets Neighbourhood was not well represented, while movement around the permitter routes was better represented.

4.5 Initial Tests and Results

4.5.1 Three scenarios were tested in the ERM, these three scenarios looked at the pedestrianisation of George's Street Lower and modal gates on Tivoli Road and Library Road. The Modal gate proposed for Clarinda Park W was not included in this phase of testing as the link did not exist within the ERM network. In later stages of testing, within the LAM, this modal gate was included.

4.5.2 The results of the tests within the ERM showed limited sensitivity to the new schemes. This was a result of the reduced level of detail within the internal road network of the Living Streets Neighbourhood. Where in a more detailed model access would be impeded and routes changed by the inclusion of the modal gates, the large catchment of the zone system meant that the access points were not impacted by the changes.

4.6 Summary

4.6.1 In order to provide a more detailed assessment of the internal roads within the Living streets, the decision was taken to progress to Local Area Modelling and the development of a bespoke model for the study area which could incorporate the additional detail required to understand the impacts of the proposed schemes.

5. LOCAL AREA MODEL DEVELOPMENT

5.1 Introduction

5.1.1 This chapter describes the development of the base year Local Area Model (LAM) for Dún Laoghaire with reference to the following aspects:

- Modelling software used;
- Model time periods; and
- Network development.

5.2 Modelling Software

For the Local Area Model, SATURN was used to model the network. The full extent of the network is coded in Simulation coding allowing for full junction representation.

The reason for using SATURN are several;

- SATURN is used as the highway component of the ERM, this maintained the relationship between the LAM and the ERM, allowing components of the ERM to be used for additional information;
- A SATURN LAM is relatively straight forward to build from the ERM as they share the same network; and
- SATURN can run very quickly for smaller networks, allowing for easy tweaks and adjustments to be made without significant runs times to process changes.

5.3 Model Time Periods and User Classes

5.3.1 The standard model time period for traffic simulation and assignment models is one hour, as the model was build from the ERM run carried out these hours where kept in alignment. Data collected for the ERM validation was reusable for the calibration of the model.

5.3.2 The ERM models 08:00 to 09:00 in the AM and 17:00 to 18:00 in the PM. Therefore, the LAM was developed, calibrated and validated to represent the following time periods:

- AM Morning peak period: 08:00 to 09:00
- PM Evening peak period: 17:00 to 18:00

5.3.3 The trip demand matrices for these time periods, representing a base year of 2022, were developed for the LAM using extractions from the ERM. The split of user classes from the ERM was maintained, however for calibration purposes the totals were aggregated into three vehicle classes;

- VC1 – Cars
- VC2 – LGVs
- VC3 - HGVs

5.4 Network Development

5.4.1 The goal in developing the LAM was to create a model that could more accurately represent the local impacts of the Living Streets Neighbourhood. While the network in the ERM was updated to represent the majority of streets within the LSN area, the zone system was considered too aggregate.

5.4.2 The extend of the LAM network is shown in Figure 5.1 below.

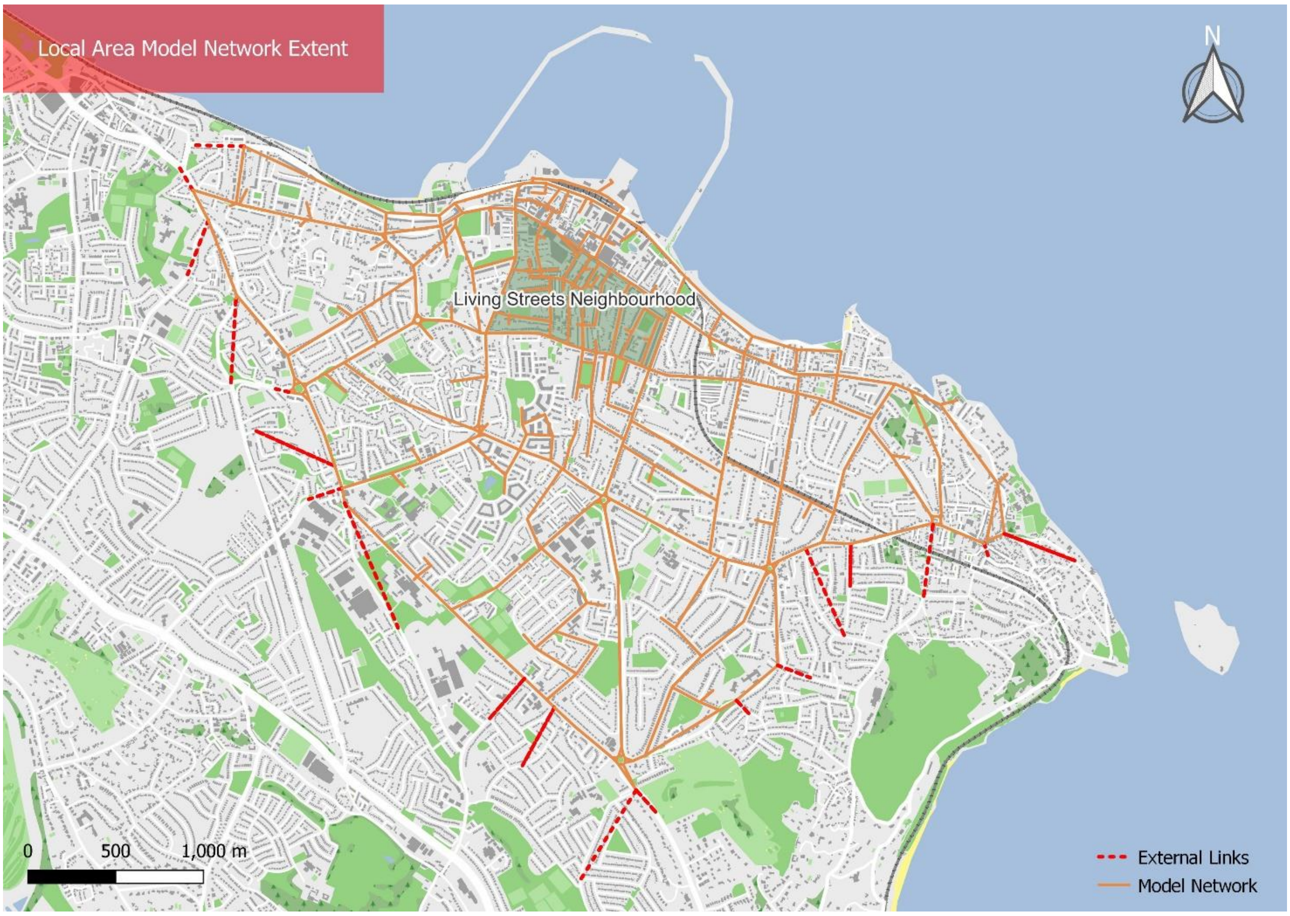

Figure 5.1 Local Area Model network

5.4.3 Additional detail over what was added to the ERM model was included in the LAM to both accommodate the new zone structure but also take advantage of the increased level of detail in demand assignment.

5.4.4 Figure 5.2 illustrates the additional road network added to the LAM to ensure suitable representation of the local network.

Figure 5.2 Local Area Model network within the Living Streets Neighbourhood

5.4.5 The short dead-end links in the figure are zone loaders used to load and unload traffic from zones onto the model network, and reflect the further developed zone network that is outlined in Figure 5.3**Error! Reference source not found.** below.

5.5 Model Zone System and Prior Matrix Development

5.5.1 Zones are the origin and destination for all trips in the model. They represent areas of population and employment by aggregating the trips together into a single entry/exit point from the network. The primary reason to develop the LAM was to increase the disaggregation of the zone system used for the modelling exercise. By disaggregating the zone system used more detail can be added to the locations where trips load and unload from the network.

5.5.2 These loading and unloading locations are particularly important in the assessment of the LSN as the area includes many small roads that can be used as rat runs. In the ERM the area is represented by 2 zones which result in trips loading directly to the perimeter roads. Through disaggregation the model can represent unloading and loading onto the local network that was internal to the ERM zones.

5.5.3 The LAM zone system is shown in Figure 5.3 below.

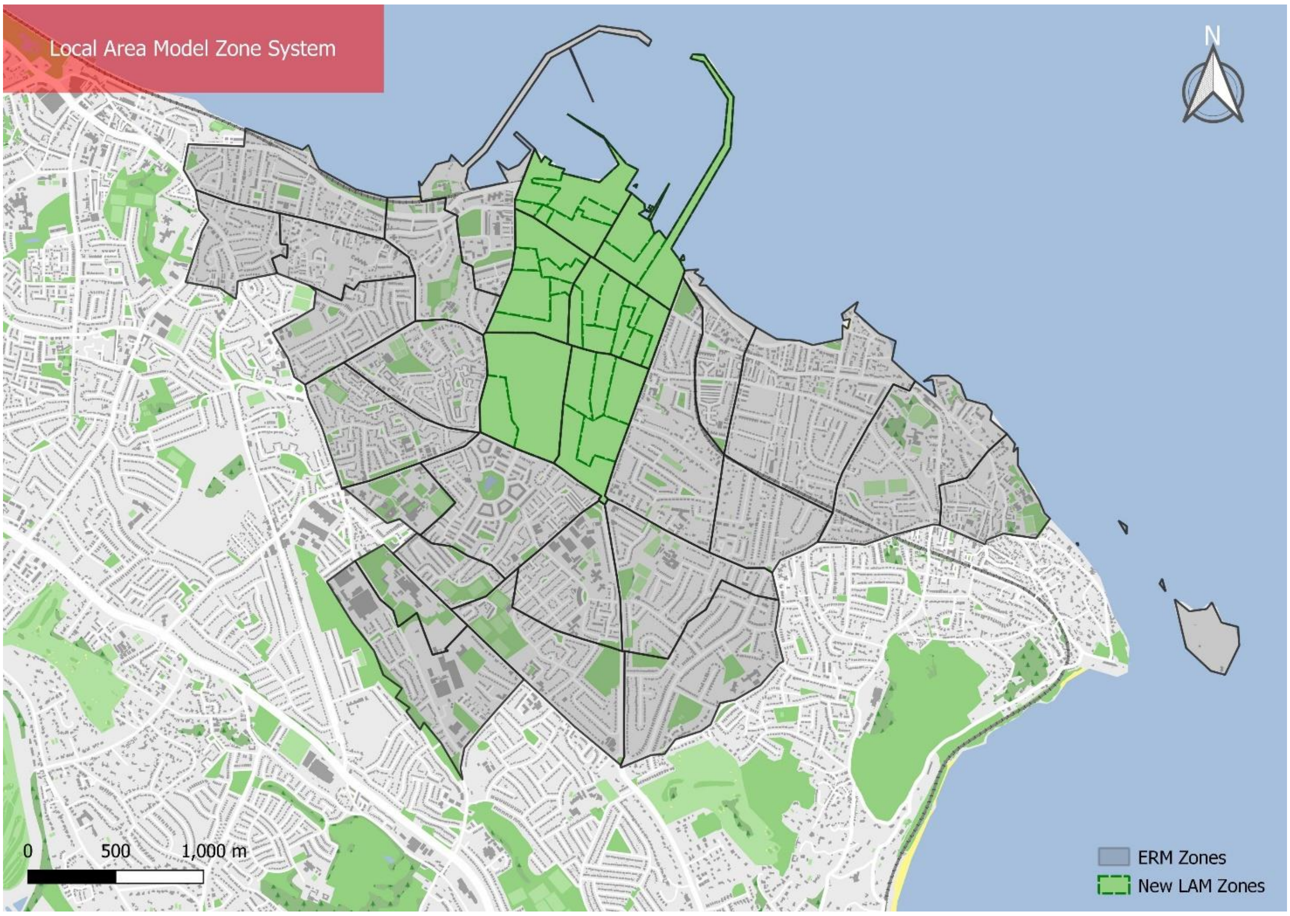

Figure 5.3 Local Area Model Zone System

5.5.4 The zones for the LAM were disaggregated based on census small areas. Only the study area was disaggregated, with the 6 ERM zones converted into 30 LAM zones.

5.6 Prior Matrix Development

5.6.1 The prior matrix developed for the LAM was derived directly from the ERM assignment through Cordoning the ERM assignment matrix.

5.6.2 This cordoned assignment matrix was disaggregated based on population, education and employment data taken from the 2016 Census.

5.7 Calibration

Traffic Surveys

5.7.1 To Calibration the model, traffic surveys gathered for the ERM validation were reused in addition to Tom Tom data for journey time information.

Criteria

5.7.2 The DMRB Volume 12a guidelines (Traffic Appraisal in Urban Areas) are a widely accepted standard in Ireland (with TII basing their guidelines on this document) that provides extremely robust validation criteria to which certain types of highway models should adhere. This document sets a guideline that 85% of links should have a GEH less than 5 (when measured in vehicles per hour) as shown in Table 5.1 below. In addition, it is commonplace to establish that 90% of assessment links have a GEH of less than 10.

Table 5.1 Calibration Acceptance Criteria

Criteria	Acceptability Guideline
GEH < 5 for individual flows	> 85% of cases

5.7.3 The GEH statistic is a measure that considers both absolute and proportional differences in flows. Thus, for high levels of flow a low GEH may only be achieved if the percentage difference in flow is small. For lower flows, a low GEH may be achieved even if the percentage difference is relatively large. GEH is formulated as:

$$\mathrm{GEH} = \sqrt{\frac{(\text{observed} - \text{modelled})^2}{0.5 \times (\text{observed} + \text{modelled})}}$$

5.7.4 The reason for introducing such a statistic is the inability of either the absolute difference or the relative difference to cope over a wide range of flows. For example, an absolute difference of 100 pcu/h may be considered a big difference if the flows are of the order of 100 pcu/h, but would be unimportant for flows in the order of several thousand pcu/h. Equally a 10% error in 100 pcu/h would not be important, whereas a 10% error in, say, 3000 pcu/h might mean the difference between adding capacity to a road or not.

5.7.5 In addition to 85% of GEHs being less than 5 it is expected that the R^2 correlation between pre matrix estimation and post estimation would be greater than 0.95. The R^2 is a marker of how much work Matrix Estimation has had to do in order to match flows to observed counts.

5.7.6 A low R^2 generally means that the starting point and counts are mismatched. A lower R^2 is often acceptable where there is high confidence in the quality and coverage of the count data.

Model Calibration Results

5.7.7 Table 5.2 below summarises the GEH calibration results for the model after the matrix estimation process, for AM and PM.

5.7.8 The figures demonstrate that an excellent calibration has been achieved for AM and PM. The R^2 value for AM was 0.88 and 0.92 for PM.

5.7.9 While the majority of zones where constrained to avoid too much variation in cell totals, the new zones within the study are had a looser constraint to match counts where counts where available near zone loaders. As there was a high confidence level in the counts due to their coverage and having been taken recently this variation was considered acceptable.

Table 5.2 Calibration Results

GEH	AM	PM
GEH < 5	91%	94%
GEH < 7	9%	6%
GEH < 10	0%	0%

5.8 Validation

5.8.1 Validation of the model was conducted using journey times from Tom Tom data.

5.8.2 PAG (Unit 5.2 Table 5.2.2 and 5.2.3) advises that modelled journey times should be within 15% of the observed time (or 60 seconds if higher) in more than 85% of routes. Table 5.3 shows the results of the validation for the two peaks.

Table 5.3 Journey Time Validation Results

PASS/FAIL	AM	PM
Pass	7	6
Fail	0	1
Pass Rate	100%	86%

5.8.3 The results show a good match for journey times with all but 1 of the AM journey times failing.

5.8.4 The failed journey time route in the PM was from Sandycove DART Station to Crofton Road, running 1 minute 36 seconds faster than observed. The reason for this difference was considered to be due to several interactions not covered by the model;

- On street parking along George's Street Upper – The on street parking on George's Street Upper can lead to slowdowns in traffic when a car attempts to park, moves slower looking for a space to park or is forced to stop to allow another car out. This interaction is not modellable in SATURN as it is random.
- Unrestricted Pedestrian Movements along Marine Road – Marine Road has several uncontrolled pedestrian crossing points, these can lead to cars slowing down to avoid conflict with pedestrians.
- Bus stops – several bus stops existing along George's Street Upper and Marine Road. These stops are in line with the road and would require cars to wait or pull around the bus leading to delays.

5.8.5 While the model meets calibration criteria set out in PAG, steps were taken to address the failed PM journey time by adjusting speeds along George's Street Upper and Marine Road to replicate the delay observed. However, these changes had knock on impacts within the wider model that affected validation and as such not retained within the final model.

6. LAM MODELLING

6.1 Scenarios and Project Phasing Overview

6.1.1 In total, 12 primary scenarios were tested within the LAM, with an additional 5 sub scenarios totalling 17 tests. These scenarios were developed in conjunction with DLRCC in an iterative manner addressing issues encountered during subsequent testing to ultimately develop the best combination of schemes to achieve the projects objectives.

6.1.2 Two reference case scenarios were developed for comparison of the scenarios;

- Do Nothing – the calibrated model representing the existing condition in 2022; and
- Do Minimum – the calibrated model but inclusive of the Glenageary Upper – Kill Avenue junction redesign included in the Dún Laoghaire Central scheme.

6.1.3 The scenarios were divided into three main bodies of work:

- **Initial Testing** – This phase of the project looked at the original proposed schemes and their impact on the network within the study area. From these scenarios an initial preferred scenario was developed.
- **Mitigation Testing with Initial Preferred Option** – Once an initial preferred scenario was selected, mitigation testing was undertaken to look at ways to reduce the negative impacts of the initial preferred scheme. This phase was followed by a workshop with DLRCC to go through the options and decide steps forward.
- **Revision of Preferred Option** – The outcome of the workshop following Mitigation Testing with the Initial Preferred Option was the development of a series of further tests addressing the key issues highlighted during the initial phases of testing. This phase of the project was followed by another workshop in which the final preferred option was agreed upon.

6.1.4 These phases and the scenarios tested within each is presented in Figure 6.1.

Initial testing

- S1: Pedestrianisation of George’s Street Lower
- S2: S1 + Library Road Modal Gate and Clarinda Park W
- S3: S2 + Tivoli Road (Between Patrick Street and Mulgrave Street)

Mitigation Testing with Initial Preferred Option

- S7a: S3 + Reversal of Windsor Terrace from Link Road to Park Road
- S7b: S3 + Reversal of Windsor Terrace from Forty-Foot to Park Road
- S8: S3+ Closure of Windsor Terrace at the Baths

Workshop

Revision of Preferred Option

- S9: Pedestrianisation of George’s Street Lower with Modal Gate on Cross Ave, Clarinda Park W, Tivoli Road (Between Patrick Street and Mulgrave Street) and Library Road. Inclusion of Reversal of Windsor Terrace from Link Road to Park Road.
- S10a: S9 but with the Tivoli Road Modal gate moved to west of Patrick Street.
- S10b: S9 but with the Tivoli Road Modal gate moved to west of Patrick Street and Library Road modal gate removed.
- S11a: S9 with bus gate on Summerhill Road Westbound.
- S11b: S10 with bus gate on Summerhill Road Westbound.

Workshop

Preferred Option

- Scenario 10b:
  - Pedestrianisation of George’s Street Lower
  - Modal Gates on Cross Ave, Clarinda Park W and Tivoli Road (West of Patrick Street)
- Reversal of Windsor Terrance between Link Road and Park Road

Figure 6.1 Modelling process and phases

6.2 Initial Testing

6.2.1 This section covers the first scenarios tested and the development of the Initial Preferred Option.

6.2.2 Three scenarios were tested in this phase of the project;

- **Scenario 1** – Pedestrianisation of Georges Street Lower from the junction of Patrick Street to the entrance of Convent Lane opposite St Michael's Hospital.

Figure 6.2 Scenario 1

- **Scenario 2** – Scenario 1 with the inclusion of a Modal Gate on Tivoli Road between Patrick Street and Mulgrave Street.

Figure 6.3 Scenario 2

- **Scenario 3 -** Scenario 2 but with the inclusion of a modal gate on Library Road south of the Bloomfields Car Park entrance and on Clarinda Park West at the northern end of the road before the junction with Georges Street Upper.

Figure 6.4 Scenario 3

6.2.3 Testing of the scenarios looked at multiple key indicators, however the ones presented in this section cover the indicators used to inform a decision on which scheme to carry forward to the next round of testing;

- Trips within the Living Streets Neighbourhood – this provides insights into the effectiveness of the modal gates and pedestrianisation in reducing traffic within the Living Streets Neighbourhood; and
- Flows on key roads within the Living Streets Neighbourhood – this provides insights into the change in traffic levels within the Living Streets Neighbourhood across the day.

6.2.4 The focus of this initial testing was to reduce through traffic within the LSN area as much as possible in line with the wider study objectives to facilitate increased active mode use. Figure 6.5 below shows the impact of each scenario on the traffic levels within the LSN, illustrating a breakdown of the lengths of trips. Local traffic is traffic that is either originating or terminating within the LSN, while through trips have neither their origin or destination within the area.

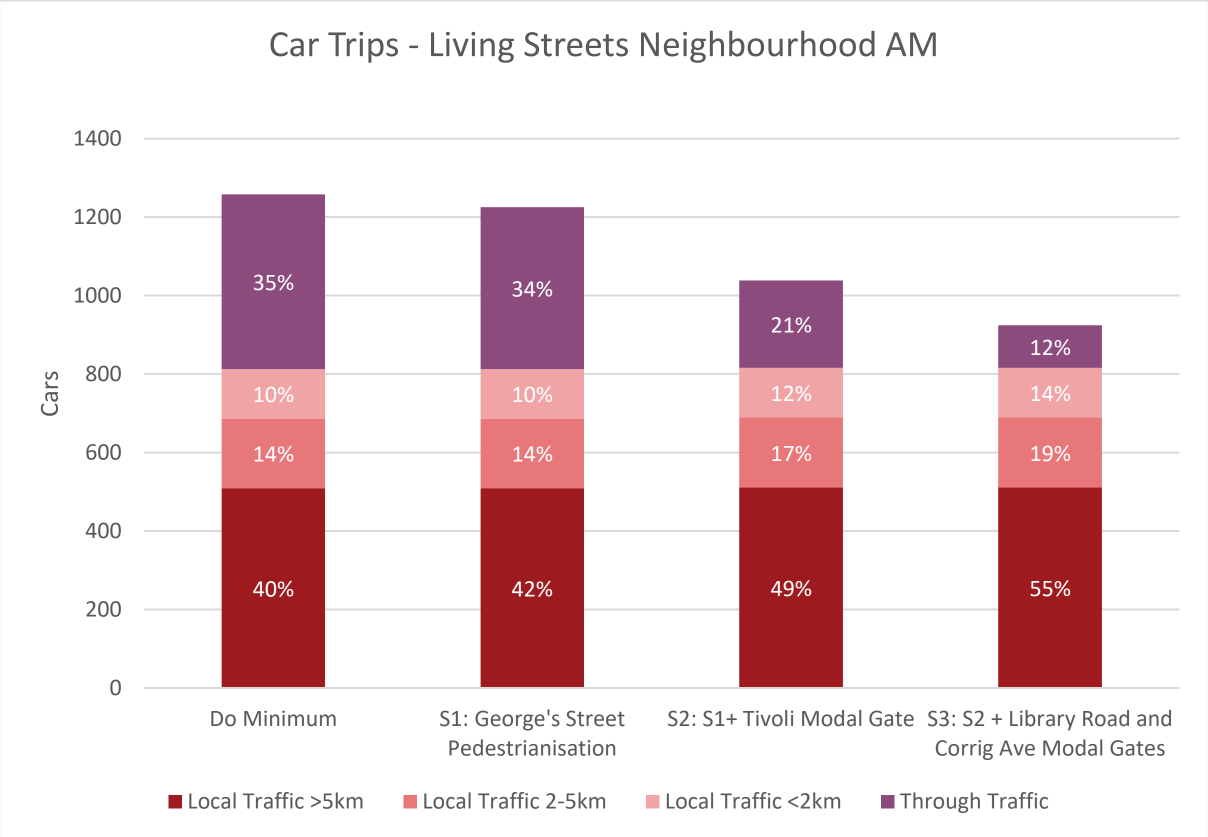

Figure 6.5 Car trips within the Living Streets Neighbourhood

6.2.5 The graph shows a clear reduction in through traffic within the LSN as the modal filters are introduced. In the 'Do-Minimum' scenario 35% of existing car trips within the LSN area are through trips, this reduces substantially to 12% of car trips in Scenario 3.

6.2.6 Figure 6.6 and Figure 6.7 below show the impact in all day flows on key roads within the LSN area.

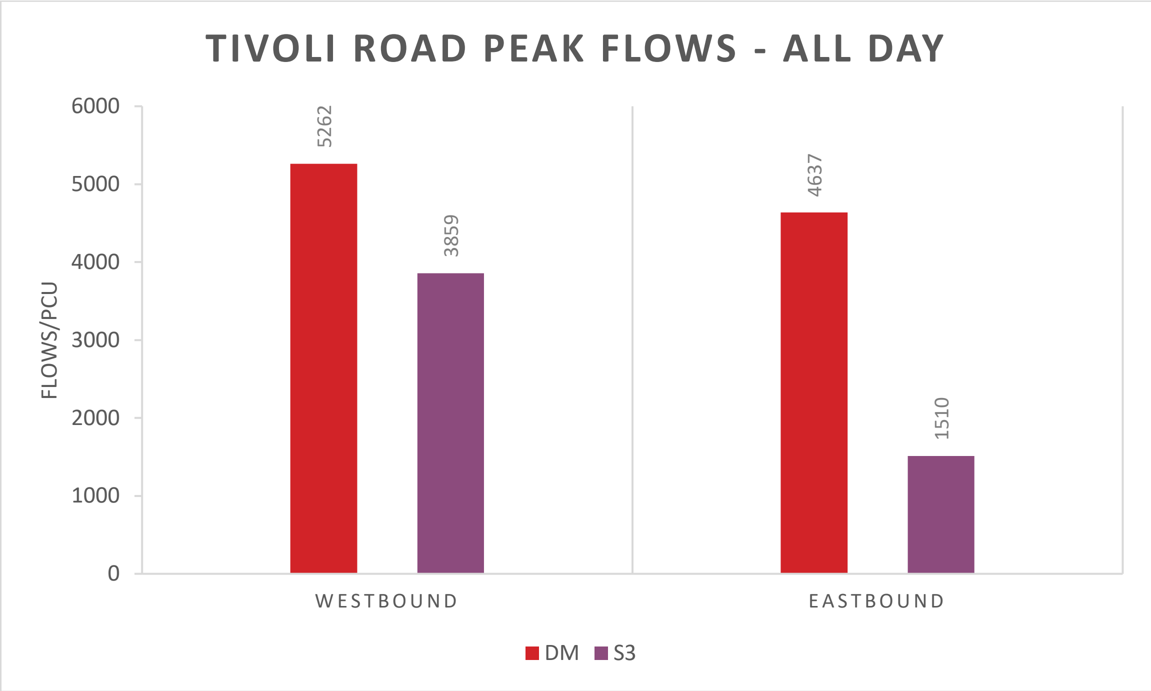

Figure 6.6 All day flows on Tivoli Road

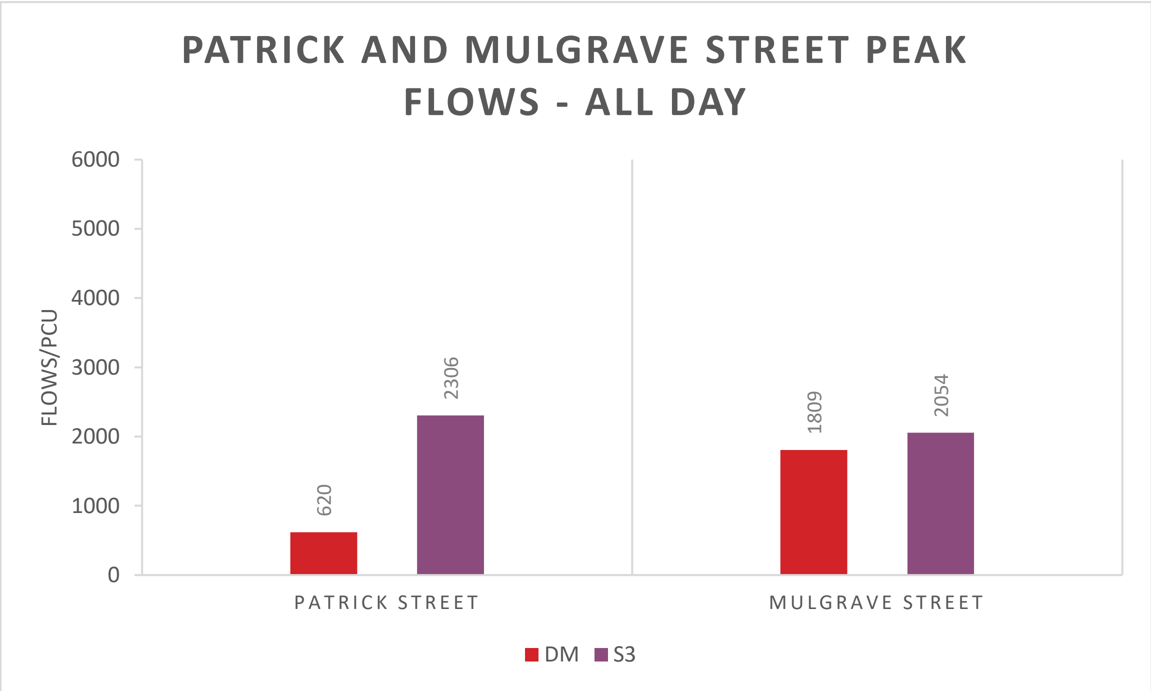

Figure 6.7 All day flows on Patrick and Mulgrave Street

6.2.7 The inclusion of all the modal gates in Scenario 3 leads to a substantial reduction in traffic on Tivoli Road but also an increase in traffic on Patrick Street. This is the result of cars using Patrick Street to pass through the LSN area from Georges Street Upper. A smaller increase also occurs on Mulgrave Street as a result of traffic bypassing the Tivoli Road modal gate. Both of these rat run routes are shown in Figure 6.8 below.

Figure 6.8 Rerouting of traffic through Living Streets Neighbourhood in Scenario 3

6.2.8 Flows redirected from the LSN area are directed onto the perimeter roads. This adds additional pressure to the roads around the LSN area but in particular brings the People's Park junction under pressure. This is due to traffic which previously travelled along Corrig Avenue and Tivoli Road instead using the People's Park Junction to either access Queen's Road along the shorefront or turning right to access George's Street Upper.

6.2.9 A summary of the initial testing is shown below with the preferred option highlighted.

Table 6.1 Summary of initial testing

SCENARIO	POSTIVE IMPACTS	NEGATIVE IMPACTS
Scenario 1	Removed vehicle flow from George's Street Lower which would allow the development of an active friendly public realm.	No change in traffic flows through the Living Streets Neighbourhood.

SCENARIO	POSTIVE IMPACTS	NEGATIVE IMPACTS
Scenario 2	Reduction in through traffic within the Living Streets Neighbourhood.	Significant rat running on local roads to avoid the Tivoli Modal Gate.
Scenario 3	Further reduction in through traffic within the Living Streets Neighbourhood over scenario 2. Rat running confined to Patrick Street and Mulgrave Street.	Some rat running still occurring. Increase in traffic volumes on neighbouring roads with increased pressure on the People's Park junction.

6.3 Mitigation Testing with Initial Preferred Option

6.3.1 This section covers the first scenarios tested and the development of the Initial Preferred Option, Scenario 3. These tests looked primarily at mitigation measures along the shorefront between Marine Road and the Forty Foot.

6.3.2 The purpose of these mitigations was to alleviate pressure on the People's Park junction to allow for further investigation of removing non-destination trips from the Living Streets Neighbourhood.

6.3.3 Three scenarios were tested in this phase of the project. Note Scenarios 4, 5 and 6 were developed for discussion but were not fully tested and subsequently discarded;

- **Scenario 7a –** Scenario 3 with reversal of one-way system on Windsor Terrace so

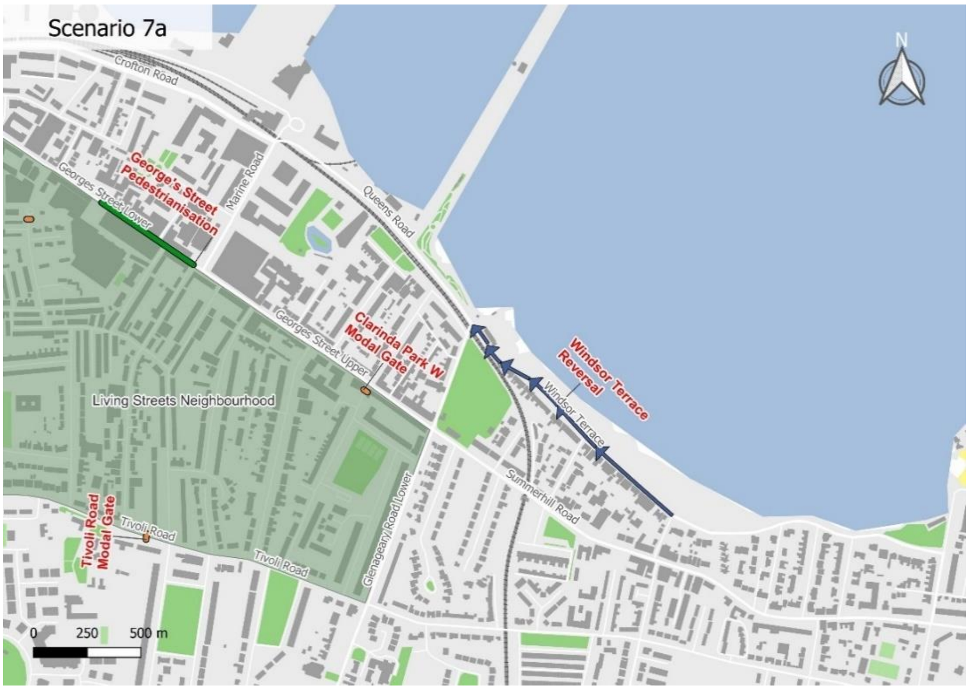

Figure 6.9 Scenario 7a

- **Scenario 7b** – Scenario 3 with reversal of one-way system on Windsor Terrace so that it runs from the Forty Foot to Park Road.

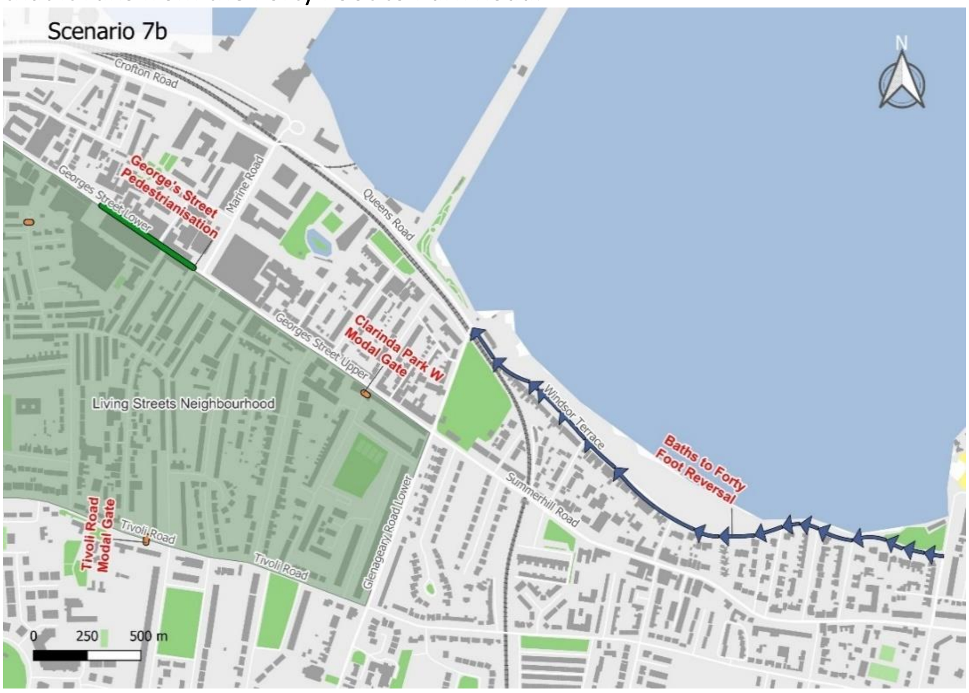

Figure 6.10 Scenario 7b

- **Scenario 8** – Scenario 3 with closure of Windsor Terrace between the car park for the baths and Park Road.

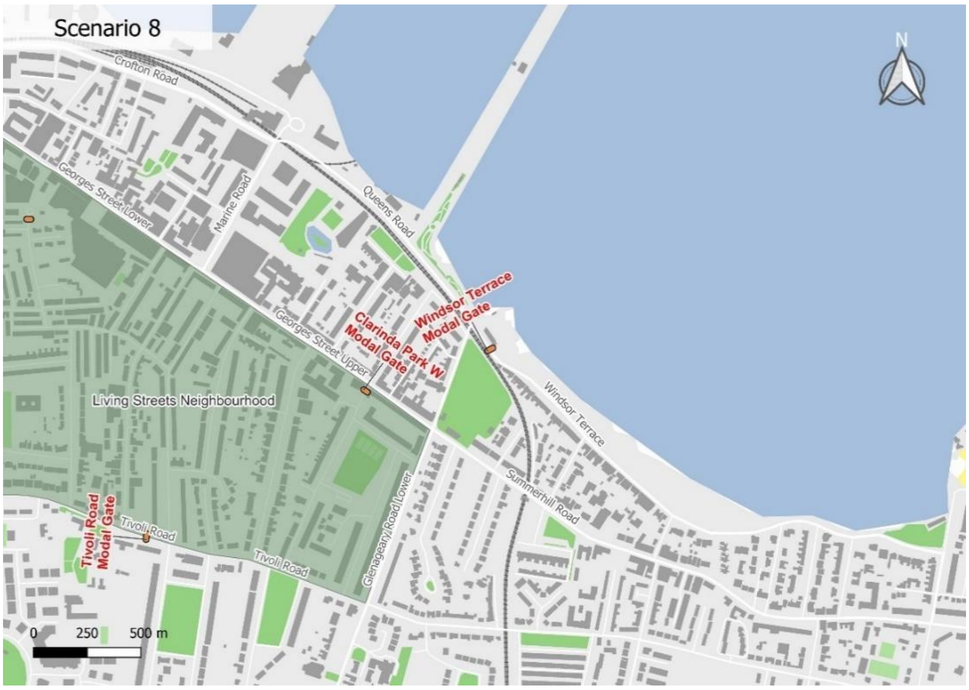

Figure 6.11 Scenario 8

6.3.4 Scenario 7a and 7b both provide substantial reductions in delay at the People’s Park junction in the AM period due to traffic rerouting along Windsor Terrace rather than passing through the junction. A comparison of Scenario 7a and 7b is shown in Figure 6.12.

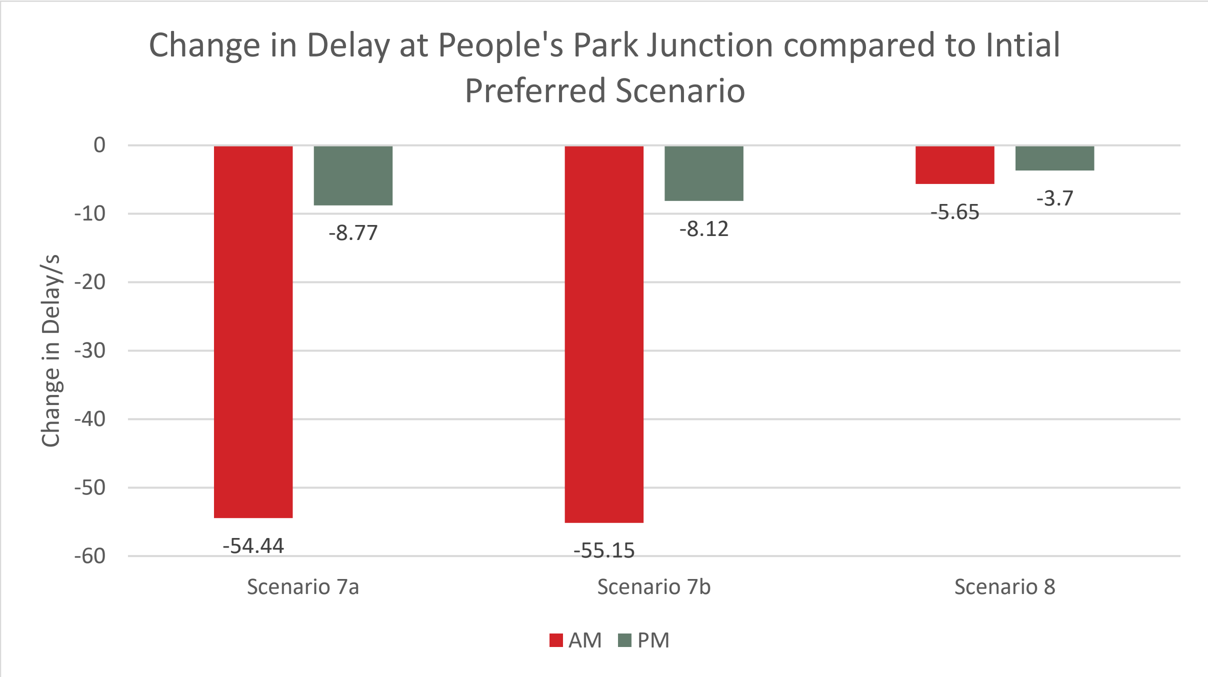

Figure 6.12 Delay changes at the People's Park Junction

6.3.5 While both Scenario 7 options provide improvements to the People's Park junction, Scenario 7a does so with a lower number of daily trips on Windsor Terrance as shown in Figure 6.13. Fewer trips means less noise and air pollution along the coastal route, particularly for the section between Sandycove Ave West and Link Road, there will also be lower vehicle speeds on this section. As a result, Scenario 7a is considered the better option to carry forward as a mitigation solution. A summary of the scenarios is provided in Table 6.2 below.

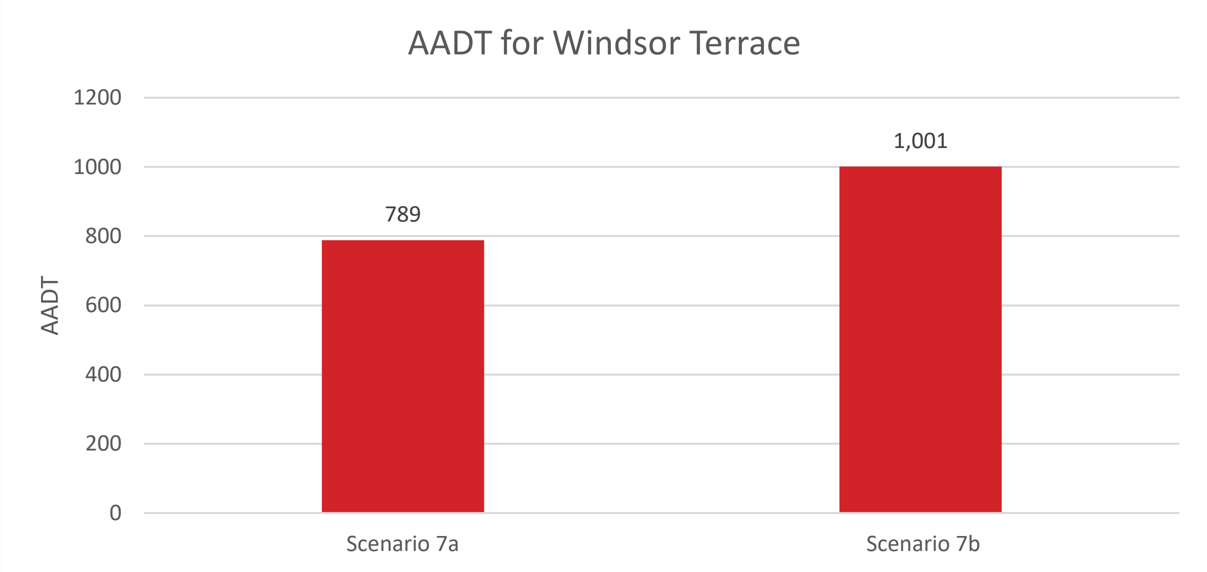

Figure 6.13 All day flow on Windsor Terrace

Table 6.2 Mitigation tests summary

SCENARIO	POSTIVE IMPACTS	NEGATIVE IMPACTS
Scenario 7a	Reduction in traffic moving through the People's Park junction. Reduction in traffic along George's Street Upper and Marine Road.	Increased traffic on Windsor Terrace and Queen's Road.
Scenario 7b	Reduction in traffic moving through the People's Park junction. Reduction in traffic along George's Street Upper and Marine Road. No advantage compared to 7a.	Increased traffic on route between Forty Foot and Baths. Greater increase compared to Scenario 7b.
Scenario 8	No discernible traffic impacts within the model. Possibility for landscaping and placemaking improvements on Windsor Terrace	No discernible traffic impacts within the model.

6.4 Revision of Preferred Option

6.4.1 This section covers the development of the Initial Preferred Option.

6.4.2 Three further refinement scenarios were tested in this phase of the project;

- **Scenario 9** – Revision of scenario 3 with an additional modal gate on Cross Ave between Patrick Street and Convent Road.

Figure 6.14 Scenario 9

- **Scenario 10a** – Scenario 9 with Tivoli Road modal gate moved to be immediately west of Patrick Street and the reversal of Windsor Terrace removed.

Figure 6.15 Scenario 10a

- **Scenario 10b** – Scenario 10a with the reversal of Windsor Terrace.

Figure 6.16 Scenario 10b

- **Scenario 11a** – Scenario 9 with bus gate on Summerhill Road limiting westbound approach to People's Park junction to bus only.

Figure 6.17 Scenario 11a

- **Scenario 11b** – Scenario 10a with bus gate on Summerhill Road limiting westbound approach to People's Park junction to Bus Only.

Figure 6.18 Scenario 11b

6.4.3 Scenario 9 and Scenario 10 options were developed to look at resolving the issues of rat running within the LSN and to try and remove all through traffic from the LSN. Scenario 9 explored the impact of the addition of the Cross Avenue modal gate in isolation which provided limited impacts.

6.4.4 The combination of the Cross Avenue Modal Gate and moving the Tivoli Modal gate to the west of Patrick Street has a substantial impact on traffic movements within the LSN. The combination of these two measures removes all through trips by closing off the available rat runs as shown in Figure 6.19. Both Scenario 10 options resulted in the same impact on trips, hence why they are combined in the graph.

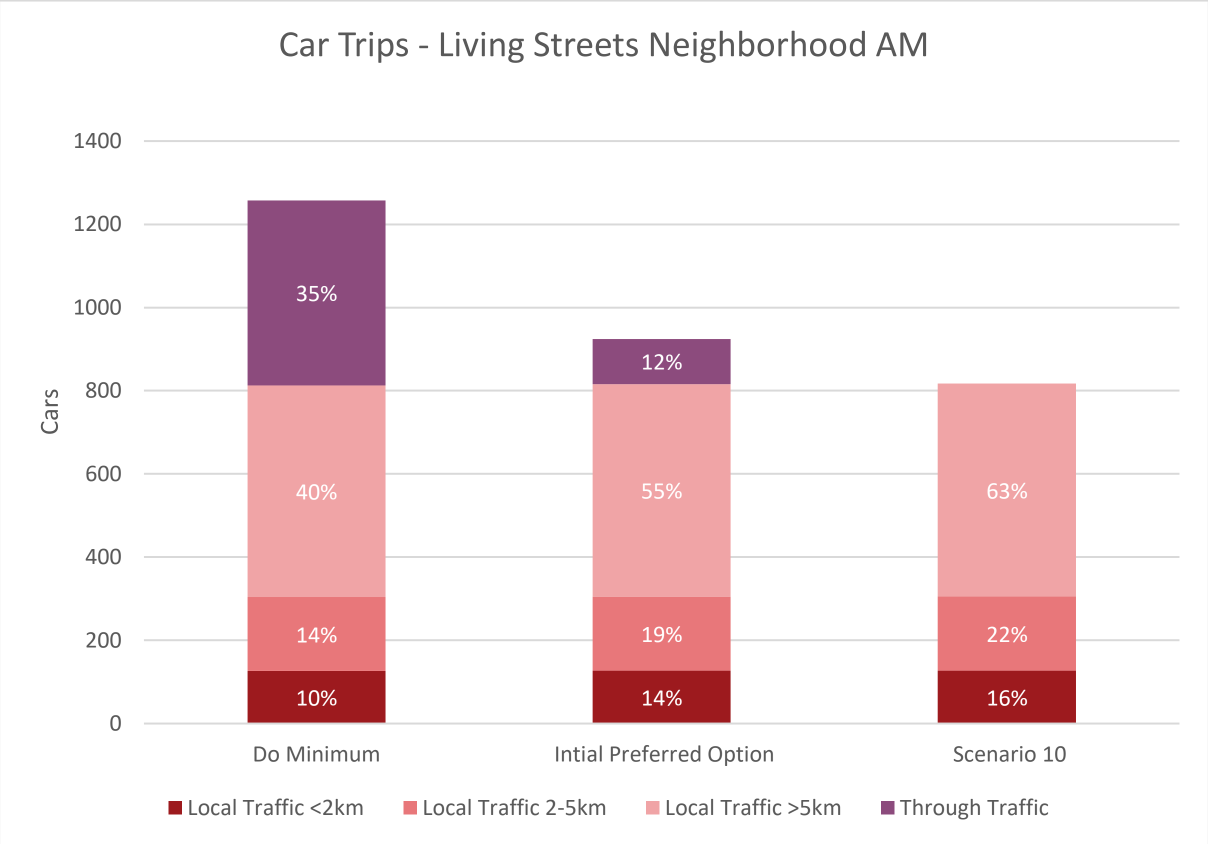

Figure 6.19 Car trips within the Living Streets Neighbourhood

6.4.5 Scenarios 10a and 10b were found to perform significantly better than the previous arrangement of modal filters. As a result, Scenarios 9 and 11a were discounted from further assessment.

6.4.6 Traffic redirected from the LTN moves onto the permitter roads. A particular area of concern was the People's Park junction. To explore the impact of this further, LINSIG modelling software was used to test the impacts of Scenario 10a, Scenario 10b and Scenario 11b on this junction in order to determine the preferred option.

6.4.7 LINSIG is a tool that models road junctions, particularly signal-controlled ones. It simulates the behaviour of vehicles at junctions and predicts the effect of changes to traffic signal timings, road layouts, and other factors on traffic flow and congestion. LINSIG is used to optimize traffic signal timings and junction design to achieve efficient traffic flow and minimize delays.

6.4.8 LINSIG measures overall junction performance in the terms of Practical Reserve Capacity (PRC). The PRC of a junction is a measure of how much additional traffic can pass through a junction while maintaining less than 90% saturation on any arm. The results of this exercise are shown in Figure 6.20.

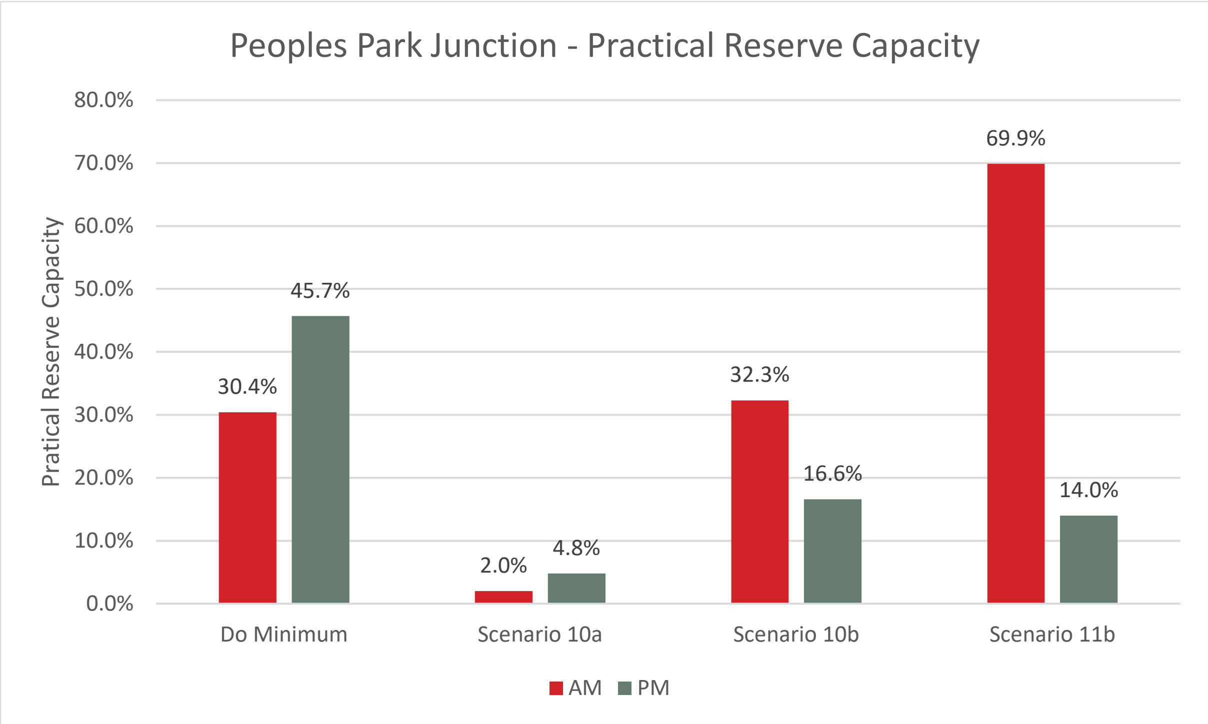

Figure 6.20 Practical Reserve Capacity at the People's Park Junction

6.4.9 Without the Windsor Terrace reversal the PRC at the People's Park junction is reduced substantially from the Do Minimum scenario. This impact is partially mitigated by the inclusion of the Windsor Terrace reversal in Scenario 10b. However, with the inclusion of the bus gate in Scenario 11b, the PRC of the junction in the AM exceeds the PRC of the junction in the Do Minimum. This is because the junction effectively operates as a two-arm junction, with Summerhill Road only requiring green time for busses.

6.4.10 Scenario 11b provides the greatest benefit to the performance of the People's Park junction, however it would also impose a significant new restriction on general traffic (no westbound traffic permitted on Summerhill Road). Scenario 10b provides sufficient mitigation without the need to restrict vehicular movements on the Summerhill Road arm. It is for this reason that Scenario 10b is carried forward as the Preferred Option. Scenario 11b provides a potential solution should traffic increases in the future lead to performance issues at this junction.

Table 6.3 Revision of Preferred Option Summary

SCENARIO	POSTIVE IMPACTS	NEGATIVE IMPACTS
Scenario 9	Concentrates rat running onto Patrick Street allowing for rat running to be isolated.	Still allows non-destination trips through the LSN area with rat running along Patrick Street.
Scenario 10a	Removes all non-destination trips.	Increases traffic on external perimeter roads. Decreased performance at the People's Park Junction with the junction performing close to capacity.
Scenario 10b	Removes all non-destination trips from the Living Streets Neighbourhood. Mitigates negative impacts of Scenario 10a on the People's Park junction.	Increases traffic on external perimeter roads. Decreased performance at the People's Park junction but retains spare capacity.
Scenario 11a	Benefits are the same as Scenario 9 but with increased capacity at People's Park Junction.	Does not fully remove through traffic from Living Streets Neighbourhood with some rat running along Patrick Street.
Scenario 11b	Benefits of Scenario 10 but with increased capacity at the People's Park Junction.	Closure of Summerhill Road to private traffic at the People's Park junction.

7. MODESHIFT MODELLING

7.1 Overview

7.1.1 The Local Area Model (LAM) used for the testing of the different scenarios is a fixed demand model, meaning that it is not capable of predicting a change in the demand for car use. This approach is considered a worst case scenario, where no drivers opt to change mode. As this scheme provides safer and more attractive routes for walking and cycling in the area a mode shift is expected.

7.1.2 Given the zoomed out strategic function of the ERM, it was not considered the most appropriate tool for assessing potential mode shift implications of a local scheme such as the Living Streets Neighbourhood. Therefore, to further understand the likely mode shift implications, an examination was undertaken of travel behaviour data collated for the Dún Laoghaire area, supplemented by a review of best practice examples from other similar projects. The approach chosen was to develop high and low scenarios based on the review of the data in order to present a range of the possible outcomes.

7.2 Examples of similar schemes

7.2.1 The Summer Streets scheme run in Dún Laoghaire in summer of 2021 provided count data at several key junction around Dún Laoghaire including;

- People's Park Junction;
- Queen's Road and Park Road;
- George's Street Lower and York Road; and
- Coal Quay Bridge junction.

7.2.2 Counts taken at these locations showed a 30% reduction in car trips westbound at the People's Park and Queen's Road/Park Road junction, and a 35% reduction eastbound at George's Street Lower/York Road and Coal Quay Bridge junctions. In addition to traffic counts, intercept customer and resident surveys were carried out, indicating that some mode shift was achieved. However, this data did not capture origin and destination information, as such it is not possible to develop mode share targets for the model.

7.2.3 Barcelona has, for several years, developed schemes similar to the Living Streets Neighbourhood called Superblocks. These schemes act in the same way as the proposed scheme, with a series of modal gates limiting through traffic and allowing only local traffic into certain areas. Data for two such blocks, the Gracia Superblock and Poblenou Superblock report 40-58% reduction in traffic to or from the Superblock[3,4,5].

7.2.4 In addition to the Barcelona Superblocks similar schemes have been implemented in the United Kingdom in the form of Low Traffic Neighbourhoods (LTN). Studies into London LTNs have found a 20% reduction in the probability of car ownership, the likelihood to own a car,

[3] New York Times, Winnie Hu, 2016, "What New York Can Learn From Barcelona's 'Superblocks'"

[4] European Bank for Reconstruction and Development, Green Cities Policy, 2018, "Urban planning with superblocks: Barcelona, Spain

[5] www.ccma.cat/324/salvador-rueda-sobre-el-pla-de-les-superilles-el-nombre-esta-al-voltant-de-les-500/noticia/2768000/

amongst all residents within the LTN.[6] While a more focused study into an LTN in Waltham Forest, North London, found a 31% decrease in traffic in the LTN and on surrounding roads. Furthermore, surveys found that car ownership had reduced by 6% after 2 years.[7]

7.2.5 This data is summarised in Table 7.1 below; The data from these similar schemes shows that they have resulted in a significant change in transport behaviour, with a greatly reduced emphasis on private car trips.

Table 7.1 Similar Schemes Data

SCHEME	INTERNAL TRAFFIC	BORDER ROAD TRAFFIC	WIDER AREA
Gracia Superblock Barcelona	40% reduction	No data	20% reduction
Poblenou Superblock Barcelona	58% reduction	2.6% increase	No Data
Waltham Forest LTN	31% reduction	31% reduction	No Data
Study of 46 LTNs spread around London City[8]	32.7% reduction	1.3% increase	No Data

[6] "Low Traffic Neighbourhoods, Car Use and Active Travel", Rachel Aldred and Anna Goodman, University of Westminster
[7] "Challenging the Car's Dominance to Bring Back Residential Streets and Support High Streets and Town Centres", Jeremy Leach, London Living Streets
[8] "Changes in motor traffic inside London's LTNs and on boundary roads", Thomas and Aldred (2023)

7.3 Mode Share Changes

7.3.1 In applying mode shift to the model it was considered important to take trip length into account as walking and cycling are significantly more appealing choices over shorter distances.

7.3.2 Active travel mode users follow a different trip length distribution to those using cars and public transport, with trips being shorter. Figure 7.1 below shows the average trip length distribution from the ERM model up to 20km.

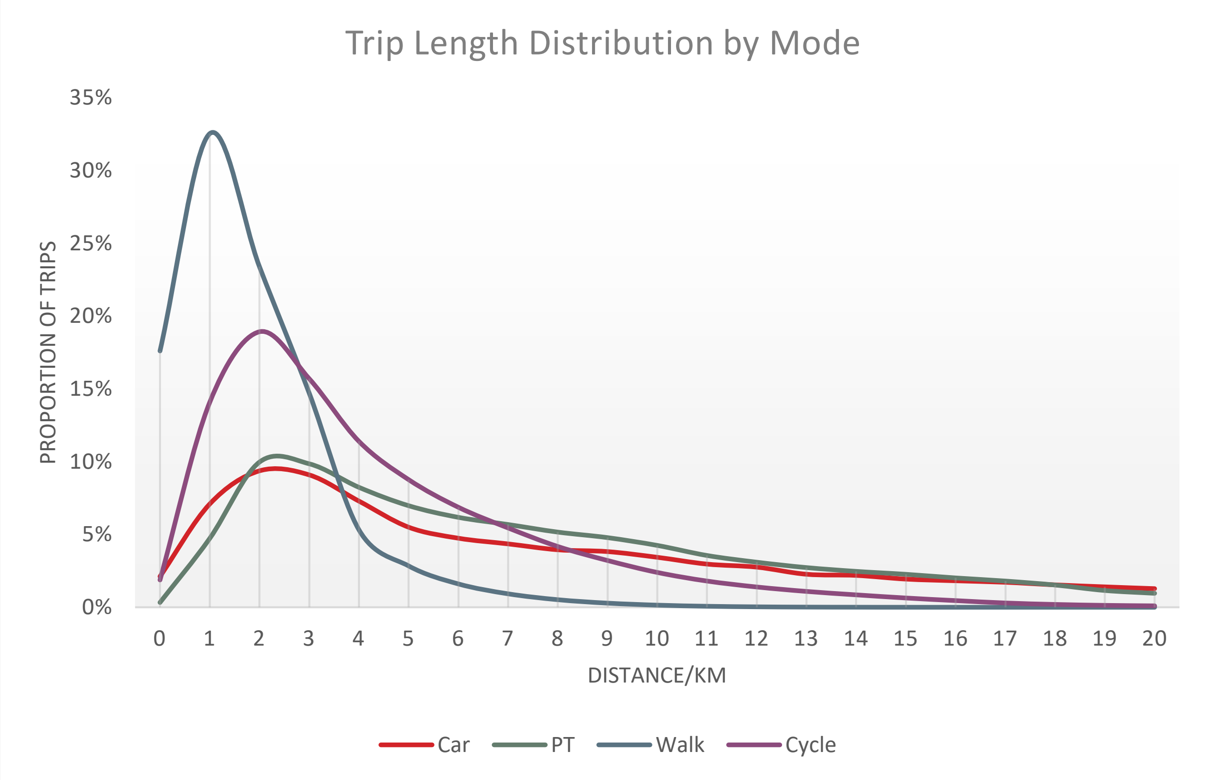

Figure 7.1 Trip length distribution

7.3.3 As can be seen from the graph, the majority of active travel trips are less than 5km with some cycle trips being longer. However, 90% of cycle trips are less than 10km. As this scheme is active travel focused it would be expected that the mode shift would be toward active modes and therefore the change would be most notable on trips less than 10km.

7.3.4 Mode shift was divided into three distance bands;

- 0-2km – Almost all trips within the study area are less than 2km in length with a small number of trips between 2 and 2.2km. This band also corresponds to the length of approximately 75% of all walk trips within the ERM;
- 2-5km – Approximately 75% of cycle trips within the ERM are completed in less than 5km; and
- 5-10km – Approximately 90% of cycle trips are less than 10km within the ERM.

7.3.5 The above categories of trips were then further sub-divided to look at local trips and external trips. Local trips are trips that originate and terminate within the study area, which includes;

Dún Laoghaire Town Centre, Living Streets Neighbourhood and Culanor Estate. External trips are trips that either originate or terminate within the study area.

7.3.6 While there is some information on trip changes from other similar schemes, there is not sufficient information to provide a single mode shift value with confidence. As such, lower and higher sensitivity scenarios were developed as Mode Shift Scenario 1 and Mode Shift Scenario 2. Scenario 2 was developed by combining the Gracia Superblock and Waltham Forest data. Internal change was taken as the higher of the two. For external mode shift, the 30% achieved in Waltham Forest for border traffic was applied to short trips, with other bands chosen to average to approximately 20% seen in Barcelona across a wider area.

7.3.7 Scenario 1 represents a midpoint between no mode shift and Scenario 2.

7.3.8 The mode shift ranges are shown in Table 7.2 for external trips.

Table 7.2 External Trip Mode shift

External Trips	Scenario 1	Scenario 2
<2km	10%	30%
2-5km	5%	15%
5-10km	2%	5%

7.3.9 The mode shift ranges are shown in Table 7.3 for internal trips.

Table 7.3 Internal Trip Mode shift

Internal Trips	Scenario 1	Scenario 2
<2km	20%	40%
2-5km	10%	20%

7.3.10 To determine the number of trips within each distance band the trip length distribution from the ERM was extracted for the relevant zones. Mode shift was then applied as a reduction in demand proportionally across all origin and destination pairs for each zone within the Living Streets Neighbourhood to represent mode shift to sustainable modes.

7.3.11 The resulting reduction in car trips in presented in Table 7.4 below;

Table 7.4 Mode shift Sensitivity Test Change in Trips

Reduction in Trips	Scenario 1	Scenario 2
AM	82	214
PM	93	248

7.3.12 The impact of these changes when applied to the mode share for the study area is shown in Table 7.5 below. This has been calculated by factoring up the AM and PM trip reduction by AADT factors and then removing this figure from the all-day trip rate.

Table 7.5 Car Mode share with mode shift applied

Car Mode share	Existing mode share	Scenario 1	Scenario 2
Internal Trips	26%	24%	22%
External Trips	53%	52%	51%

7.3.13 Internal trips in the table are not equivalent to the internal trips reported in the evidence documents due to different areas covered. In the evidence documents, the internal trips are trips within the low traffic neighbourhood. In the table above Internal Trips are trips within the study area that remain within the study area, this area is larger than the Living Street Neighbourhood.

7.3.14 These changes in mode shift do not account for any mode shift outside of the Living Streets Neighbourhood. It would be expected that the impact of the Living Streets Neighbourhood would result in changes in mode choice on trips that previously passed through the Living Street Neighbourhood, however evidence for this is limited and as such was not accounted for. This redistribution of trips away from private vehicles is known as “traffic evaporation”, this is where total road traffic reduces as the available road space for private vehicles is reduced.

7.3.15 Sensitivity tests of the preferred options using the estimated mode shifts are presented in Section 8.

8. PREFERRED OPTION MODELLING RESULTS

8.1 Overview

8.1.1 The results of the Local Area Modelling led to a preferred option of Scenario 10b which includes:

- Pedestrianisation of Georges Street;
- Modal Gates at; Clarinda Park West, Cross Avenue and Tivoli Road (west of Patrick Street);
- Reversal of the direction of one-way car traffic on Windsor Terrace between Link Road and Park Road;
- Busses rerouted back along Crofton Road to make their return journeys towards the city (instead of using George's St Lower).

8.1.2 The preferred option is shown in the map below in Figure 8.1.

Figure 8.1 Preferred Option

8.1.3 The objectives against which the modelling of the options was carried out is provided in Table 8.1 below. This section of the report goes through the results for each objective in detail.

Table 8.1 Objectives and KPIs

Objective	Method of Measurement
Promote inclusive, sustainable mobility and reduce car dependency by making walking, cycling and public transport more convenient, enjoyable, and safer for all.	Change in car trips along key active corridors.
	Change in traffic volumes passing through the Living Streets area.
Improve the neighbourhood by reducing traffic and related noise and air pollution; and increasing climate resilience through planting and greening initiatives.	Change in emissions levels within the Living Streets Neighbourhood.
	Change in traffic levels within the Living Streets Area on key routes.
Enhance the economic vibrancy of Dún Laoghaire as a mixed-use town and its attractiveness as a destination by facilitating the sustainable and efficient movement of people and goods, and by creating an environment that people want to linger in.	Review of zonal access to ensure all zones remain accessible by car, ensuring those who need to travel by car still can.
	Change in travel situation, delays and junction performance, on perimeter roads.
Improve connections between bus, rail and active travel facilities to make it easier for people to access sites of interest in the town, the seafront and surrounding neighbourhood.	Change in car trips along key active travel corridors.
	Alternative bus route catchment analysis.
Promote health and wellbeing in the community by enabling safer active travel and enhancing the public realm for outdoor play, recreation, and social interaction.	Change in traffic levels within the Living Streets Area.
	Change in traffic along key active corridors and outside schools.
	Change in air quality withing the area.
Promote equitable travel options and urban design that creates a safe and welcoming experience for all members of society, regardless of age, gender, ability, or income.	Retain access/egress routes for the Living Streets Neighbourhood for car users.
	Change in traffic volumes passing through the Living Streets area.
	Change in traffic levels within the Living Streets Area on key routes and outside schools.
	Change in travel situation, delays and junction performance, on perimeter roads.

8.2 Vehicle Flow Levels

8.2.1 This section looks at the impacts of the LSN on traffic flows both in, and around the LSN area. The reduction of traffic within the LSN is key to the success of the scheme allowing for a more active mode friendly environment.

8.2.2 It is also important to understand the impacts of the redistribution of traffic on the roads on the periphery and external to the LSN. While the objectives of the scheme are to improve the local environment for active travel users it is important that the traffic redistribution does not have an overly negative impact on general traffic.

Through Trips and Destination Trips

8.2.3 Figure 8.2 below shows the reduction in car trips within the LSN area with the Preferred Option in place.

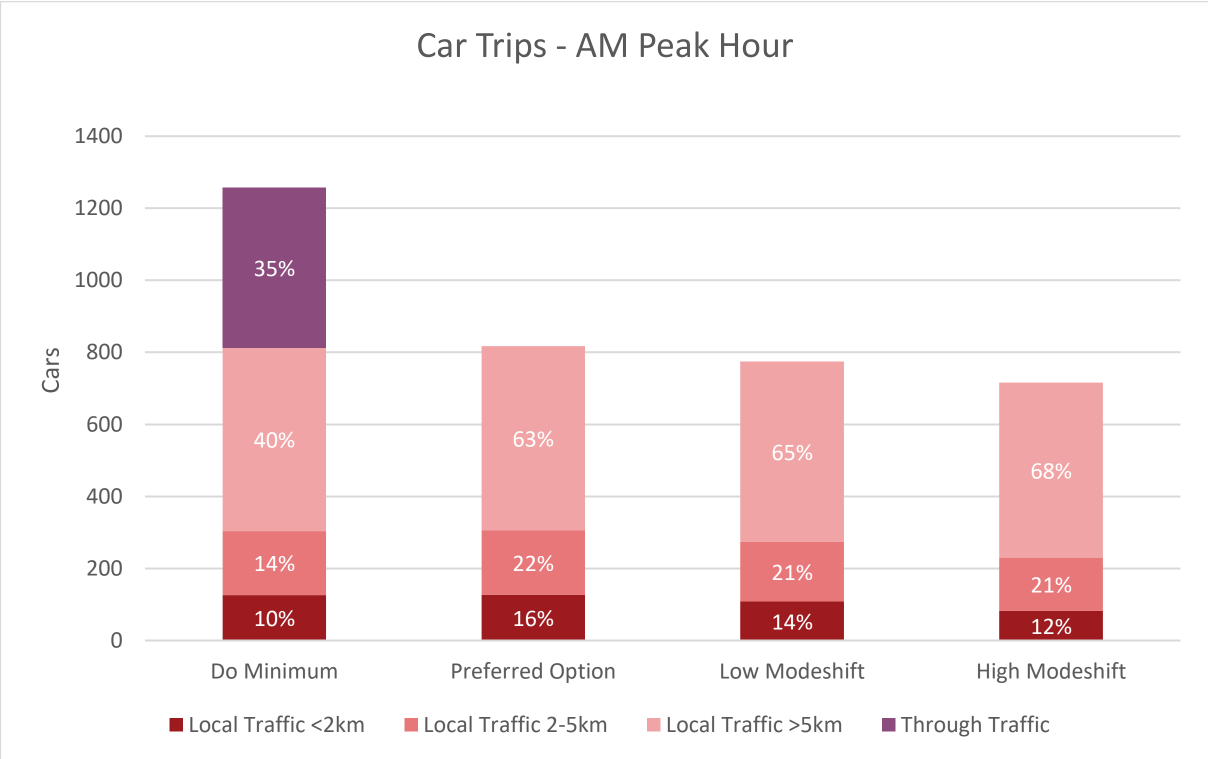

Figure 8.2 Car trips within the Living Streets Neighbourhood

8.2.4 Inclusion of the Preferred Scheme results in a reduction in overall car trips by 35% with all trips within the LSN now local trips. If the higher mode shift scenario can be achieved this reduction in traffic is increased to 43%.

Promote inclusive, sustainable mobility – by reducing unnecessary trips within the LSN the network is safer and more accessible to walk and cycle.

Promote equitable travel options and urban design – reduction of car traffic within the LSN allows for more space to reallocated to active modes, in particular pedestrians who make up 63% of all local trips in the LSN area.

8.2.5 While there is an increase in traffic on Marine Road, 62%, and George's Street Upper, 30%, many of these trips remain destination trips travelling to Dún Laoghaire town centre as shown in Figure 8.3 and Figure 8.4.

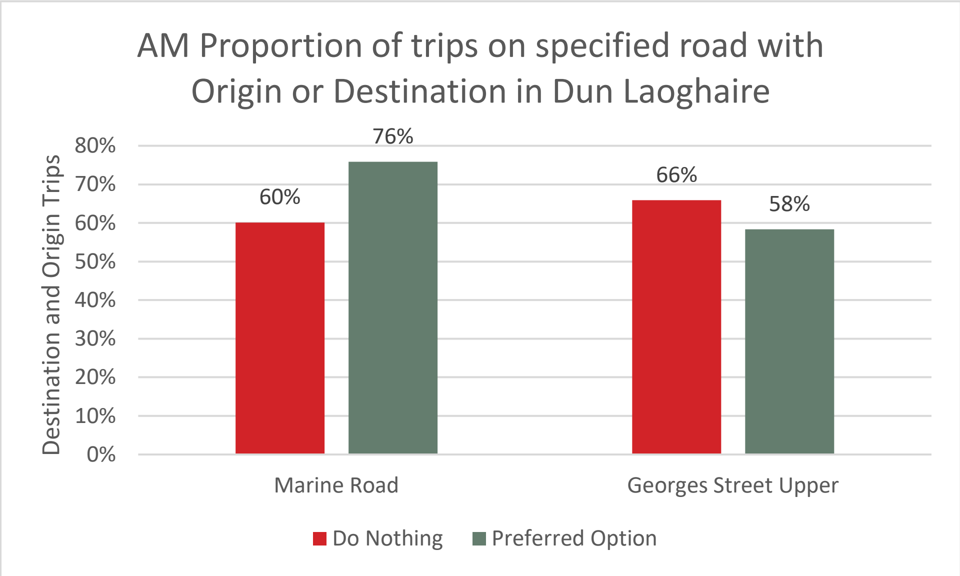

Figure 8.3 Proportion of Destination Trips AM

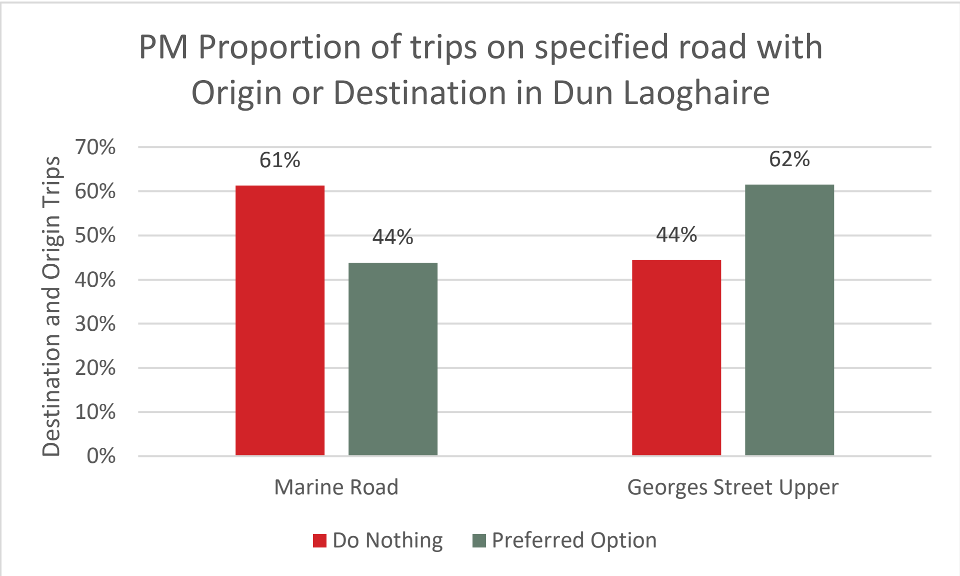

Figure 8.4 Proportion of Destination Trips PM

8.2.6 The analysis on destination trips shows that with the preferred scheme in place, car trips will continue to use George's Street Upper and Marine Road to access commercial or leisure needs in Dún Laoghaire town centre. The total number of destination trips to are area is the same as in the do minimum scenario.

Enhance the economic vibrancy – by providing continued access to the centre of Dún Laoghaire for access by all transport modes.

Flows within the Living Streets Neighbourhood

8.2.7 Figure 8.5 and Figure 8.6 on the next page show the change in peak traffic flows on the roads both within and on the boundaries of the LSN, as well as the proposed key active travel corridors. These maps do not include the impact of mode shift and so represent a worst case scenario.

8.2.8 As can be seen in these maps, the traffic levels within the LSN are reduced while the impacts on the permitter roads is varied, with some roads experiencing increased traffic while others are not impacted. The performance of the permitter roads is covered later in this section.

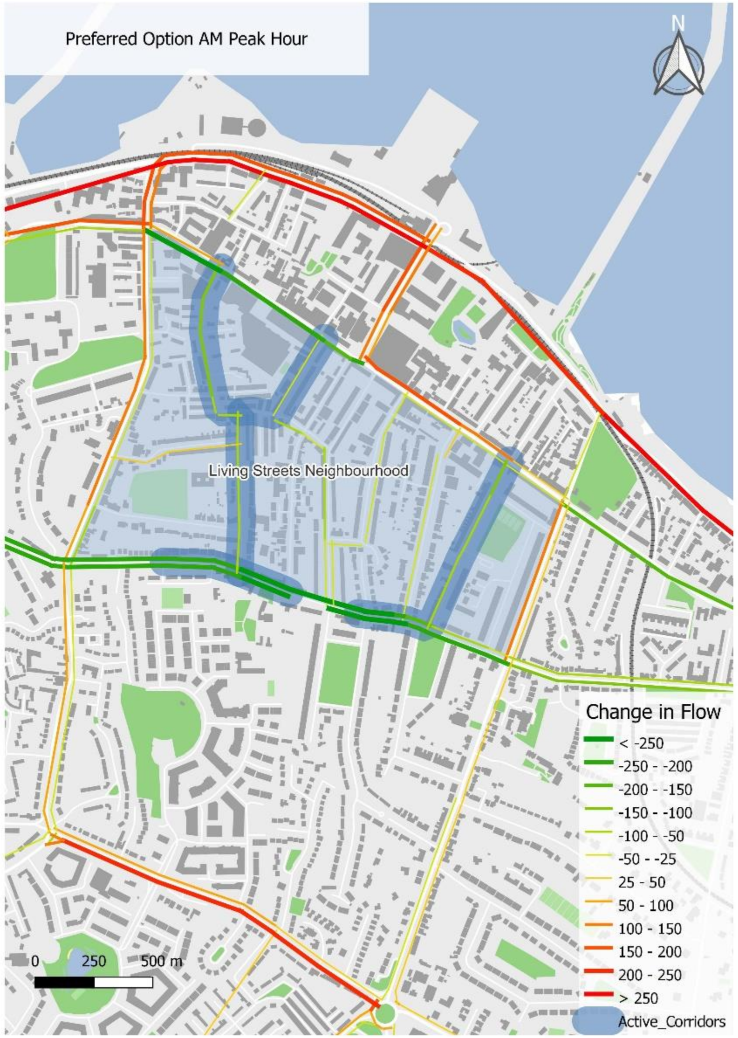

Figure 8.5 Change in AM flow

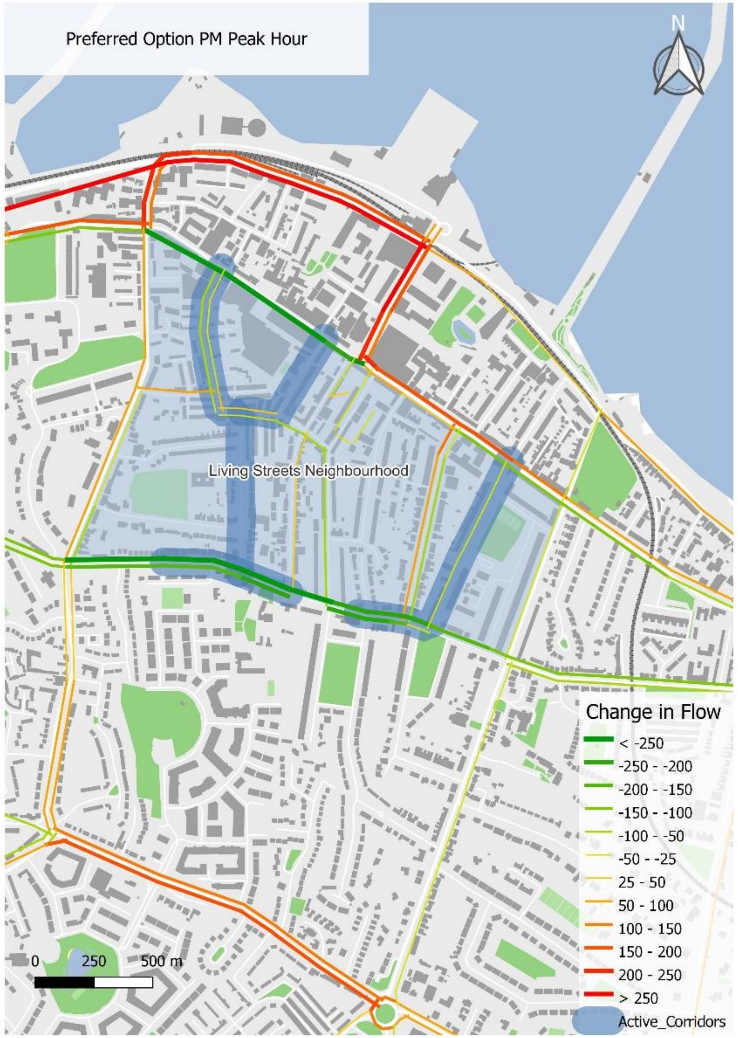

Figure 8.6 Change in PM flow

8.2.9 Figure 8.7 and Figure 8.8 below show the max peak hour flow levels of key roads within the LSN in Passenger Car Units (PCU). PCU is a unit of measurement used within the model to represent the road space used by 1 car.

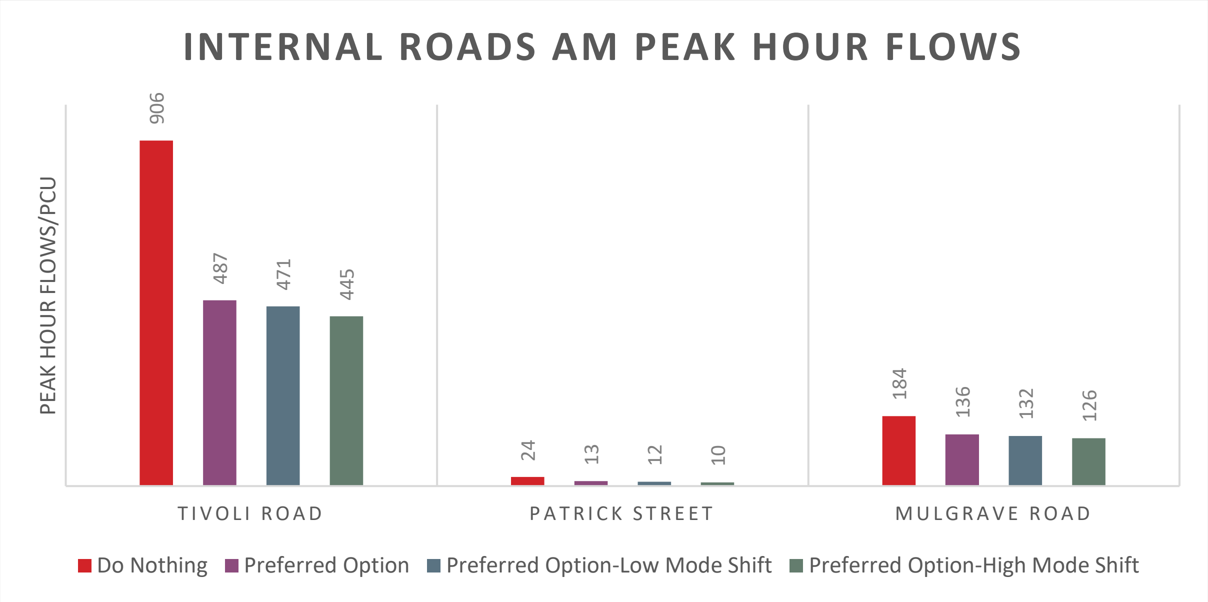

Figure 8.7 AM flows on key internal roads

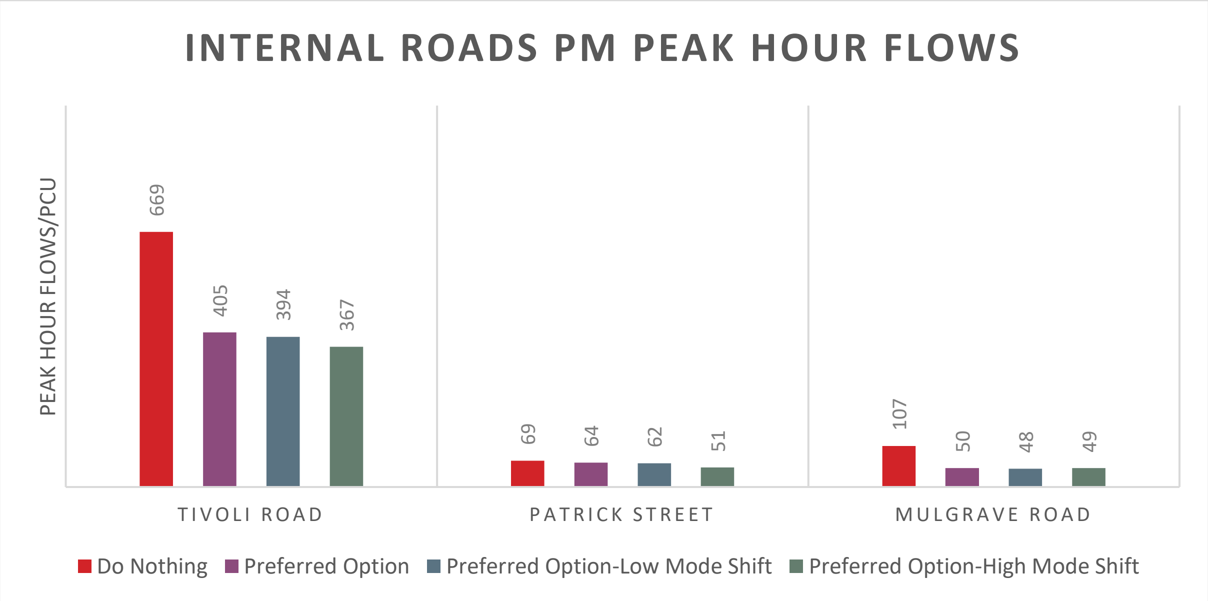

Figure 8.8 PM flows on key internal roads

8.2.10 With the LSN in place the largest reduction in peak hour traffic is on Tivoli Road with a reduction of 46% in the AM peak and 39% in the PM peak. This is due to the removal of through traffic on the link, meaning Tivoli Road no longer acts as a throughfare but as a link for local traffic only.

Improve the neighbourhood – by reducing the traffic volumes along Tivoli Road and other roads within the Living Streets Neighbourhood noise levels will be lower.

Promote health and wellbeing in the community – through the reduction of traffic, particularly on Tivoli Road, the environment within the Living Street's neighbourhood is much safer for active travel users through reduced conflict with traffic and reduced emissions from vehicles.

8.2.11 Figure 8.9 below shows the impact of the LSN on the proposed Active Travel corridors. Flows are taken from the maximum along the western corridor and eastern corridor excluding Tivoli Road.

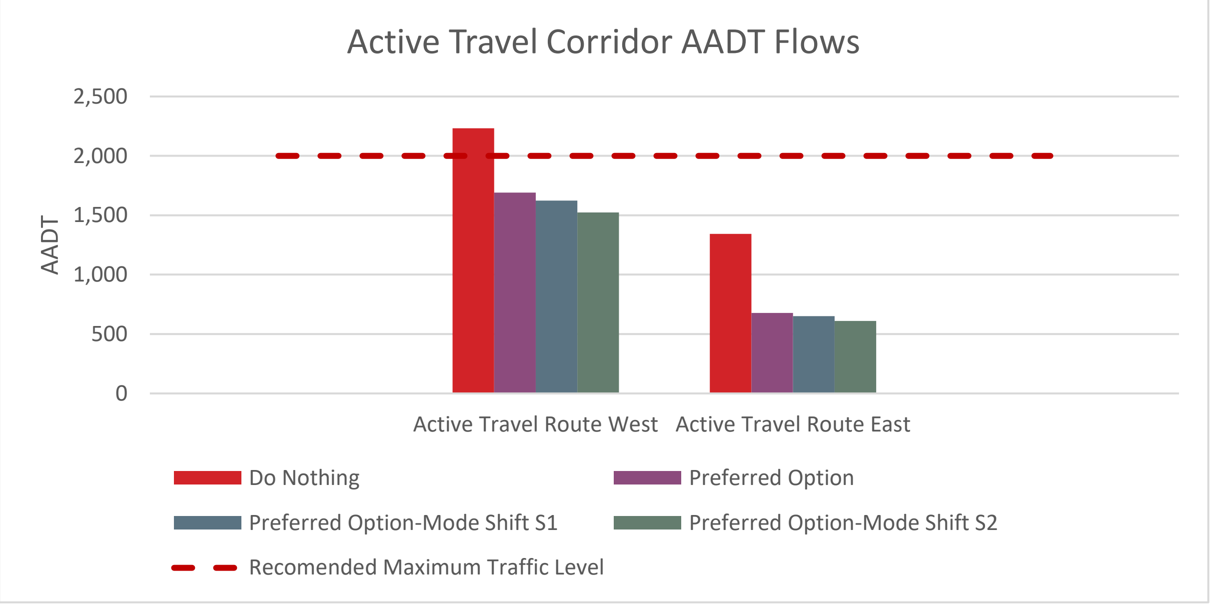

Figure 8.9 AADT on active travel corridors

8.2.12 The National Cycle Manual recommends a maximum flow of 2,000 vehicles a day on links with on-road unsegregated cycle facilities. In the Do Nothing, the Active Travel Route West does not meet this criteria.

8.2.13 Introduction of the preferred scheme reduces the traffic on both corridors, with the West Active Travel Corridor reducing to meet the recommended criteria of 2,000 vehicles a day.

8.2.14 While the East Active Travel Corridor met the criteria in the Do Nothing, traffic along this route is further reduced with the introduction of the preferred option.

Promote inclusive, sustainable mobility– by reducing traffic along the key active travel corridors, the routes become safer for cyclists and pedestrians thereby helping to encourage new users.

Improve connections – the reductions in traffic along the key corridors facilitates the development of improved connections from the Living Streets Neighbourhood and the Culanor development to the town centre and main public transport services.

Promote health and wellbeing in the community – as key active travel routes it is important that the traffic levels be sufficiently low to reduce potential conflicts between motorised traffic and active mode users. The preferred option achieves this goal.

8.2.15 While traffic flows are reduced by removing through trips from the LSN area, efficient access is still retained for vehicular trips travelling to or from the LSN. Figure 8.10 below shows the access routes for the western and eastern half of the LSN for users who still need access by car.

Figure 8.10 Access routes for local traffic

Promote equitable travel options and urban design – not all trips are achievable by active mode or public transport, for those who need to drive the preferred scenario retains access to the Living Streets Neighbourhood.

Flows outside the Living Streets Neighbourhood

8.2.16 Figure 8.11 shows AADT flows on key perimeter roads around the LSN. It should be noted that AADT flows have been calculated on AM and PM peak hours flows.

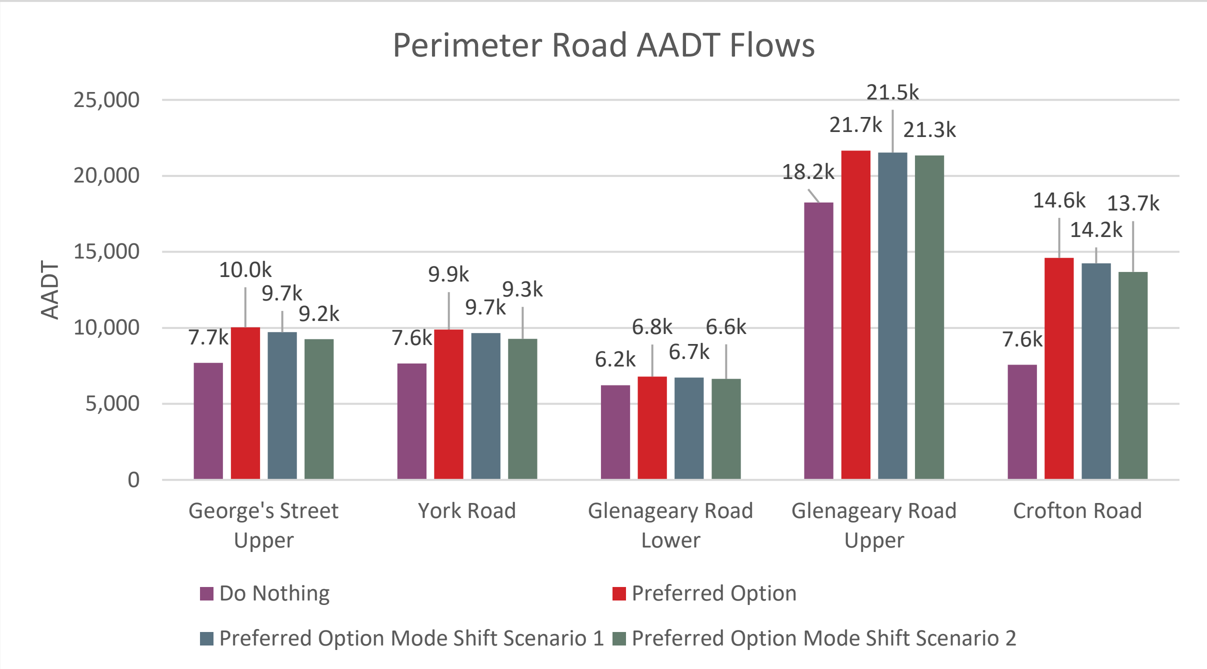

Figure 8.11 AADT flows on key perimeter roads

8.2.17 With through traffic unable to use Tivoli Road to pass through the LSN, it is expected that traffic, both destination and through, would be consolidated on perimeter roads. The impact of this movement in traffic routeing is provided below under the scenario were there is no mode shift and Mode Shift Scenario 2 sensitivity test. It should be noted that Mode Shift Scenario 1 assumes no mode shift outside of the Living Streets Neighbourhood.

8.2.18 Changes in motorised vehicle traffic on the perimeter roads is;

- George’s Street Upper – additional 2300 vehicle movements per day with no mode shift, 1500 with mode shift scenario 2;
- York Road – additional 2300 vehicle movements per day with no mode shift, 1700 with mode shift scenario 2;
- Glenageary Road Lower – additional 600 vehicle movements per day with no mode shift, 400 with mode shift scenario 2;
- Glenerageary Road Upper – additional 3500 vehicle movements per day with no mode shift, 3100 with mode shift scenario 2; and
- Crofton Road – additional 7000 vehicle movements per day with no mode shift, 6100 with mode shift scenario 2.

8.2.19 The flows on Crofton Road increase substantially over the flows on other roads, however much of this increase is in the outbound direction between Marine Road and Coal Quay Bridge and is driven by several factors:

- 27% of the AM and PM increase is the result of bus services being routed back along Crofton Road due to the closure of George's Street Lower.
- 29% and 36% of the increase in the AM and PM respectively are driven by the closure of George's Street Lower and the Modal Gate on Tivoli; and
- 44% and 40% of the increase in the AM and PM respectively are a result of the reversal of Windsor Terrace allowing a new route connecting Sandycove and Dalkey to Blackrock.

8.2.20 While total daily traffic increases on most perimeter roads, Glenageary Road Lower does not have an increase in traffic in both time periods. In the AM, Glenageary Road Lower has an increase of 37% and in the PM a decrease of 6%.

8.2.21 The increase in the AM is the result of additional traffic on the inbound arm due to the closure of through access along Tivoli. This increase is the result of traffic that previously used available routes through the Living Streets Neighbourhood area being redirected onto Glenageary Road Lower.

8.2.22 In the PM, traffic reduction is small, 36 PCU, and is the result of a low level of redistribution of traffic away from Glenageary Road Lower to avoid the People's Park Junction.

8.2.23 The impacts of these changes on perimeter roads are explored in the following section looking at junction performance at key junctions around the perimeter of the scheme.

8.3 Junction Performance

8.3.1 For a more robust assessment of the impacts of traffic diversion on the junctions within the study area a LINSIG model was developed for each junction. LINSIG is a detailed junction modelling tool specialising in the performance of signalised junctions.

8.3.2 Six key junctions were modelled in LINSIG to assess the impacts of the schemes, these junctions are shown in Figure 8.12 below.

Figure 8.12 Junctions tested in LINSIG

8.3.3 All junctions were tested with two scenarios:

- Do Nothing – No changes to the existing situation with flows taken from traffic counts; and

- Preferred Option – No changes to existing junction layout with Preferred Scenario flows, signal timings optimised.

8.3.4 The exception to this is the Glenageary Road junction which was tested with the Dún Laoghaire Central layout as a Do Minimum.

8.3.5 The measurement used to determine the junction's performance is Practical Reserve Capacity (PRC). The PRC of a junction is a commonly used measure of how much additional traffic can pass through a junction while maintaining less than 90% saturation on any arm. For example, a PRC of 20% would allow for a 20% increase in traffic before any arm reached 90% saturation.

8.3.6 The PRC for the junctions for the Do Nothing and Preferred Option are shown Figure 8.13 and Figure 8.14 for AM and PM respectively below.

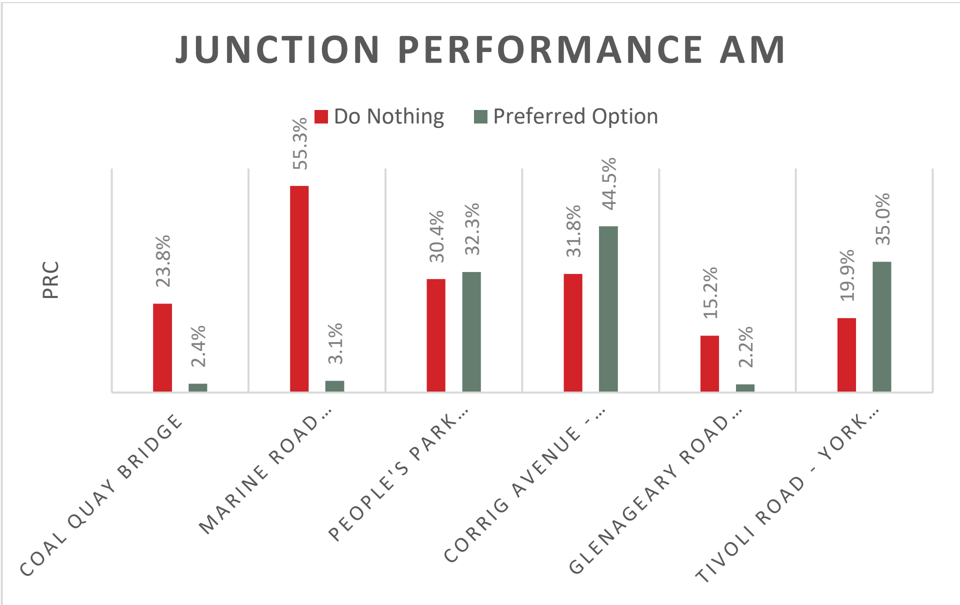

Figure 8.13 Junction Performance AM

In the AM, with the preferred option, the PRC of three junctions is reduced, and three junctions increased, when compared to the Do Min. The junctions that see reductions in PRC are;

- Coal Quay Bridge – with 2.4% PRC, the junction is operating close to 90% capacity;
- Marine Road Junction – with 3.1% PRC there is limited spare capacity at the junction but the junction is still performing within capacity; and
- Glenageary Road Junction – with 2.2% PRC the junction is operating close to 90% capacity but is able to handle the increased traffic.

8.3.7 Three junctions experience an increased PRC value with the preferred option in place:

- People's Park Junction – junction operates with spare capacity in the Do Nothing and has a very small increase in PRC in the Preferred Scenario.
- Corrig Avenue – junction operates within capacity in Do Nothing scenario. A reduction in east west traffic has resulted in additional spare capacity with the preferred scenario; and
- Tivoli Road – junction operates within capacity in the Do Nothing scenario. A reduction in east west traffic has resulted in increased spare capacity with the preferred scenario.

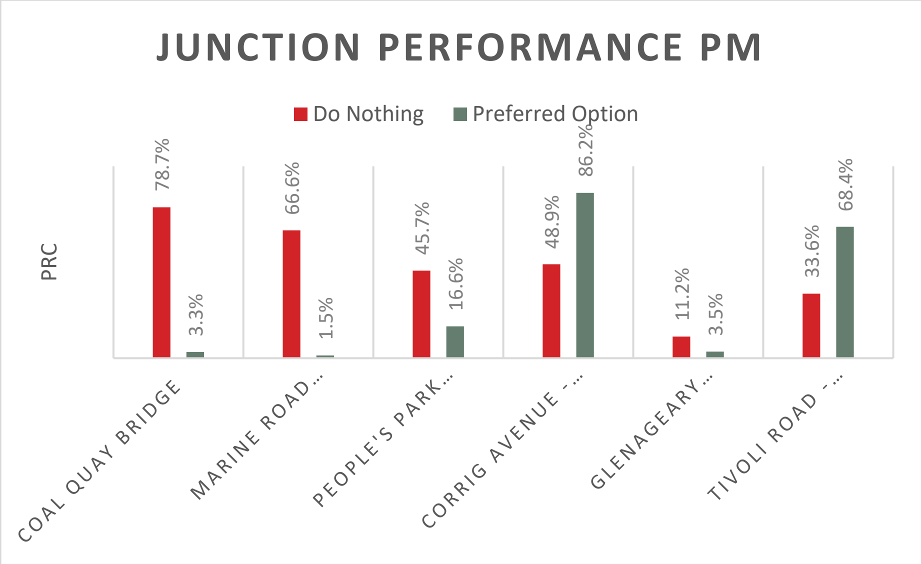

Figure 8.14 Junction Performance PM

In the PM, the PRC of the same four junctions lowers while two junctions improve. The junctions that see reductions in PRC are;

- Coal Quay Bridge – with 3.3% PRC the junction is very closed to 90% capacity
- Marine Road Junction – with 1.5% PRC there is very limited spare capacity at the junction but the junction is still performing within capacity;
- People's Park Junction – with 16.6% PRC the junction still has sufficient spare capacity to handle traffic; and
- Glenageary Road Junction – with 3.5% PRC the junction is operating close to 90% capacity but is able to handle the increased traffic.

8.3.8 Two junctions have increased PRC with the preferred option;

- Corrig Avenue – junction operates within capacity in the Do-Nothing scenario. A reduction in east west traffic has resulted in additional spare capacity with the preferred scenario.
- Tivoli Road – junction operated within capacity in the Do-Nothing scenario. A reduction in east west traffic has resulted in increased spare capacity with the preferred scenario.

8.3.9 Two of the junctions with the largest reduction in PRC are the Coal Quay Bridge and Marine Road junctions. Both of these junctions have reduced from having spare capacity to operating close to 90% capacity.

8.3.10 As part of the wider works in Dún Laoghaire, Barry Transportation have explored new designs for these junctions to connect the Coastal Mobility Route through Dún Laoghaire and accommodate traffic changes from the Living Streets Neighbourhood. The Glenageary Road junction is being upgraded as part of a separate project by DLRCC that has already passed through the planning process and so is not discussed further in this report.

8.3.11 These new designs are discussed in more detail in the option selection report by Barry Transportation; 22410-BTL-XX-CMR-RP-CE-00023_CMR_Options Assessment Report as part of the Coastal Mobility Route work. The preferred options contained within this report have been examined using LINSIG and are presented below.

Coal Quay Bridge

8.3.12 The emerging preferred option for Coal Quay Bridge is Option 2 from the Options Selection Report shown in Figure 8.15 below.

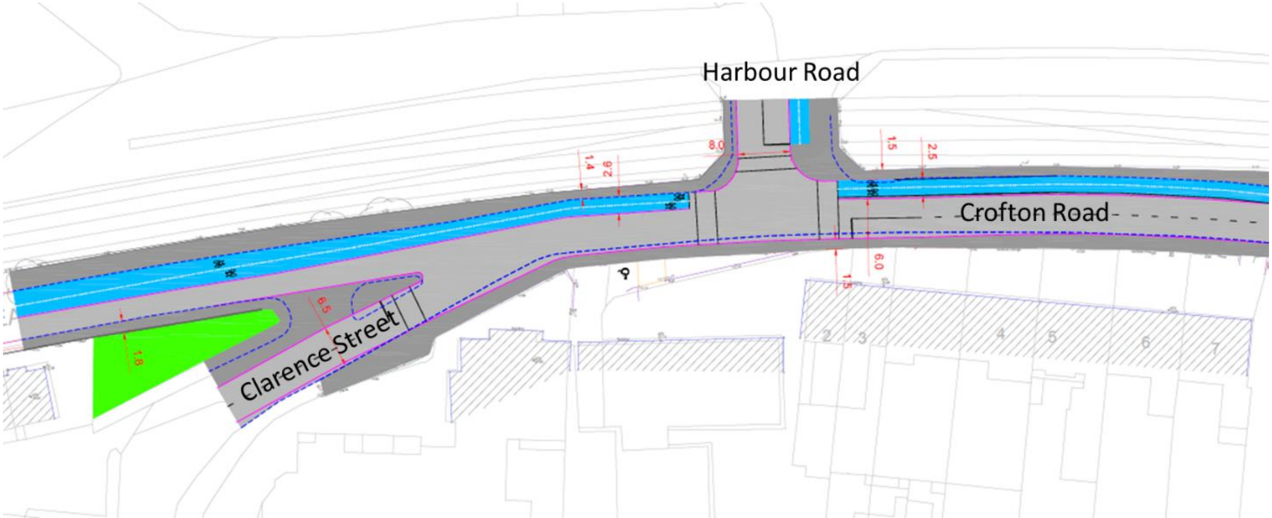

Figure 8.15 Revised layout of Coal Quay Bridge Junction

8.3.13 The redesign of the junction focuses on providing a segregated cycle path through the junction for cyclists on the Coastal Mobility Route. Two variations of this junction were tested:

- As shown in Figure 8.15 with the existing signals between the Coal Quay Bridge arm and Clarence Road removed; and
- As shown in Figure 8.15 with the existing signals between the Coal Quay Bridge arm and Clarence Road retained.

8.3.14 In the single junction configuration, the primary issue encountered during testing was the requirement for long inter-green times, up to 15 seconds, to allow vehicles to clear through the length of the junction to avoid conflicts with other phases. The areas of conflict are shown in Figure 8.16.

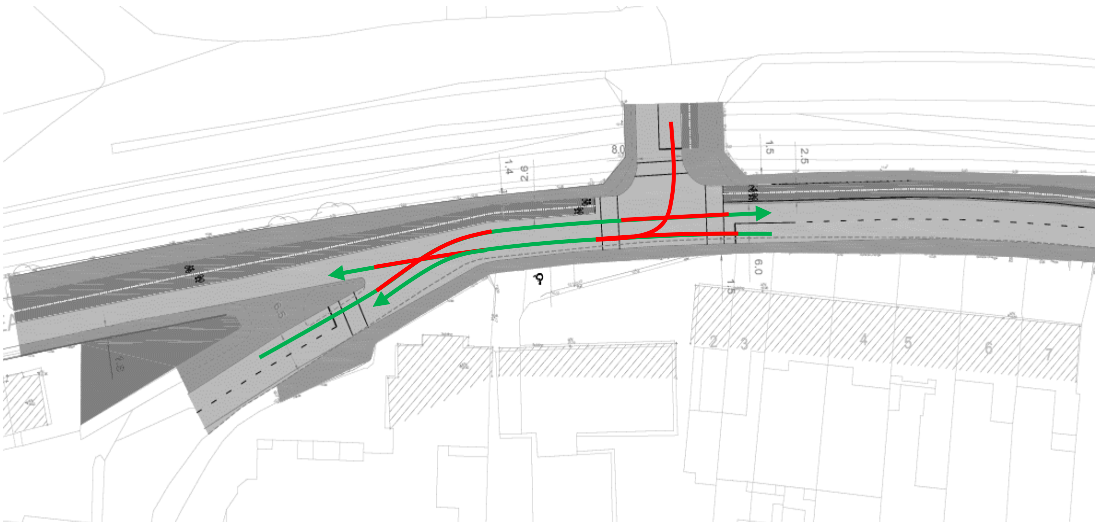

Figure 8.16 Coal Quay Bridge Conflict Areas

8.3.15 This can be mitigated to some extend by rearranging the phasing in a particular order to minimise required green times to run in the following order;

- Clarence Street – can begin as soon as pedestrian crossings are cleared;
- Crofton Road – once Clarence Street traffic has crossed western side of the junction there are no further conflicts with Crofton Road as right turn into Coal Quay Bridge is banned;
- Coal Quay Bridge (every second cycle) – no conflict with Crofton Road once traffic has cleared the eastern part of the junction; and
- Pedestrian Phase – this has the longest intergreen as traffic from Coal Quay Bridge or Crofton Road must clear the full junction before green time provided.

8.3.16 Coal Quay Bridge can also be called every second cycle in this configuration due to the low level of traffic during the AM and PM peaks.

8.3.17 The split junction option further mitigates the long green times by creating a waiting point in the middle of the junction. In this scenario traffic that has not passed through the full junction before the end of the intergreen time is stopped and held until the next green phase.

8.3.18 The results of the testing for these two options are shown in Figure 8.17 below.

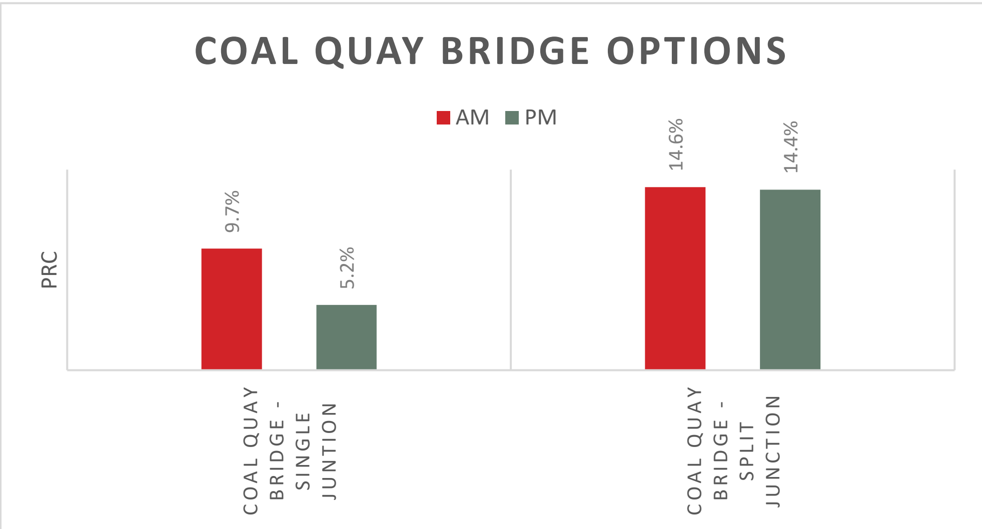

Figure 8.17 Coal Quay Bridge Options PRC

8.3.19 LINSIG diagrams for the single junction configuration is shown in Appendix A.

Marine Road Junction

8.3.20 The two emerging preferred options for the Marine Road junction are shown in Figure 8.18 and Figure 8.19 below;

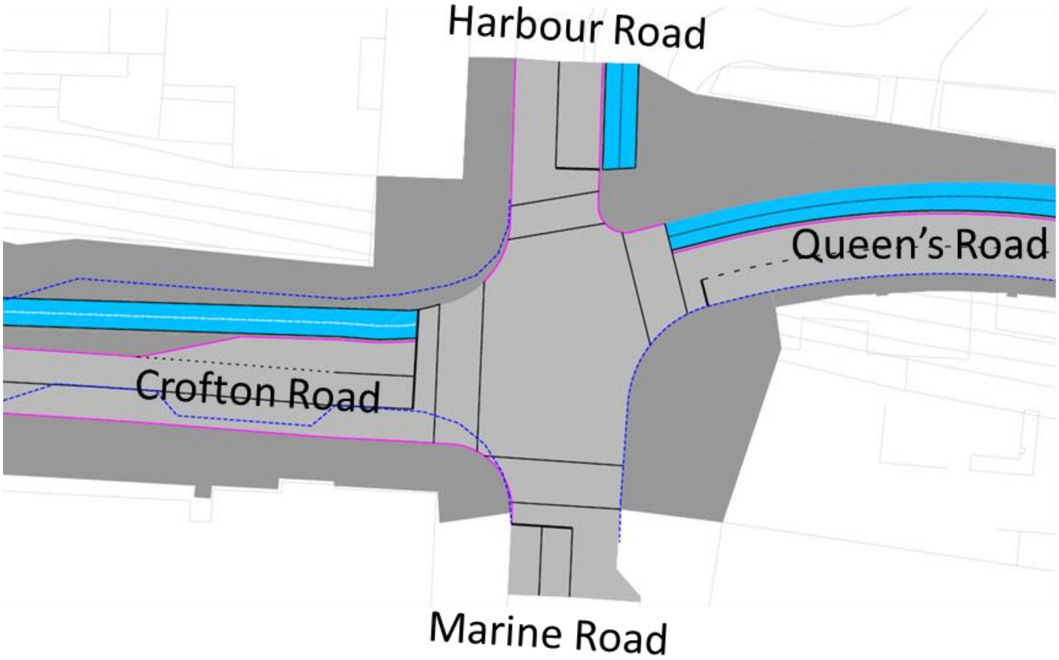

Figure 8.18 Revised layout of Marine Road Junction – Left Turn Pocket

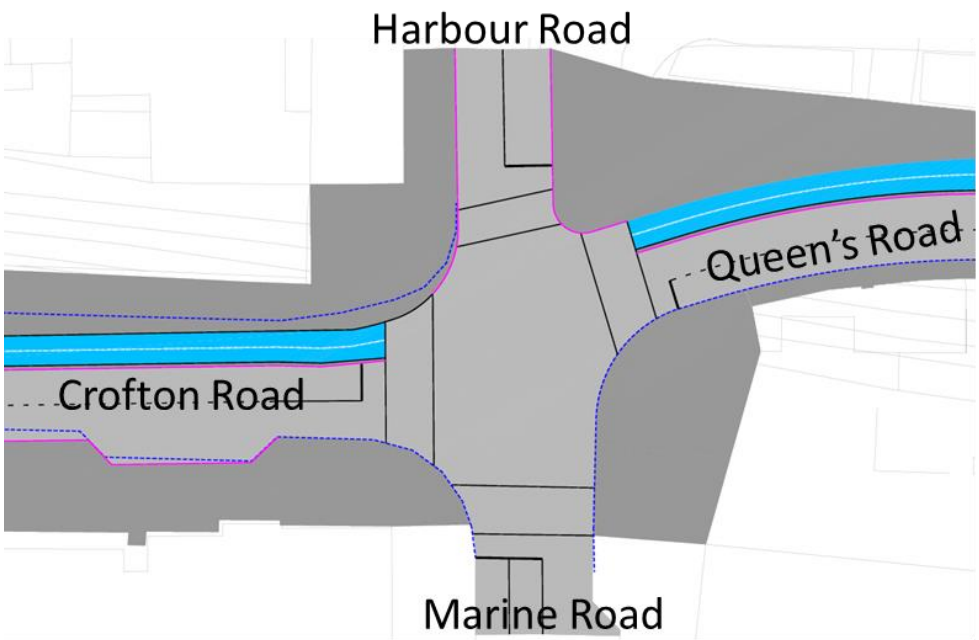

Figure 8.19 Revised layout of Marine Road Junction – No Left Turn Pocket

8.3.21 As with the redesign of the Coal Quay Bridge junction the focus of the changes is on providing segregated cycle facilities for cyclists on the Coastal Mobility Route. Two variations of this junction were tested:

- As shown in Figure 8.15, this option has a left turn flare from Crofton Road into Harbour Road to facilitate a separate phase for left turners; and
- As shown in Figure 8.15 this option excludes the left turn flare with all turns going on a single green phase.

8.3.22 The results for these two options are shown in Figure 8.20 below.

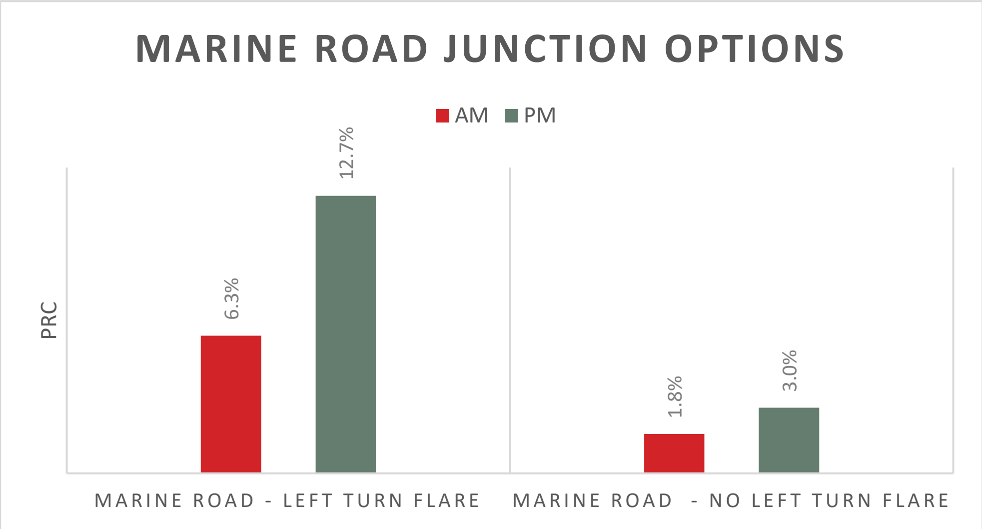

Figure 8.20 PRC for revised junction layouts

8.3.23 The Marine Road junction performs significantly better with the inclusion of the left turn flare. The left turn flare allows for traffic turning left, from Crofton Road to Harbour Road, to be held back to avoid conflict with the cycle lanes. As a result of this, straight on and movements to Harbour Road from the cycle lanes can run in parallel to vehicle movements from Crofton Road to Marine Road and Queen's Road. However, turns from the Coastal Mobility Route to Marine Road would need to be held back for the combined phase.

8.3.24 The phasing applied to the left turn flare option is shown in Figure 8.21 below:

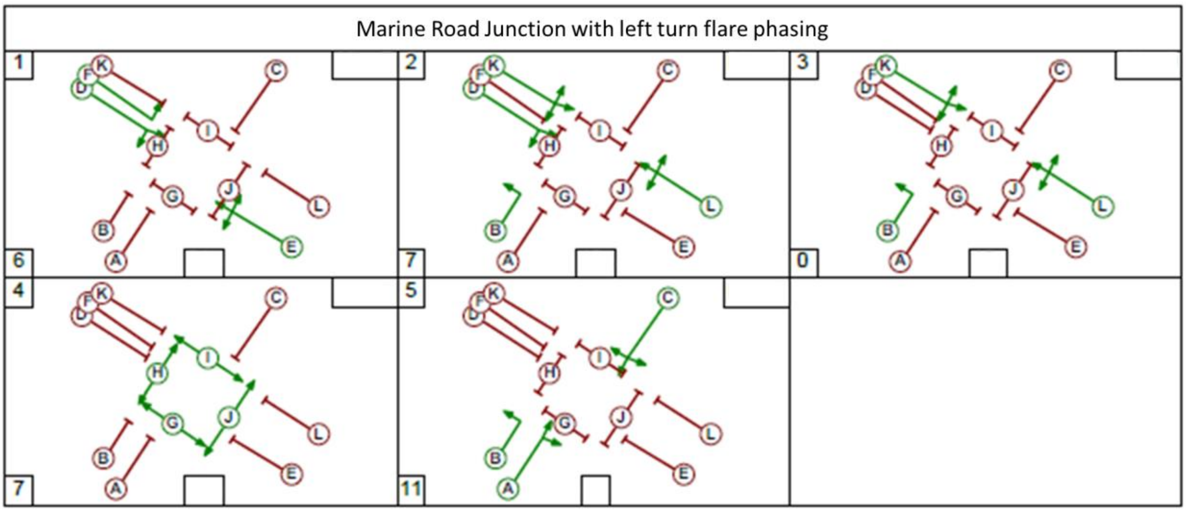

Figure 8.21 Marine Road Junction phasing with left turn flare

Without the left turn flare, the CMR and Crofton Road cannot run at the same time, reducing the green time available for both movements as shown in the phasing in Figure 8.22 below.

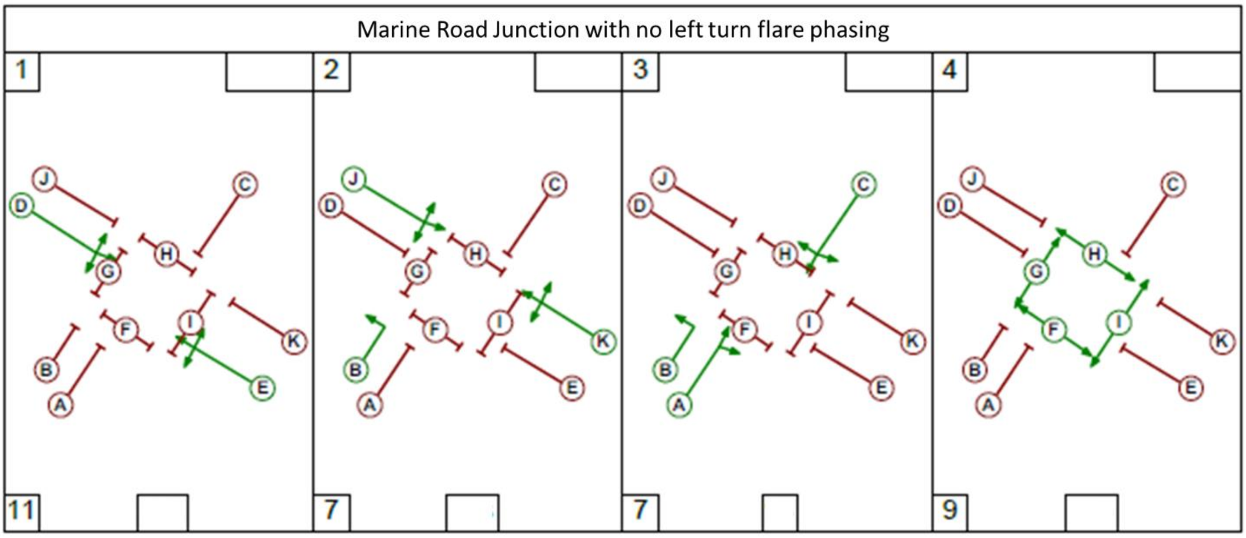

Figure 8.22 Marine Road Junction phasing with no left turn flare

8.3.25 LINSIG diagrams for the left turn option are shown in Appendix A.

8.4 Emission Impacts

8.4.1 Impacts of the scheme on emissions within the area was calculated using the NTA's Environment Module which uses ENEVAL, a calculation tool that calculates emissions based on traffic volume, speed and vehicle type. The ENEVAL database includes profiles for 1249 different vehicle types. Modelled flows are proportionally attributed to these different vehicle types based on a fleet profile.

8.4.2 ENEVAL is not an air quality tool, but instead provides data on volumes of vehicle tailpipe emissions generated on a link by link basis.

8.4.3 Figure 8.23 and Figure 8.24 below shows the vehicle emissions in the Do Minimum Scenario and Preferred Scenario.

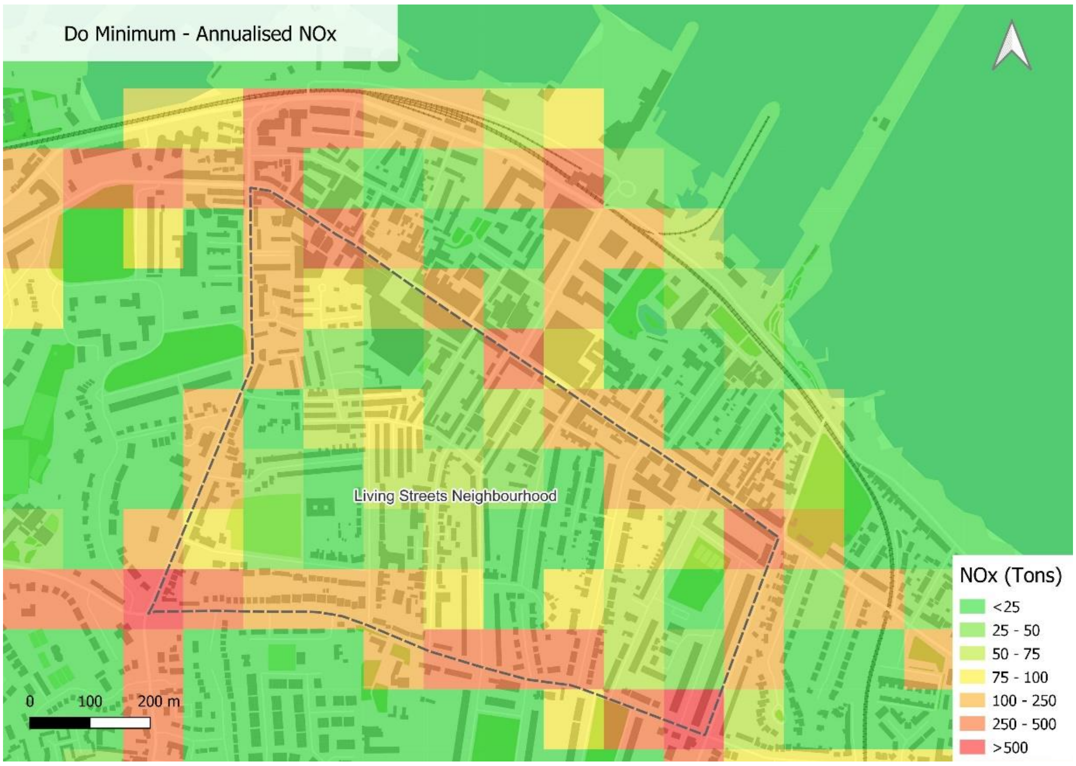

Figure 8.23 Do Minimum Nox Emissions

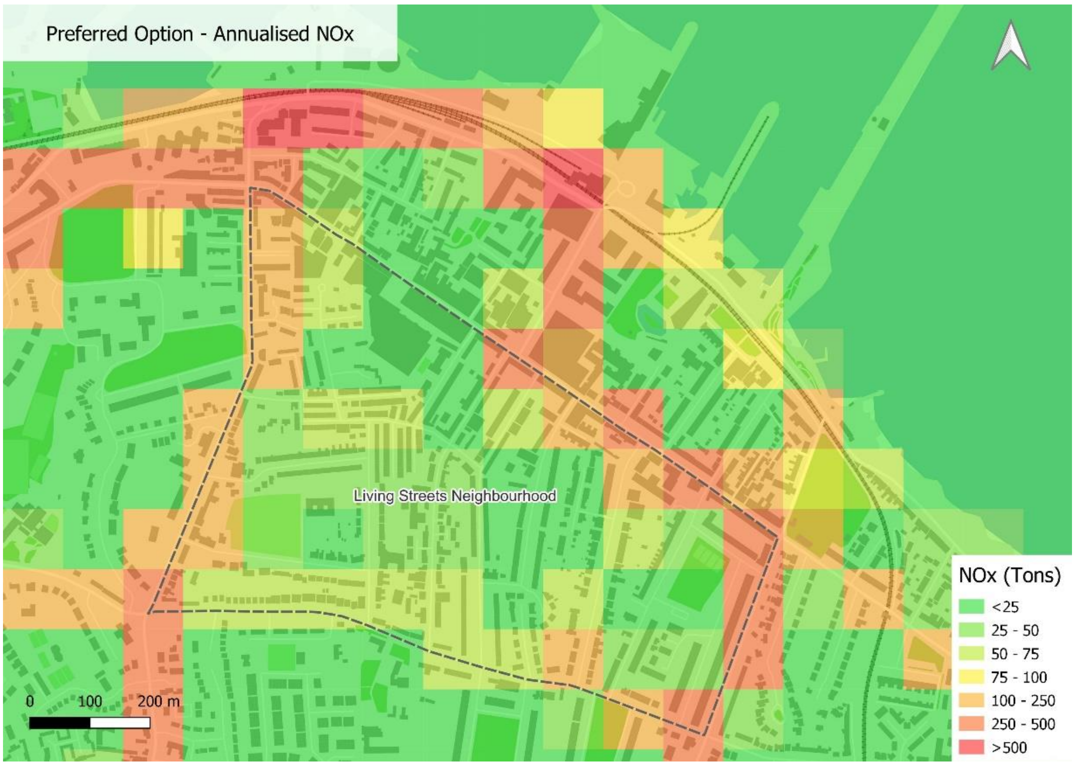

Figure 8.24 Preferred Option Nox Emissions

8.4.4 The emissions maps show an improvement in emissions levels within the Living Streets Neighbourhood area with a 26% reduction in Nox compared to the Do Minimum and Georges Street Lower, a 37% reduction along the length of the street. The reduced level of emissions within the LSN would contribute toward a healthier environment within the area.

8.4.5 As a result of the redirected traffic there is an increase along routes that see an increased flow in traffic, in particular George's Street Upper, Marine Road and Crofton Road. Emissions also increase at the Sallynoggin Roundabout, which is predicted due to the increased traffic at the roundabout.

Improve the neighbourhood – the removal of car trips from within the Living Streets Neighbourhood leads to reductions in harmful emissions levels.

8.5 Bus Route Options

8.5.1 Full pedestrianisation of George's Street Lower would require an alteration to existing and planned bus routes that currently use the Crofton-Marine-George's Street Loop as shown in Figure 8.25.

Figure 8.25 Existing bus loop along George's Street Lower

8.5.2 Living Streets: Dún Laoghaire - Options Assessment Report has been prepared by Barry Transportation, part of this report looks at options for the routing of bus services. Two routes from this report have been examined in more detail in this report;

- **Route Option 1** – Busses uses the existing route as far as Crofton and then turn back using the Harbour Road roundabout to leave Dún Laoghaire via Crofton.
- **Route Option 6** – Busses enter Dún Laoghaire via a new route; Glenageary Road Upper – Glenageary Road Lower – George's Street Upper – Marine Road and use the Harbour Road roundabout to turn back and use the same route to exit.

8.5.3 The two options are shown in Figure 8.26.

Figure 8.26 Bus route options

8.5.4 Option 1 is the same scenario used in the modelling of the preferred option.

8.5.5 Two KPIs were used in the assessment of the bus routes; population and jobs catchment, and journey time.

Bus Catchments

8.5.6 The catchments of the inbound and outbound routes is shown in Figure 8.36 and Figure 8.37. Two catchment bands were used to assess the routes; 400m and 100m. The 400m distances are defined as acceptable distances for passengers to walk for access to a bus stop under CIHT (Chartered Institution of Highways and Transportation) guidance[8] while the 100m was requested to represent those with reduced mobility.

[8] www.ciht.org.uk/media/4459/buses_ua_tp_full_version_v5.pdf

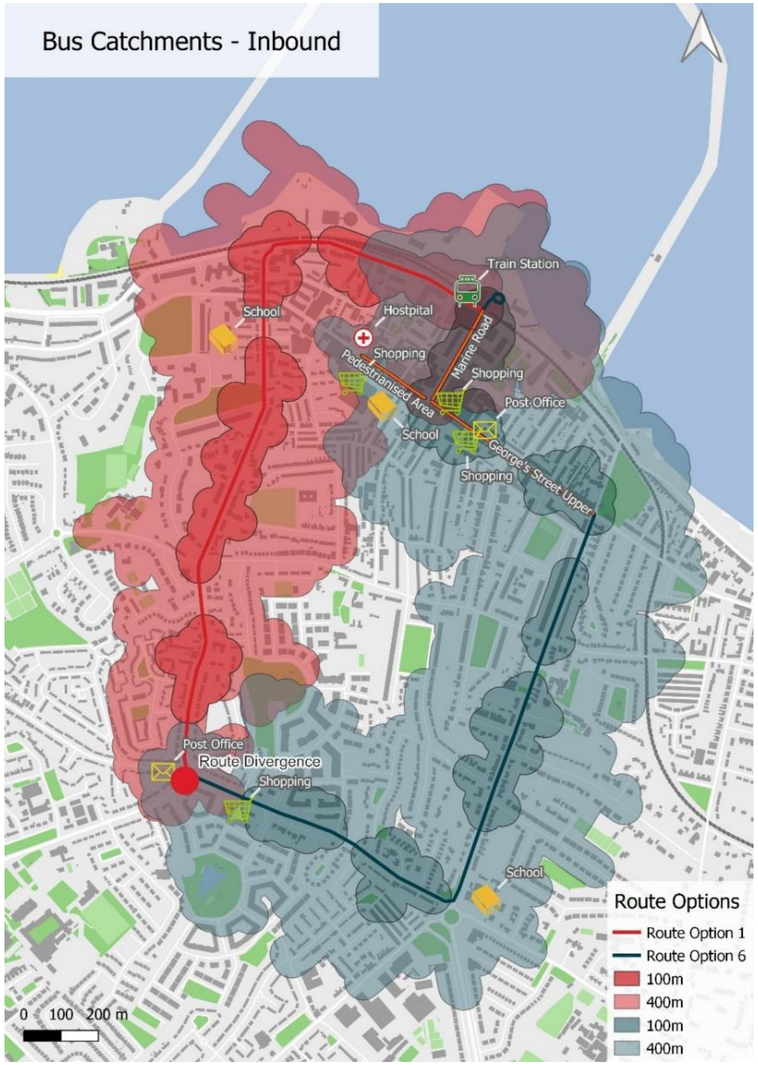

Figure 8.27 Inbound Bus Catchments

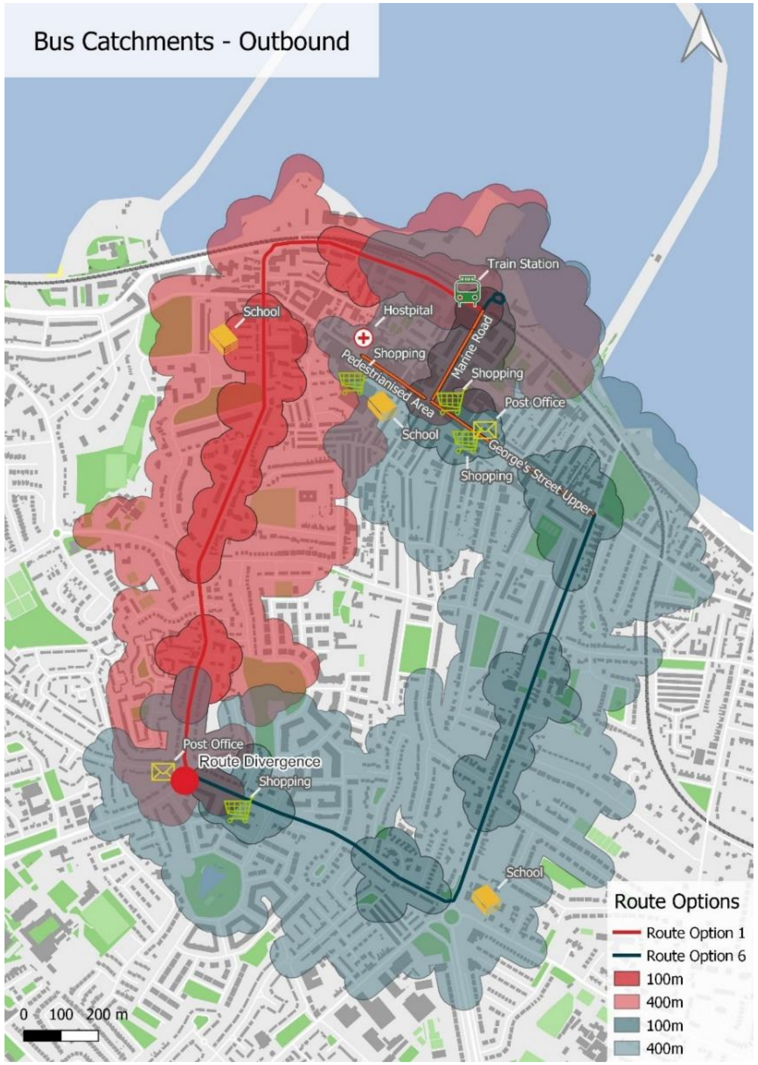

Figure 8.28 Outbound Bus Catchcments

8.5.7 The population and jobs catchment for these routes is shown in Table 8.2 and Table 8.3below.

Table 8.2 Inbound bus catchment

INBOUND	POPULATION		JOBS	
	100m	400m	100m	400m
Route Option 1	1,295	5,528	1,105	4,256
Route Option 6	1,558	5,791	1,386	4,537
Difference	263	263	281	281
	20%	5%	25%	7%

Table 8.3 Outbound bus catchment

OUTBOUND	POPULATION		JOBS	
	100m	400m	100m	400m
Route Option 1	1,193	5,426	1,004	4,156
Route Option 6	1,786	6,018	1,318	4,469
Difference	592	592	313	313
	50%	11%	31%	8%

8.5.8 With both the inbound and outbound directions the catchment for population and jobs is higher on Route Option 6. This route also captures key amenities within the town centre within the 100m catchment such as the post office and Dún Laoghaire Shopping Centre.

8.5.9 Both routes offer service to St Michael's Hospital and Bloomsfield shopping centre, but in both cases these are not within the 100m catchment. However, route Option 6 does provide a stop at the top of George's Street Lower with minimal incline of 1m between the stop and St Michael's Hospital.

8.5.10 Route Option 1 however, has an incline of 5m between the stop on Clarence Street and St Michael's Hospital, and an incline of 12m between the Crofton Street Stop and St Michael's Hospital.

Journey Times

8.5.11 Bus Journey times were measured along each of the route options for outbound and inbound services in both the AM and PM peak period. These journey times do not account for stopping times for the loading and unloading of passengers.

8.5.12 Both routes have different lengths, so any comparison between the two should take a count of these differences. The overall route lengths from the point the routes diverge are:

- Route Option 1 – 2.8km inbound and 2.9km outbound (the difference is due to the Sallynoggin Roundabout); and
- Route Option 6 - 2.2km both inbound and outbound.

8.5.13 Total journey times for the routes are shown in Table 8.4 and Table 8.5below.

Table 8.4 AM bus journey times

AM	INBOUND			OUTBOUND		
	Do Minimum	Preferred Option	Difference	Do Minimum	Preferred Option	Difference
Option 1	6m 56s	7m 8s	12s	6m 28s	6m 46s	18s
Option 6	8m 7s	8m 30s	23s	6m 19s	6m 24s	5s
Difference	71s	81s		-10s	-22s	

Table 8.5 PM bus journey times

PM	INBOUND			OUTBOUND		
	Do Minimum	Preferred Option	Difference	Do Minimum	Preferred Option	Difference
Option 1	6m 1s	6m 10s	9s	7m 10s	8m 18s	67s
Option 6	7m 21s	7m 25s	4s	6m 53s	7m 48s	55s
Difference	81s	75s		-17s	-30s	

8.5.14 For both route options the journey time increases within the Preferred Option, however the PM outbound is most affected within increases of approx.. 1minute for both options.

8.5.15 Route Option 1, in both the AM and PM , is the faster route option for inbound traffic. In the PM this is reversed, with Route Options 6, despite being longer, offering a faster route out from Dún Laoghaire.

8.5.16 A breakdown of the journey times along the length of the bus routes is shown in Figure 8.40 Figure 8.45 .

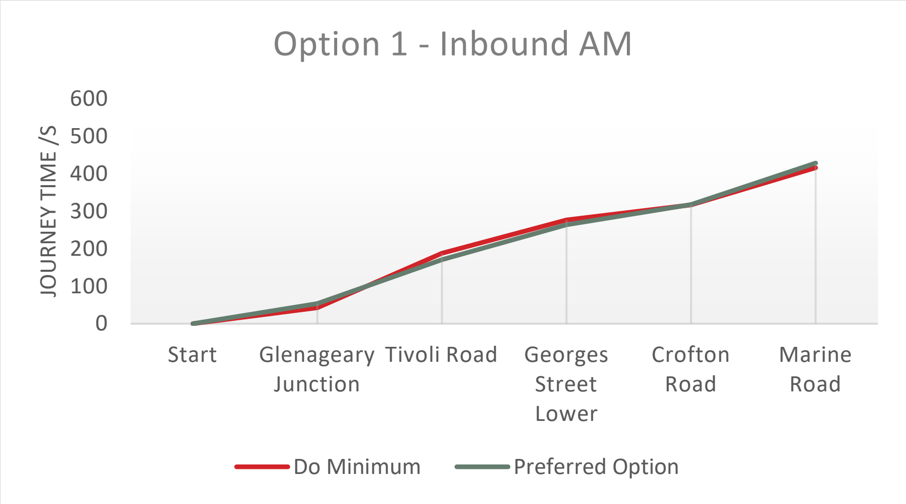

Figure 8.31 Route Option 1 Inbound AM

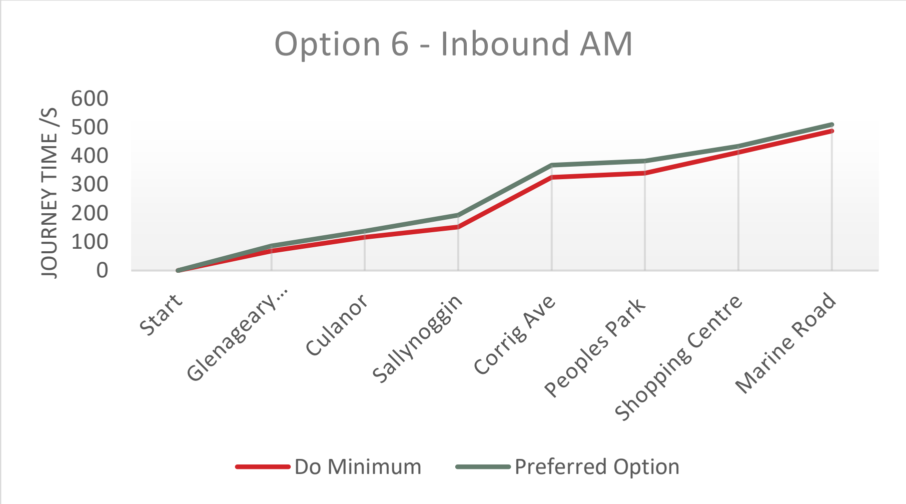

Figure 8.32 Route Option 6 Inbound AM

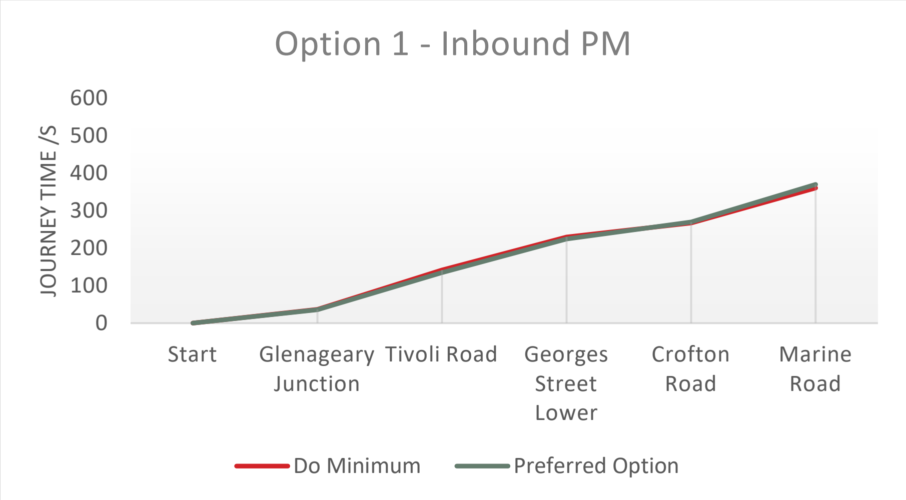

Figure 8.30 Route Option 1 Inbound PM

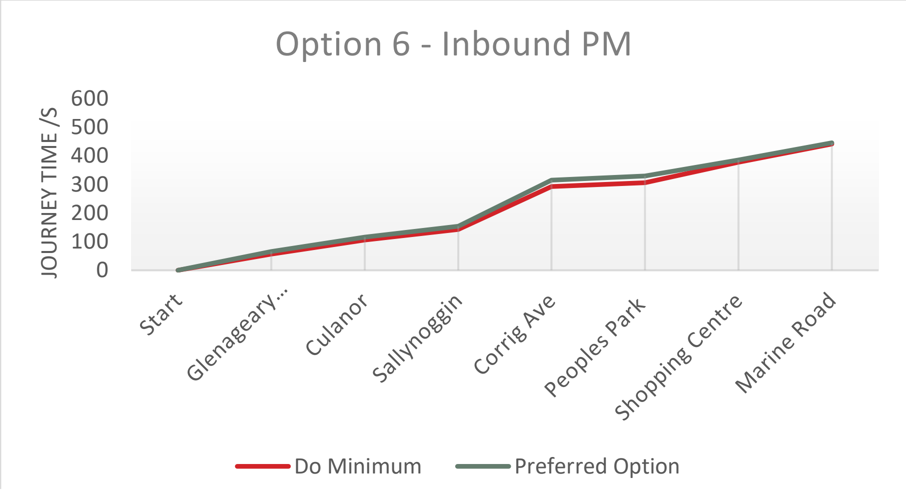

Figure 8.29 Route Option 6 Inbound PM

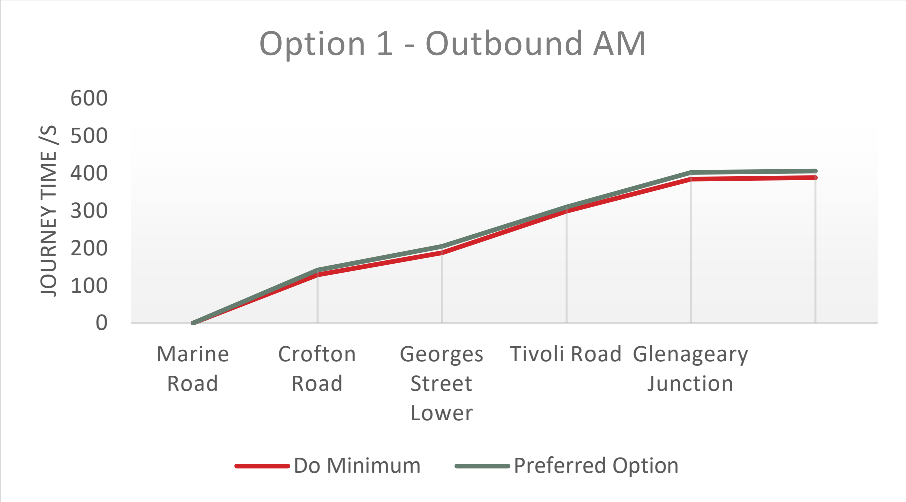

Figure 8.34 Route Option 1 Outbound AM

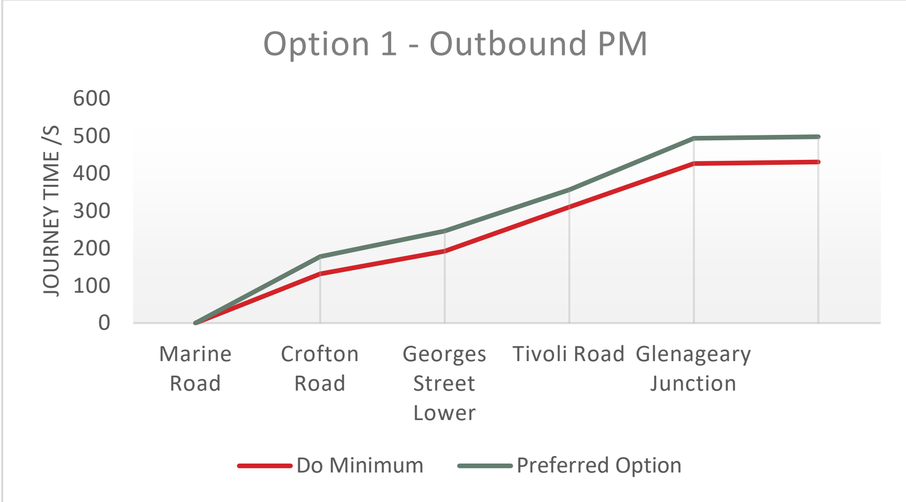

Figure 8.33 Route Option 1 Outbound PM

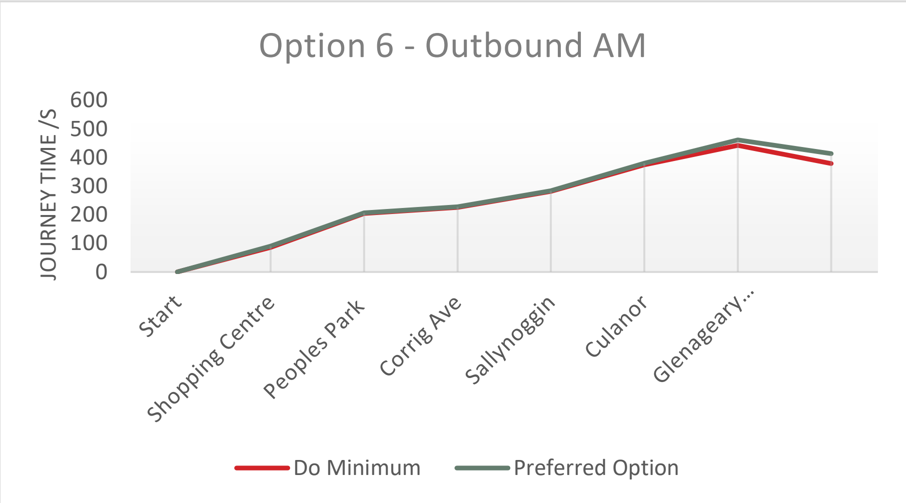

Figure 8.36 Route Option 6 Outbound AM

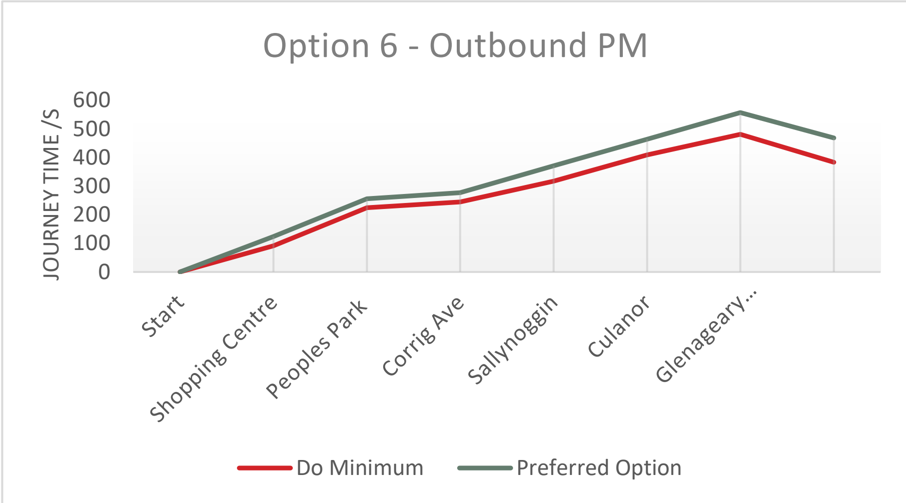

Figure 8.35 Route Option 6 Outbound PM

8.5.17 Inbound delays are minimal compared to the Do Minimum for both options, however in the PM delays are more notable for the outbound leg.

8.5.18 For Route Option 1, the primary source of delay on the outbound leg occurs along Crofton Road at the Coal Quay Bridge junction. This is the result of increased traffic along Crofton Road. For Route Option 6, there is no single source of delay, with delays accruing along the length of the journey.

8.5.19 On journey times, Route Option 1 offers better journey times and with the PM outbound delay associated with a single junction the delay would be easier to mitigate through a change to a single junction rather than Option 6 that experiences accumulation of small delays at multiple junctions.

8.5.20 Both routes offer positive and negatives, these are summarised in Table 8.6 below.

Table 8.6 Summary of Bus Route Options

SCENARIO	POSITIVE IMPACTS	NEGATIVE IMPACTS
Route Option 1	• Quicker inbound route than Route Option 6.	• Closest bus stop to St Michaels and Bloomfields has an incline of 12m making it less accessible to those with reduced mobility.
Route Option 6	• Higher catchment of jobs and population within both the 100m and 400m catchment bands. • Bus stop is level with key locations of St Michael’s Hospital and Bloomfields.	• Slower inbound route. • While faster outbound PM route, the delays are accumulated through multiple junctions making it harder to mitigate.

Improve connections – The pedestrianisation of George’s Street Lower requires the busses to redirected along an alternative route removing direct bus service to Bloomfields and St Michaels. Both of the routes tested result in marginal increases in journey time, up to approx. 1min. Route Option 6 allows for increased catchment, as well as a bus stop without an incline to Bloomfields and St Michaels.

8.6 Summary

8.6.1 Table 8.7 below provides a summary of the preferred option against project objectives.

Table 8.7 Summary performance of preferred scheme against objectives

OBJECTIVE	PREFERRED SCHEME IMPACT
Promote inclusive, sustainable mobility and reduce car dependency by making walking, cycling and public transport more convenient, enjoyable, and safer for all.	Through the removal of motorised through traffic (traffic not originating or travelling to the Living Street neighbourhood) car movements within the area are reduced in the AM peak, by a minimum of 35%, even if there is no movement away from use of private vehicles to other modes of transport (mode shift). This reduction in motorised traffic across the areas results in the following reductions on individual roads; • 31-84% along Tivoli Road; • 33% on Patrick Street; and • 28% on Mulgrave Street. The above numbers assume no mode shift occurs, when a mode shift was applied an average reduction of 43% across the area was achieved in the sensitivity test with localised reductions of; • 37-94% along Tivoli Road; • 47% on Patrick Street; and • 34% on Mulgrave Street. These reductions will provide a safer, more walking and cycling friendly environment for residents and visitors to move about the area.
Improve the neighbourhood by reducing traffic and related noise and air pollution; and increasing climate resilience through planting and greening initiatives.	The preferred option diverts through traffic away from the neighbourhood, thereby reducing car trips within the area by 35% during the morning (AM) peak with no mode shift and 43% within the high mode shift sensitivity scenario. These reductions in through traffic lead to reductions in harmful emissions, with a predicted reduction of 26% and 37% NOx within the Living Streets Neighbourhood and George's Street Lower respectively. Some of the shortest trips can then be more easily made by walking or cycling, while the longer distance (strategic trips) will be

	reallocated on the network (i.e. changing routes or destinations). The addition of three modal filters also allows for new areas of tree planting and landscaping at each location.
Enhance the economic vibrancy of Dún Laoghaire as a mixed-use town and its attractiveness as a destination by facilitating the sustainable and efficient movement of people and goods, and by creating an environment that people want to linger in.	The preferred option facilitates active travel by creating a network of streets with low levels of car traffic between Glenageary Road Upper, Glenageary Road Lower, York Road and Crofton Road. This will allow residents and visitors to have safer and more pleasant journeys by active modes. Walking and cycling are more efficient ways for people to move around and do not require large areas for car parking, These changes are achieved while retaining access to the town centre and wider area for those who choose to use their car. This results in more people within the town.
Improve connections between bus, rail and active travel facilities to make it easier for people to access sites of interest in the town, the seafront and surrounding neighbourhood.	On key routes through the Living Streets Neighbourhood identified as Active Travel Corridors there is a predicted minimum 34% reduction with no mode shift, and 40% reduction in the mode shift sensitivity tests. Reduced car traffic on these routes facilitates safer and more pleasant movement by active modes. In addition, reduction in traffic along Tivoli Road, and pedestrianisation of Georges Street Lower, would allow for easier and safer movement of people via sustainable transport to key destinations (work, retail) within and outside of the town centre including the seafront and nearby villages. The preferred option achieves this while retaining car access to the town centre, including all car parks.
Promote health and wellbeing in the community by enabling safer active travel and enhancing the public realm for outdoor play, recreation, and social interaction.	Reduced traffic, including an elimination of all HGV through trips, will provide a safer and healthier environment, with a significant reduction in harmful emissions and noise pollution. Two key routes through the neighbourhood, identified as active

	travel corridors, see reductions in motorised vehicle numbers below 2,000 vehicles per day, which is identified as the safe design limit for unsegregated cyclists; • Western route on Tivoli Terrace E reduced from 2,200 to 1,700; and • Eastern route on Clarinda Park W reduced from 1,300 to 700. These safer routes will encourage a greater number of walking and cycling trips which would have health benefits resulting from the increased physical activity. Safer walking and cycling routes to schools will be created that will allow more children to walk and cycle to the schools in the area. Research has shown that children who use active modes to get to school are much more likely to keep up these habits later in live and this leads to significant health benefits. The streets outside of the schools will also be safer and calmer which would create an environment that is more conducive to outdoor play, recreation and social interaction.
Promote equitable travel options and urban design that creates a safe and welcoming experience for all members of society, regardless of age, gender, ability, or income.	The preferred option retains access to the area for those who choose or need to use a car, only removing through traffic. The reductions in car traffic provide safer spaces for pedestrians and cyclists, who account for over 63% of all local trips, this will help achieve the project objective of creating a place which is safer, more vibrant and pleasant for people of all ages, abilities and genders. The pedestrianised section of George's St Lower will be fully landscaped with high quality paving, planting and seating, creating a safe, welcoming and attractive environment for all. Several other parklets will also be created at Tivoli Road, Cross Ave and Clarinda Park with new seating and landscaping.

	The introduction of the modal gates will lead to a redistribution of motorised vehicle traffic with a consolidation of this traffic along the permitter roads. This will increase the daily vehicle trips along these routes. Individual junction modelling of all junctions along the perimeter roads has been done and the results show that sufficient capacity remains to accommodate these changes with a minimal increase in travel times of 2-4 mins during the peak periods. Modelling of the preferred option focused on no change in mode choice and sensitivity tests looking at mode choice changes within the study area. However, the mode choice impacts of the scheme on the wider area are not covered, though schemes that reallocated road space typically lead to "traffic evaporation" as a result of movement to alternative modes. The project will optimise the operation of all traffic lights in the wider area to suit the new traffic patterns, this will improve the efficiency of all junctions. It will also involve road safety improvements such as a new signalised pedestrian crossing on York Road and improved pedestrian crossing facilities at the Glenageary Road/Corrig Road junction.

9. CONCLUSION

9.1.1 The Living Streets scheme in Dún Laoghaire aims to create a more liveable environment where all mode choices are catered for and the more sustainable travel choices are prioritised. It seeks to improve the local environment through improvements in noise and air quality and providing safer, active mode friendly routes through the area.

9.1.2 A multistage modelling process was carried out to explore multiple options to achieve the objectives of the study. Modelling of the preferred option made use of the NTA's Eastern Regional Model, a Local Area Model built in SATURN and individual junction modelling in LINSIG.

9.1.3 The preferred option includes:

- Pedestrianisation of Georges Street;

- Modal Gates at; Clarinda Park West, Cross Avenue and Tivoli Road (west of Patrick Street); and
- Reversal of the direction of one-way traffic on Windsor Terrace between Link Road and Park Road.

9.1.4 Further bus route options assessment and options assessment for individual junctions is provided by Barry Transportation in the following documents:

- Bus Route Option Selection – Living Streets: Dún Laoghaire – Options Assessment Report
- Junction Option Selection – Living Streets: Coastal Mobility Route – Options Assessment Report

9.1.5 The preferred option meets the study objectives by providing reduced levels of traffic within the Living Streets Neighbourhood with through trips removed. This in turn provides the following benefits:

- Safer and more pleasant streets for walking and cycling;
- Reduction in barriers for pedestrians through reduced conflict with vehicles;
- Reduced emissions within the Living Streets Area.

9.1.6 The modelling indicated that the removal of through trips does result in increased traffic flow on perimeter roads when no mode-shift is taken into account. This was considered a worst-case scenario as some mode shift would be expected based on best practice experience of similar schemes.

9.1.7 Junction modelling of key junctions around the permitter roads using LINSIG showed that with simple changes to phasing and timings the increases in traffic flows can be accommodated at the majority of junctions.

9.1.8 The exception to this is the Coal Quay Bridge junction, which in its current configuration operates near capacity with the increased traffic on Crofton Road. However, this junction is being considered for redesign to accommodate the connection of the CMR through Dún Laoghaire. The new designs have been tested with the increased flow on Crofton Road and operate within capacity.

Summary

9.1.9 The Living Streets Neighbourhood scheme has positive impacts for residents and active mode users within Dún Laoghaire with reduced levels of traffic within the Living Streets Neighbourhood that will facilitate an improved active travel environment.

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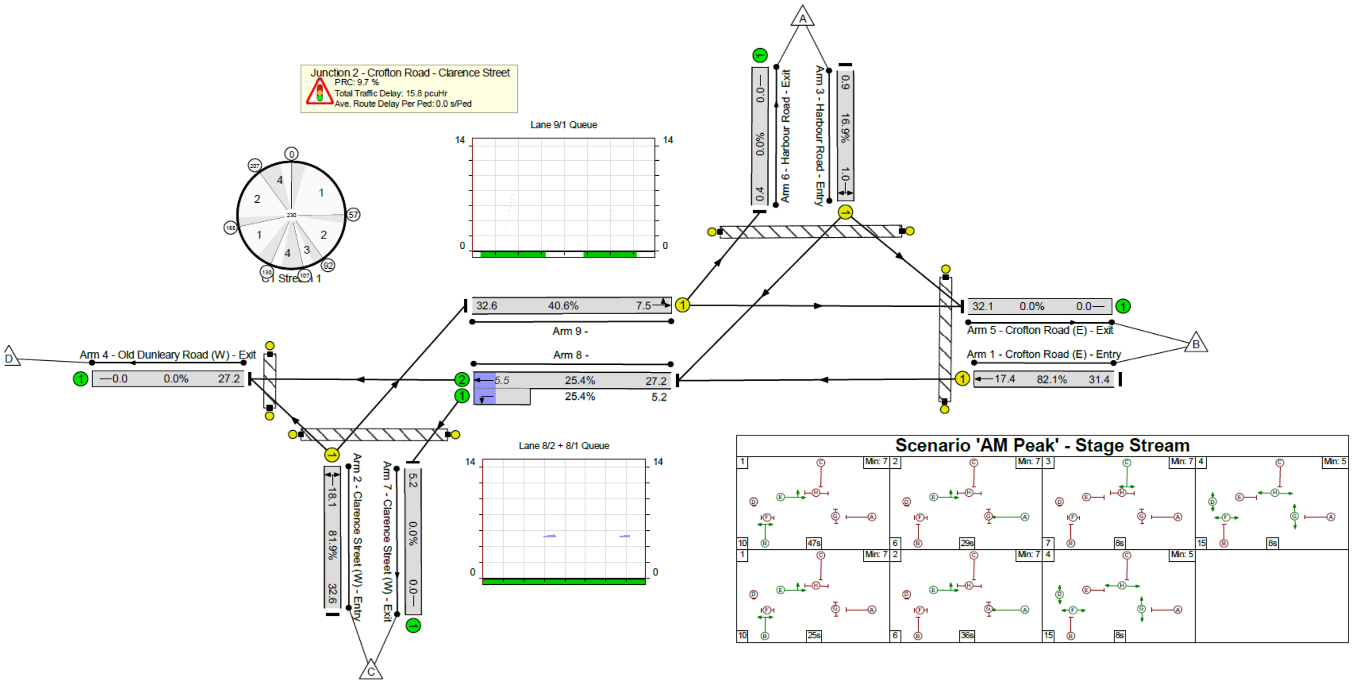
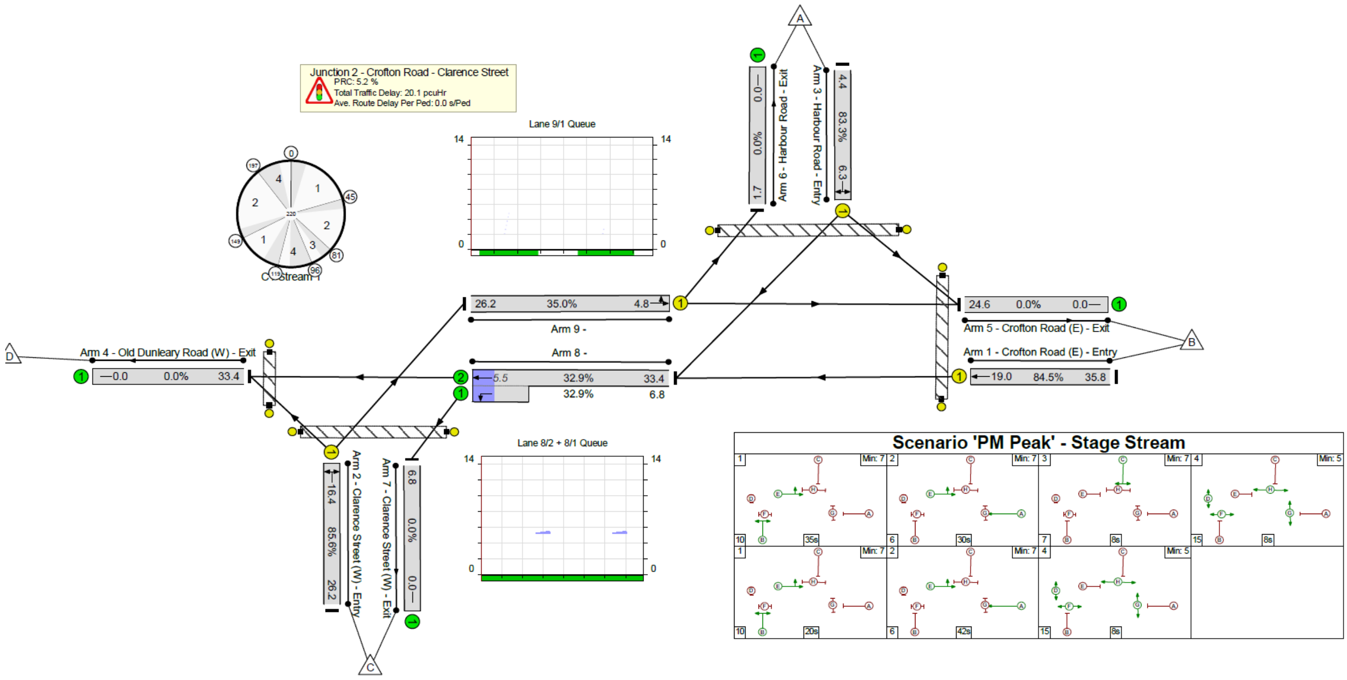
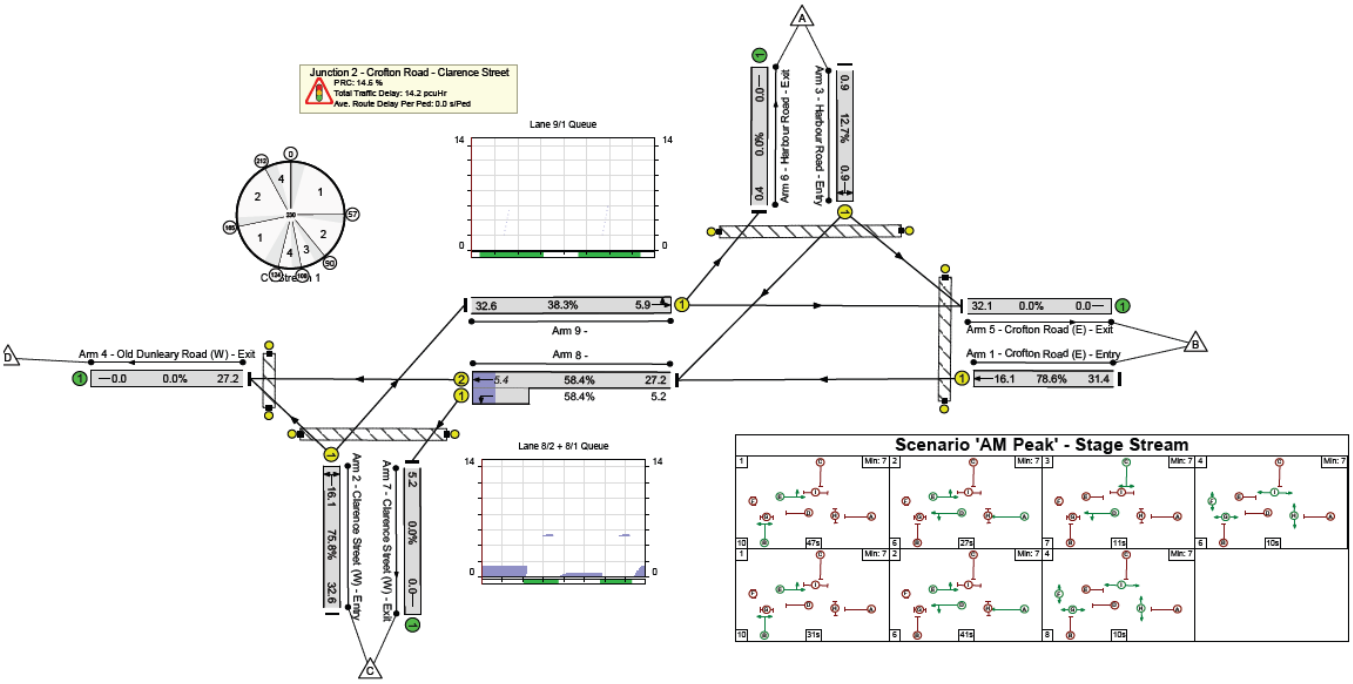
APPENDIX A – LINSIG DIAGRAMS



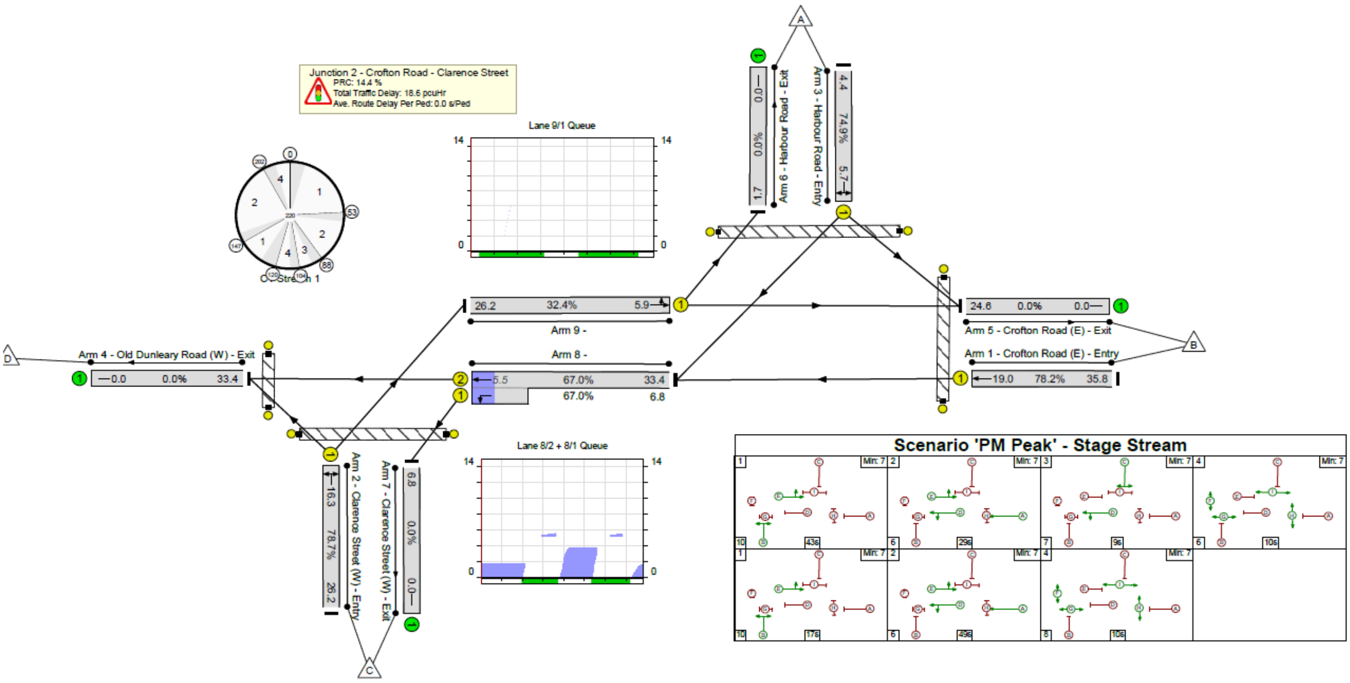
Coal Quay Bridge AM – Single Junction



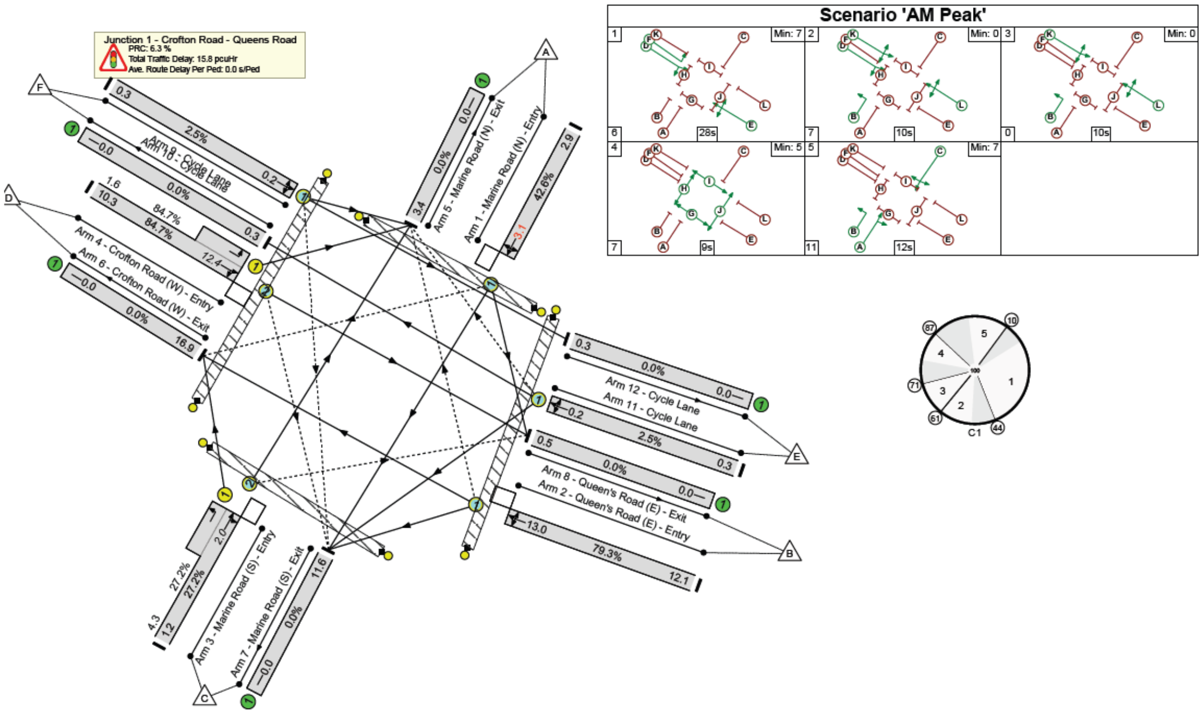
Coal Quay Bridge PM – Single Junction



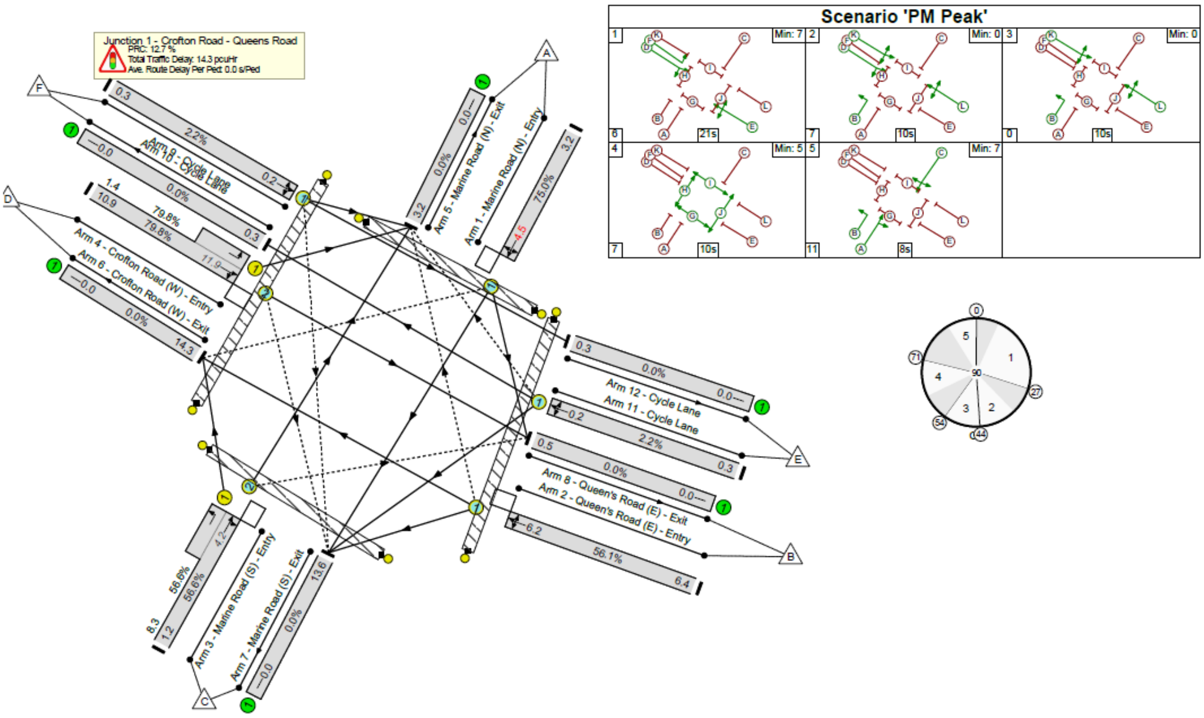
Coal Quay Bridge AM – Split Junction



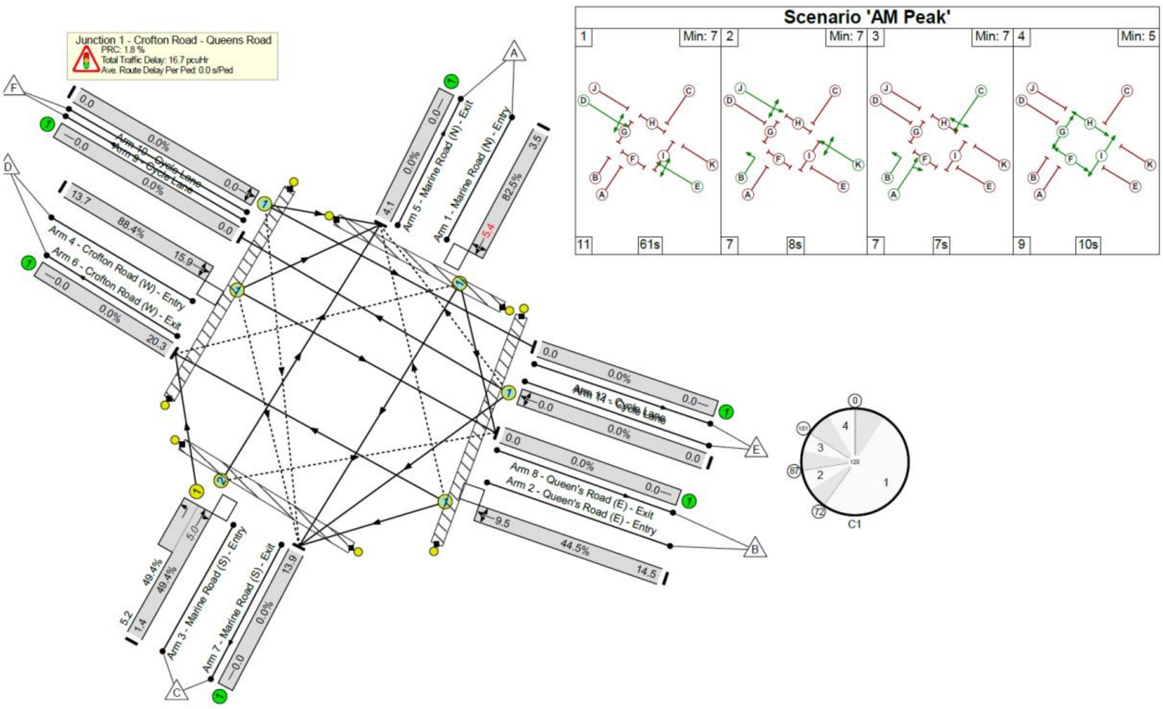
Coal Quay Bridge PM – Split Junction



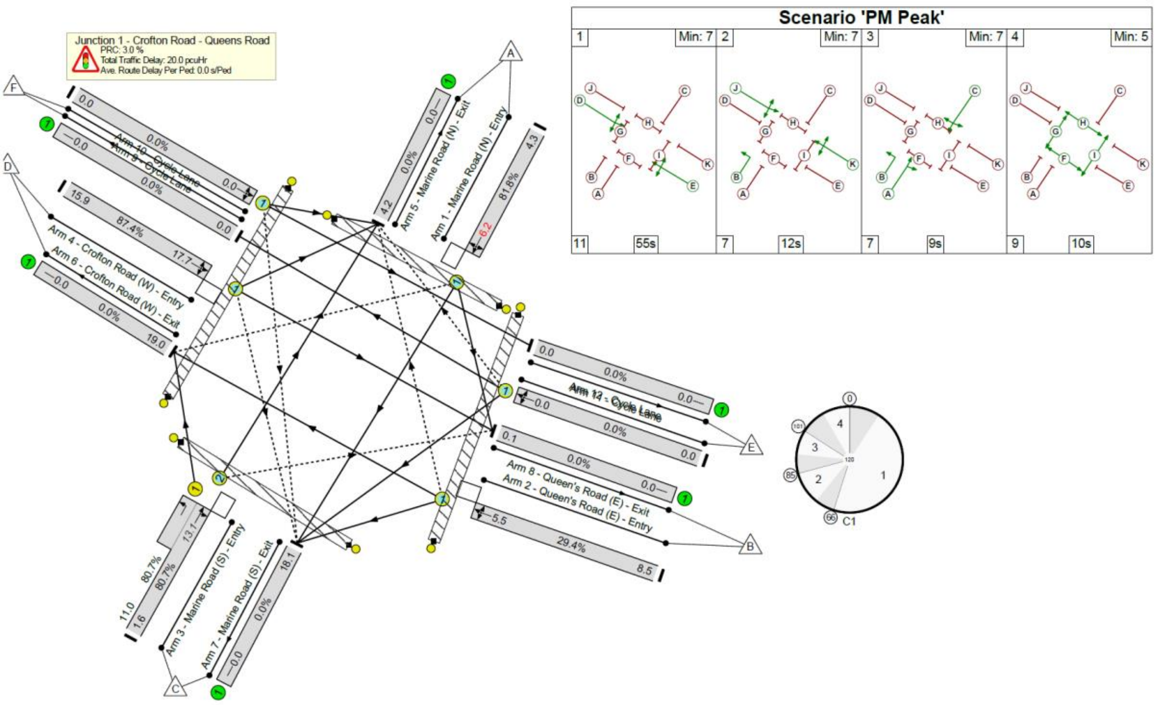
Marine Road junction AM – with left turn flare



Marine Road junction PM – with left turn flare



Marine Road junction AM – with no left turn flare



Marine Road junction PM – with no left turn flare