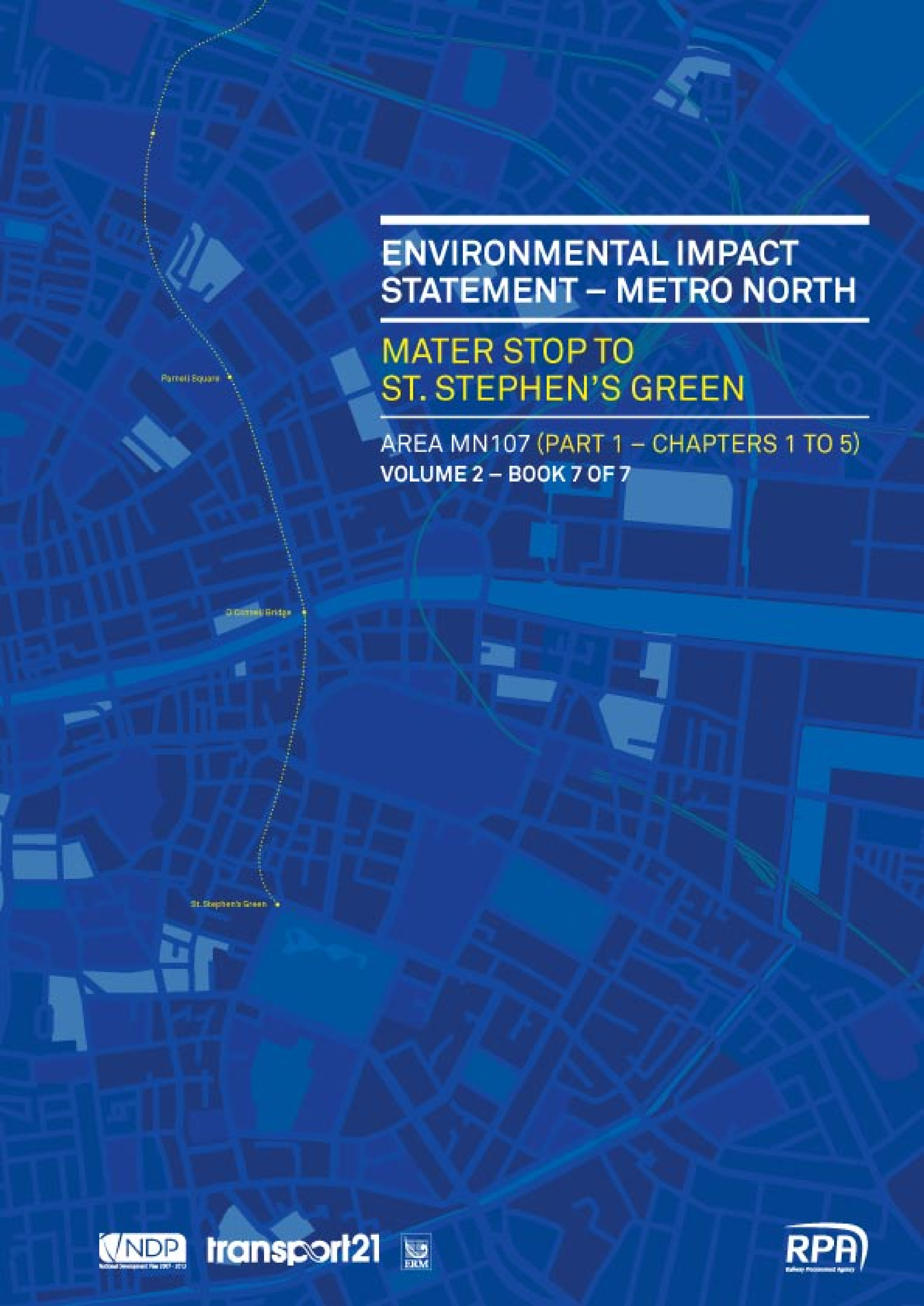

ENVIRONMENTAL IMPACT STATEMENT – METRO NORTH

MATER STOP TO ST. STEPHEN'S GREEN

AREA MN107 (PART 1 – CHAPTERS 1 TO 5)

VOLUME 2 – BOOK 7 OF 7


METRO NORTH ROUTE
AREA MN101 – MN107
LEGEND
METRO ROUTE
AREA BOUNDARY
METRO ROUTE (BORED TUNNEL)
METRO ROUTE (CUT & COVER TUNNEL)
METRO ROUTE (ELEVATED TRACK)
METRO WEST
AREA NAME
METRO NORTH FUTURE POSSIBLE STOP
METRO WEST FUTURE POSSIBLE STOP
METRO STOP NAME
PARK & RIDE FACILITY
LUAS INTERCHANGE
BUS INTERCHANGE
RAIL INTERCHANGE
POSSIBLE DEPOT
AREA MN101
Estuary
Seatown
Swords
Fosterstown
AREA MN102
AREA MN103
Airport
METRO WEST
Dardistown
AREA MN104
Northwood
Ballymun
AREA MN105
Dublin City University
Griffith Avenue
AREA MN106
Drumcondra
Mater
Parnell Square
Phoenix Park
O'Connell Bridge
AREA MN107
St. Stephen's Green
Luas Green Line
Luas Red Line
DUBLIN HARBOUR

ENVIRONMENTAL IMPACT STATEMENT – METRO NORTH

MATER STOP TO ST. STEPHEN'S GREEN

AREA MN107

VOLUME 2 – BOOK 7 OF 7

National Development Plan 2007 - 2013

Railway Procurement Agency

ENVIRONMENTAL IMPACT STATEMENT

For ease of local identification this Environmental Impact Statement (EIS) has been divided into seven areas. These areas are numbered Area MN101 to Area MN107 inclusive going from Belinstown in north County Dublin to St. Stephen's Green in the city centre.

The environmental impact of the proposed scheme in each of these areas is set out in individual books numbered MN101 to MN107 and which collectively make up Volume 2 of this EIS.

The Environmental Impact Statement (EIS) is being published in three separate Volumes as follows:

VOLUME 1

Introduction to the scheme and a description of the receiving environment

Volume 1 of the EIS is set out in 25 Chapters as follows:

Chapter 1 Introduction

Chapter 2 Need and Objectives

Chapter 3 Legislation

Chapter 4 Planning and Policy Context

Chapter 5 Alternatives

Chapter 6 Description of the Scheme

Chapter 7 Consultation

Chapter 8 Human Health

Chapter 9 Difficulties Encountered

Chapter 10 – 25
Description of the baseline environment

VOLUME 2

Environmental Impact – Area MN101

Environmental Impact – Area MN102

Environmental Impact – Area MN103

Environmental Impact – Area MN104

Environmental Impact – Area MN105

Environmental Impact – Area MN106

Environmental Impact – Area MN107

Volume 2 of the EIS is set out in 18 Chapters as follows:

Chapter 1 Introduction to Areas MN101 -107

Chapter 2 Human Beings: Landuse

Chapter 3 Human Beings: Socio-economics

Chapter 4 Human Beings: Noise

Chapter 5 Human Beings: Vibration

Chapter 6 Human Beings:
Radiation and Stray Current

Chapter 7 Human Beings: Traffic

Chapter 8 Flora and Fauna

Chapter 9 Soil and Geology

Chapter 10 Groundwater

Chapter 11 Surface Water

Chapter 12 Air and Climatic Factors

Chapter 13 Landscape and Visual

Chapter 14 Material Assets: Agronomy

Chapter 15 Material Assets: Archaeology, Architectural Heritage and Cultural Heritage

Chapter 16 Material Assets:
Non Agricultural Property

Chapter 17 Material Assets: Utilities

Chapter 18 Interrelationships, Interactions and Cumulative Impacts

VOLUME 3

Book 1 of 2
Specialist maps – baseline and impact

Book 2 of 2
Annexes to the EIS

Volume 3 of the EIS is set out in 2 books.

Book 1 of 2 contains all baseline and impact assessment maps and Book 2 of 2 contains annexes to the EIS e.g. technical reports.

EIS NON-TECHNICAL SUMMARY (NTS)

EIS METHODOLOGY

The methodology used in this EIS generally involves the following steps:

- Definition of the study area;
- Data collection and description;
- Baseline description and evaluation;
- Identification of potential environmental impacts and the potential areas to be affected;
- Description and evaluation of the impacts;
- Derivation of mitigation measures to minimise the impact;
- Description of the residual impacts of the scheme.

Further detail in relation to the EIS methodology is provided in Volume 1 of the EIS.

ENVIRONMENTAL IMPACT STATEMENT STUDY TEAM

The EIS was prepared on behalf of the Railway Procurement Agency (RPA) by a study team led by Environmental Resources Management (Ireland) Ltd, who were responsible for the overall assessment management and co-ordination as well as for the production of the Landuse, Socio-economics, Noise, Vibration (part), Radiation and Stray current, Flora and Fauna, Soil and Geology (part), Air and Climatic factors, Non Agricultural Property and Utilities chapters of this EIS. The other members of the study team are outlined in the table below.

AVAILABILITY OF THE EIS

This EIS is available to download for free through the RPA website at www.dublinmetronorth.ie

Copies of this EIS including the Non-Technical Summary may be purchased by any member of the public during normal office hours at the following location:

Railway Procurement Agency (RPA)
Parkgate Street
Dublin 8

The EIS may be purchased as a complete document for a sum of €170.00 (Volumes 1, 2 & 3)

The EIS can also be purchased as individual books e.g:

- Copies of Volume 1 may be purchased for €30.00 each;
- Copies of Volume 2 (individual book e.g. MN101) may be purchased for €15.00 each;
- Copies of Volume 3 (individual books e.g. Book 1 of 2) may be purchased for €15.00 each;
- Copies of the NTS of this EIS may be purchased for €5.00 each.

A DVD version of the whole EIS may be purchased for €15.00 which includes Volume 1; Volume 2 (Area MN101 – MN107); Volume 3 (Book 1 of 2 and Book 2 of 2) and the Non-Technical Summary.

Input	Contributor
Human Health	EHA Consulting Group
Human Beings: Vibration	Rupert Taylor F.I.O.A
Human Beings: Traffic	MVA Consulting
Soil and Geology	Jacobs Engineering Ireland Ltd.
Groundwater	AWN Consulting
Surface Water	AWN Consulting
Landscape and Visual (photomontages)	Digitech
Material Assets: Agronomy	Curtin Agricultural Consultants
Material Assets: Archaeology, Architectural Heritage and Cultural Heritage	CRDS Ltd.

CONTENTS

01 INTRODUCTION TO AREA MN107

Metro North is the next phase of Dublin's integrated light rail network. The proposed scheme will serve an 18km corridor from Belinstown in the north of County Dublin to St. Stephen's Green in the city centre via Dublin Airport.

Metro North is the next phase of Dublin's integrated light rail network. The proposed scheme will serve an 18km corridor from Belinstown in the north of County Dublin to St. Stephen's Green in the city centre via Dublin Airport. Metro North is a light rail system running on a line of sight basis, at grade, in underpasses or on elevated sections between Belinstown and Fosterstown and under full signal control on a segregated alignment between Fosterstown Stops and St. Stephen's Green. Metro North will run in a mix of bored and cut and cover tunnels beneath the city and in bored tunnels beneath Dublin Airport.

For ease of local identification, in this EIS the proposed scheme has been divided into seven areas. These areas are numbered Area MN101 to Area MN107 inclusive going from Belinstown in north County Dublin to St Stephen's Green in the city centre. The environmental impact of the proposed scheme in each of these areas is set out in individual books numbered MN101 to MN107 and which collectively make up Volume 2 of this EIS. This document relates to **Area MN107** Mater Stop to St. Stephen's Green.

On leaving the Mater Hospital the route turns south easterly under the Dorset Street/ North Frederick Street junction and on to Parnell Square East where a cut and cover stop, Parnell Square, will be constructed. To the south of Parnell Square, the route proceeds in tunnel under O'Connell Street to O'Connell Bridge Stop. This stop is located under the River Liffey and access to this stop is provided to the north and the south of O'Connell Bridge. Entrances to the north of the River Liffey will facilitate interchange with the Luas Red Line. From O'Connell Bridge the route proceeds beneath Westmoreland Street and College Green and under buildings between Clarendon Street and Grafton Street. The terminus stop, St. Stephen's Green, is located in the north west corner of the Green. Entrances to this stop are outside the Green on St. Stephen's Green North and St. Stephen's Green West. This stop will permit interchange with the Luas Green Line services and the proposed Iarnród Éireann Interconnector. Turnback of Metro vehicles is via a tunnel loop under St. Stephen's Green.

02 HUMAN BEINGS: LANDUSE

This chapter of the EIS describes the potential impacts on landuse which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107.

2.1 INTRODUCTION

This chapter of the EIS describes the potential impacts on landuse which may arise due to activities associated with the construction and operation of the proposed scheme in Area MN107.

2.2 STUDY AREA

The study area for the assessment is set out in Table 2.1.

Table 2.1 Study area

Criteria	Width of study area (on both sides of the alignment)
Temporary and permanent land-take	All areas encompassed by the Compulsory Purchase Order (CPO) line for permanent land-take
Severance	

2.3 IMPACT ASSESSMENT METHODOLOGY

The source and type of all potential impacts are described in Section 2.4.1. Mitigation measures to be put in place are defined in Section 2.4.2. The extent to which mitigation is needed increases as the significance of the impact increases. Residual impacts are evaluated in Section 2.4.3 in terms of magnitude and significance.

2.3.1 Magnitude

The criteria used to assess the magnitude of impacts are shown in Table 2.2.

Table 2.2 Criteria for assessment of impact magnitude

Criteria	Impact magnitude
- Permanent land-take - Permanent severance	very high
- Temporary land-take for a period of more than 1 year or near/in residential areas - Temporary severance for a period of more than 1 year or near/in residential areas	high
- Temporary land-take for a period of less than 1 year - Temporary severance for a period of less than 1 year	medium
- Land-take in existing streetscapes	low
- N/A	very low

2.3.2 Significance

The significance of all impacts is assessed in consideration of the magnitude of the impact and the quality of the area (functional value) upon which the impact has an effect. The quantity of the land-take, relative to the affected landuse, is necessarily a factor of magnitude, and has therefore been taken into account in the assessment of an impact's significance.

2.4 IMPACT ASSESSMENT METHODOLOGY

2.4.1 Impact identification

The impact of the proposed scheme on the landuse along the alignment has been assessed with reference to two categories: temporary and permanent impacts.

Temporary impacts
Temporary impacts typically occur during construction. These impacts are short to medium-term in nature. Sources of temporary impact include: construction compounds and construction activities.

Permanent impacts
Permanent impacts are long-term impacts associated with the structure and operation of the scheme. Sources of permanent impacts include all permanent, above-ground, built structures associated with the scheme including stops, tracks, bridges, viaducts, substations, park & ride sites, ancillary roads, access ways, tunnel portals and areas affected by permanent changes to traffic routes.

The types and sources of impact considered in this chapter are summarised in Table 2.3. Table 2.3 also provides clarification as to whether the impact assessment of each impact type is carried out on a qualitative or quantitative basis.

Table 2.3 Impact identification

Potential impact type	Impact source	Assessment type: qualitative/ quantitative*
Construction phase		
Temporary land-take	Temporary construction compounds, construction roads, tunnel launching sites, cut & cover locations, tunnel portals, storage areas, temporary land-take associated with the CPO etc.	Quantitative and qualitative
Temporary severance (only impacts that don't result in permanent land-take)		Qualitative
Permanent land-take	Road widening for construction roads, etc.	Quantitative and qualitative
Operational phase		
Permanent land-take	Scheme infrastructure: track; stop locations; access and egress locations; substations etc.	Quantitative and qualitative
Permanent severance		Qualitative

*Quantities are not calculated for land-takes in the existing streetscapes.

2.4.2 Mitigation measures

The amount of land taken for the proposed scheme has been minimised as much as possible and areas of land-take have been carefully chosen so as to try to minimise the level of impact that occurs.

In cases where land that has to be taken on a temporary basis, existing landuses will be maintained where possible and the land will be reinstated and returned to its original use as quickly as possible. Measures are to be taken where possible to ensure that open spaces remain easily accessible through the provision of, for example, adequate gating, redirected footpaths, pedestrian crossings and agricultural access routes.
Road diversions and other traffic management mechanisms are to put in place before roads are closed to minimise severance impacts. Temporary road closures and diversions will be minimised, in number and duration, wherever possible.

In some locations, hoarding and other mechanisms will be used to ensure that the boundary of land-take is clearly demarcated so as to minimise the potential for 'drift' of the sites and impacts on adjacent landuses. The hoarding will be used to provide public information about the proposed scheme and alternative access arrangements to local businesses and facilities. Landscaping of areas will be designed so as to complement the surrounding landuses. A more detailed specific description of the mitigation measures to be put in place at each location is provided in Table 2.4 and Table 2.5.

2.4.3 Assessment of residual impacts

2.4.3.1 Project scenario: construction phase

Temporary land-take
All the temporary land-take within Area MN107 will be associated with the construction of stops. At the location of the Parnell Square Stop there will be temporary land-take for a period of more than 1 year of approximately 0.3ha. This land-take will mostly consist of land within the existing streetscape, but will also include a small amount of temporary land-take from the Rotunda Hospital and the Garden of Remembrance. The temporary land-take will be for a period of more than one year and the area in which it will be located has a rating of very high functional value. Due to the fact that the temporary land-take will mostly be in the existing streetscapes and will be for a period of more than 1 year the significance of the impact post mitigation is Medium. There will be impacts on traffic as a result of the temporary land-take; these are detailed further in the Traffic chapter of this EIS (Volume 2, Chapter 7).

There will be temporary land-take from Westmoreland Street in order to facilitate the construction of the O'Connell Bridge Stop. The temporary land-take will be approximately 0.2ha in area. This temporary impact will have a large impact on traffic and various mitigation measures will be introduced to minimise the impact. The area in which the temporary land-take will occur is rated as high functional value and the temporary land-take will be for a period more than 1 year. However, because the land-take is in the existing streetscape the significance of the impact post mitigation is Low.

There will be a temporary land-take of High significance in St. Stephen's Green. The area in which St. Stephen's Green is located is rated as very high functional value and the temporary land-take will be for a period of more than 1 year. St. Stephen's Green is classified as an Open Space and Recreational landuse. The temporary removal of a portion of this amenity from a city centre location will have a significant impact on the users of the park. St. Stephen's Green is an important city centre open space that is intensively used by the public. The temporary land-take, which will be a construction compound and the location from which the Tunnel Boring Machines will be extracted, extends over approximately 0.2ha. The remaining areas of the park will be maintained as open space. Some lands, within the existing streetscape, surrounding St. Stephen's Green will also form part of the temporary land-take. The area of the temporary land-take will be reinstated as open space post construction. The post mitigation impact significance of this temporary land-take is High.

The locations of the temporary land-take are illustrated on maps (Landuse Impact) included in Volume 3, Book 1 of 2.

Temporary severance
There will be no temporary severance in Area MN107 as a result of the construction of the proposed scheme. At Parnell Square, there will be temporary inconveniences to traffic. Similarly, on O'Connell Street, Burgh Quay, D'Olier Street and Westmoreland Street as well as all other streets within the immediate vicinity, there will be disruptions to traffic as a result of the construction of the O'Connell Bridge Stop. A complete list of streets affected is included the Traffic chapter of this EIS (Volume 2, Chapter 7).

2.4.3.2 Project scenario: operational phase

Permanent land-take
Within Area MN107 all the permanent surface level land-take is associated with the stop features above ground. At Parnell Square there will be permanent land-take in the existing streetscape. Due to the fact that the permanent land-take is in the existing streetscape the significance of the impact is Low. It will not cause any severance but there will be permanent features on lands within the Rotunda Hospital grounds and on open space lands adjacent to the Garden of Remembrance.

The permanent land-take associated with the above ground features of O'Connell Bridge Stop will be of Low impact significance because it also will not cause severance and will not adversely impact on adjacent landuses. The above ground features of the O'Connell Bridge Stop include stop entrances, emergency exhaust vents, passenger lifts and emergency escape stairs.

The permanent land-take associated with St. Stephen's Green Stop also includes stop entrances, passenger lifts, emergency escape stairs, exhaust vents, etc. St. Stephen's Green is located in an area of very high functional value. The permanent land-take will be from land that has been classified as open space and recreation as well as land in the existing streetscape. The permanent land-take and above ground features of the St. Stephen's Green Stop will be sensitively designed and in keeping with the environment of St. Stephen's Green and have thus been ascribed a Low impact significance.

Throughout Area MN107 there will be substratum permanent land-take to accommodate the tunnels beneath the surface. This land-take will have no impact on the existing surrounding landuses, but will limit the future landuses directly above it. The significance of this impact is determined to be Low due to the fact that the substratum permanent land-take will have no impact on surface landuses.

The locations of the permanent land-take are illustrated on maps (Landuse Impact) included in Volume 3, Book 1 of 2.

Permanent severance

There will be no permanent severance in Area MN107 as a result of the operation of the scheme.

Table 2.4 Summary of predicted impacts in Area MN107 occurring during the construction phase

Impact ID	Location	Source of impact	Impact description	Functional Value (FV) of affected area	Mitigation measure	Post mitigation: Magnitude	Post mitigation: Significance
MN107/ CN-01	LA 25 Phibsborough and Mountjoy residential areas, Mater Hospital and Parnell Square on lands classified as Open Space and Recreational and Educational/ Institutional/ Community/ Civic and lands in the existing streetscapes	Land surrounding Parnell Square Stop and stop box compound 17	- Temporary land-take of more than 1 year from Open Space and Recreational, Educational/ Institutional/ Community/Civic lands and lands in the existing streetscapes. - The area of this construction compound will be approximately 0.3ha, the majority of which will be in the existing streetscapes. - Land surrounding the Parnell Square Stop will be temporarily used for the construction of the Parnell Square Stop. It will require re-diverting of some traffic.	very high	- As little land as possible will be temporarily taken. The land will be returned to its original use as quickly as possible. - Roadways, cycleways and footpaths will be diverted and/or re-provided wherever possible.	medium	Medium

Impact ID	Location	Source of impact	Impact description	Functional Value (FV) of affected area	Mitigation measure	Post mitigation	
						Magnitude	Significance
MN107/ CN-02	LA 26 O'Connell Street to College Street on lands in the existing streetscapes	Land surrounding O'Connell Bridge Stop and stop box compound 18.	- Temporary land-take of more than 1 year from lands in the existing streetscapes. - The area of this construction compound will be approximately 0.2ha, which will be completely in the existing streetscapes. - Land surrounding the O'Connell Bridge Stop will be temporarily used for the construction of the O'Connell Bridge Stop. It will require re-diverting of traffic.	high	- As little land as possible will be temporarily taken. The land will be returned to its original use as quickly as possible. - Roadways, cycleways and footpaths will be diverted and/or re-provided wherever possible.	low	Low
MN107/ CN-03	LA 35 St. Stephen's Green on lands classified as Open Space and Recreational	Construction compound 19 and land surrounding St. Stephen's Green Stop	- Temporary land-take for more than 1 year of Open Space and Recreational uses lands. - The area of this construction compound will be approximately 1.9ha. - Lands within and surrounding St. Stephen's Green will be temporarily used for the construction of the St. Stephen's Green Stop. - The total area of St. Stephen's Green is approximately 9ha.	very high	- As little land as possible will be temporarily taken. The land will be returned to its original use as quickly as possible. - The remaining areas of St. Stephen's Green will be kept open to cater for park users. - Information will be made available about nearby alternative open spaces.	high	High

Table 2.5 Summary of predicted impacts in Area MN107 occurring during the operational phase

Impact ID	Location	Source of impact	Impact description	Functional Value (FV) of affected area	Mitigation measure	Post mitigation Magnitude	Post mitigation Significance
MN107/ OP-01	LA 25 Phibsborough and Mountjoy residential areas, Mater Hospital and Parnell Square on lands classified as Residential Areas, Residential with Mixed Uses (Commercial/ Retail/Office) Educational, Institutional/ Community/ Civic and lands in the existing streetscape	Tunnel constructed by TBM	- Permanent land-take from Residential Areas, Residential with Mixed Uses (Commercial/Retail/ Office) Educational, Institutional/ Community/Civic and lands in the existing streetscape. - There will be substratum permanent land-take beneath the surface. This will have no impact on the existing surrounding landuses, but limits the future landuses above it.	very high	- As little land as possible will be taken. - The tunnel will be constructed at such a depth so that it will not impact on the current surface level landuses.	low	Low
MN107/ OP-02	LA 25 Phibsborough and Mountjoy residential areas, Mater Hospital and Parnell Square on lands classified as Open Space and Recreational, Educational/ Institutional/ Community/ Civic and lands in existing streetscape	Parnell Square Stop buildings, vents, emergency exhaust vents and maintenance access stairs	- Permanent land-take from Open Space and Recreational, Educational/ Institutional/ Community/Civic lands and lands in the existing streetscapes. - There will be minimum amount of permanent land-take attributable to the surface buildings/features of Parnell Square Stop.	very high	- As little land as possible will be taken. - The above ground stop features will be finished to a high quality and will be designed to fit in with the existing built environment.	low	Low

Impact ID	Location	Source of impact	Impact description	Functional Value (FV) of affected area	Mitigation measure	Post mitigation Magnitude	Post mitigation Significance
MN107/ OP-03	LA 26 O'Connell Street to College Street on lands in existing streetscape	O'Connell Bridge Stop buildings, emergency exhaust vents, equipment hatch to Luas sub-stations, emergency tunnel exhaust vents, vents, hatch to plant room, stop entrances, access hatch, ESB sub-station, emergency tunnel escape stairs, passenger lifts, emergency escape stairs and lifts	- Permanent land-take from lands in the existing streetscapes. - There will be minimum amount of permanent land-take attributable to the surface features of O'Connell Bridge Stop.	high	- As little land as possible will be taken. - The above ground stop features will be finished to a high quality and will be designed to fit in with the existing built environment.	low	Low
MN107/ OP-04	LA 26 O'Connell Street to College Street on lands classified as Commercial/ Retail/Business, Residential with Mixed Uses (Commercial/ Retail/Office) and lands in the existing streetscapes	Tunnel constructed by TBM	- Permanent land-take from Commercial/ Retail/Business, Residential with Mixed Uses (Commercial/ Retail/Office) and lands in the existing streetscapes. - There will be substratum permanent land-take beneath the surface. This will have no impact on the existing surrounding landuses, but limits the future landuses above it.	high	- As little land as possible will be taken. - The tunnel will be constructed at such a depth so that it will not impact on the current surface level landuses.	low	Low
MN107/ OP-05	LA 33 Grafton Street and environs on lands classified as Commercial/ Retail/Business and lands in the existing streetscapes	Tunnel constructed by TBM	- Permanent land-take from Commercial/ Retail/Business and lands in the existing streetscapes. - There will be substratum permanent land-take beneath the surface. This will have no impact on the existing surrounding landuses but limits the future landuses above it.	high	- As little land as possible will be taken. - The tunnel will be constructed at such a depth so that it will not impact on the current surface level landuses.	low	Low

Impact ID	Location	Source of impact	Impact description	Functional Value (FV) of affected area	Mitigation measure	Post mitigation Magnitude	Post mitigation Significance
MN107/ OP-06	LA 35 St. Stephen's Green on lands classified as Open Space and Recreational uses	St. Stephen's Green Stop buildings, stop entrances, passenger lifts, emergency escape stairs and lifts, vents and maintenance stairs, exhaust vents, and light wells on pond island	- Permanent land-take from Open Spaces and Recreational and lands in the existing streetscapes. - There will be minimum amount of permanent land-take attributable to the surface features of St. Stephen's Green Stop.	very high	- As little land as possible will be taken. - The above ground stop features will be finished to a high quality and will be designed to fit in with the existing built environment. - As much natural vegetation will be maintained and reinstated in order to return the environment to a city centre park. - Features removed from the park to facilitate the construction phase will be returned as soon as practical.	low	Low
MN107/ OP-07	LA 35 St. Stephen's Green on lands classified as Open Space and Recreational uses and lands in the existing streetscapes	Tunnel constructed by TBM	- Permanent land-take from Open Space and Recreational uses and lands in the existing streetscapes. - There will be substratum permanent land-take beneath the surface. This will have no impact on the existing surrounding landuses, but limits the future landuses above it.	very high	- As little land as possible will be taken. - The tunnel will be constructed at such a depth so that it will not impact on the current surface level landuses.	low	Low

03 HUMAN BEINGS: SOCIO-ECONOMICS

This chapter of the EIS evaluates the potential socio-economics impacts arising from the construction and operation of the proposed scheme in Area MN107.

This chapter of the EIS evaluates the potential socio-economics impacts arising from the construction and operation of the proposed scheme in Area MN107.

The socio-economic assessment will examine the potential impacts on:

- Demography;
- Unemployment;
- Employment classification;
- Travel to work data and commuting;
- Economic benefits and employment creation.

3.1 IMPACT ASSESSMENT METHODOLOGY

The impact assessment methodology in this chapter is set out in a number of steps:

- Impact identification
- Impact assessment
- Derivation of mitigation measures
- Assessment of residual impacts

3.1.1 Study area

The study area for this assessment is set out in Table 3.1.

Table 3.1 Study area

Criteria	Width of study area (on both sides of the alignment)
General/scheme-wide impacts	Greater Dublin Area and the Irish State
Localised impacts	Electoral Districts (EDs) in Area MN107 which are within 500m of the alignment

3.1.2 Impact identification

3.1.2.1 General/scheme-wide impacts

These impacts address the overall or 'global' socio-economic impacts of the scheme and will focus on Metro North as a piece of transport infrastructure. This section will examine the scheme-wide positive and negative impacts of the construction and operation of the scheme, which include the cumulative impacts of relevant localised impacts.

3.1.2.2 Localised (MN107) impacts

These impacts will focus on the location of key construction activities along the alignment. The construction methodology will also be of direct interest.

Localised impacts will also focus on the potential impacts which may arise from the operation of the scheme.

EDs of particular interest (e.g. those with higher than average unemployment rate or those with a higher than average car ownership rate) will also be highlighted.

3.1.3 Impact assessment

3.1.3.1 Magnitude

The criteria used to assess the different impacts associated with this scheme are shown in Table 3.2.

Table 3.2 Criteria for assessment of impact magnitude

Criteria	Impact magnitude
- Long-term (15+ years) and/or substantial change in population levels, employment, employment classification or mode of travel to work (i.e. reduced congestion and commuting delays). - Long-term economic disruption to residents, businesses and commuters from construction activities. - Substantial improvements in quality of life due to significantly reduced commuting times, improved commuting experience and reliability of service.	very high
- Long-term and significant change in population levels, employment, employment classification or mode of travel to work. - Short-term (1 - 5 years) economic disruption to residents, businesses and commuters from surface-construction activities. - Significant improvements in quality of life due to reduced commuting times, improved commuting experience and reliability of service.	high
- Long-term and moderate change in population levels, employment, employment classification or mode of travel to work. - Short-term and substantial change in population levels, employment, employment classification or mode of travel to work. - Temporary (less than 1 year) economic disruption to residents, businesses and commuters from surface-construction activities. - Moderate improvements in quality of life due to reduced commuting times, improved commuting experience and reliability of service.	medium
- Long-term and minor change in population levels, employment, employment classification or mode of travel to work. - Short-term and significant change in population levels, employment, employment classification or mode of travel to work. - Minor improvements in quality of life due to reduced commuting times, improved commuting experience and reliability of service.	low
- Long-term and insignificant change in population levels, employment, employment classification or mode of travel to work.	very low

3.1.3.2 Significance

The matrix used to define the significance of impacts is shown in Table 3.3.

All socio-economic receptors along the alignment have been classified as having a very high functional value. Socio-economic receptors in this case refer to the key socio-economic factors and data sets (employment level, demographics etc.).

Table 3.3 Criteria for assessment of impact significance

		Magnitude of impact				
		very low	low	medium	high	very high
Functional value of affected receptor	very high	Not significant	Low significance	Medium significance	High significance	Very high significance

3.1.4 Derivation of mitigation measures

Mitigation measures are only defined by any impacts that are deemed to be of Medium significance, and greater, in Table 3.3. The extent to which mitigation is needed increases as the significance of the impact increases. The logical basis for providing mitigation for impacts of Medium significance and above is that such measures should only be focused on significant environmental effects of the scheme.

3.1.5 Assessment of residual impacts

Residual impacts that will persist after mitigation measures have been put in place are summarised in Table 3.7.

3.2 IMPACT ASSESSMENT

3.2.1 Project scenario: construction phase

3.2.1.1 General/scheme-wide impacts

Direct economic impacts

The economic expenditure of construction workers' wages will result in a considerable portion of this expenditure being spent in the regional economy of the Greater Dublin Region over the approximate 5 year construction period, thereby resulting in indirect/secondary economic benefits. The estimated level of average direct employment during the 5 year construction programme is approximately 3,100. Table 3.4 provides a breakdown of this estimated level of employment during construction.

Table 3.4 Average construction employment for Metro North

Construction Year	Average direct construction employment
1	4,000
2	4,000
3	3,500
4	2,500
5	1,500
Annual average	3,100

Although the direct employment is short-term (approximately 5 years), it is possible to equate this short-term employment to a level of permanent employment. The EIS for Crossrail (a major rail scheme in London which consists of a twin-bore tunnel on a west-east alignment under central London and the upgrading of existing National Rail lines to the east and west of central London) uses an employment multiplier of 10 employment years during construction as being the equivalent of one permanent job. Using this employment ratio, the equivalent level of permanent employment/full-time employment (FTE) is provided in Table 3.5. In total, the full time equivalent direct employment (FTE) generated by the construction phase is 1,550 jobs.

Table 3.5 Permanent- equivalent level of construction employment

Construction Year	Person years equivalent	Permanent years employment equivalent
1	4,000	400
2	4,000	400
3	3,500	350
4	2,500	250
5	1,500	150

It is likely that the majority of the construction workforce will be resident in the Greater Dublin Area, given the fact that this is where the majority of construction workers resided during the recent period of high-levels of construction activity in Greater Dublin.

However, there has been a reduction in levels of activity in the construction sector in the start of 2007 and the fall-off in construction activity has accelerated since late 2007 and is currently continuing. The Quarterly National Household Survey (CSO, 5th March 2008) notes that construction employment in Q4 (Sept. – Nov. '07) fell by 5,600 (-2.0%) and that the overall decrease in construction employment fell by 15,200 during 2007, and stood at 279,000 at the end of November 2007. Provisional 2008 data has indicated ongoing significant falls in construction-related employment in Ireland and a rise in overall unemployment. In the context of the significant fall construction-related employment (and rising overall unemployment), and given the fact that the Greater Dublin Area is the largest urbanised area of Ireland, it is likely that the majority of construction workers will be sourced from the Greater Dublin Area.

Overall it is likely that there will be more than sufficient capacity in the construction sector of the Greater Dublin Area to build the proposed scheme and the construction of the proposed scheme will not result in displacement of construction employees away from other large-scale infrastructural projects. Thus, the proposed scheme will not delay or impede the development of other strategic infrastructure projects in the Greater Dublin Area.

Overall, the proposed scheme will result in positive impacts due to direct employment creation and this is a positive impact of very low magnitude and Very low significance.

Indirect socio-economic impacts

Particular sectors of the regional economy (i.e. the economy of the GDA of Dublin, Wicklow, Kildare and Louth) are also likely to benefit are those in construction (and related industries) and the material supplying industry (steel, concrete etc.). There will also be secondary/spin off impacts due to expenditure of wages and salaries in the local economy by the construction workforce. These sectors are likely to include accommodation (e.g. B&Bs) and daily subsistence (e.g. lunch and evening meals) providers. The assessment of socio-economic effects in the Crossrail EIS assumed an employment multiplier of 1.5 (i.e. each permanent job (or equivalent) will generate an additional 0.5 permanent job). The Crossrail EIS multiplier of 1.5 is based on multipliers used in other recent major rail schemes in the UK, such as:

- Thames link 2000: 1.5;
- Channel Tunnel Rail Link: 1.4.

Other construction-related employment multipliers used in recent studies for the Scottish Executive were:

- Manufacture of structural metal products: 1.52;
- Manufacture of other general purpose machinery: 1.51;
- Manufacture of special purpose machinery: 1.63;
- Manufacture of other transport equipment: 1.33;
- Construction: 1.86.

Following a consideration of these comparable multipliers, it was decided that a multiplier of 1.5 was appropriate for the proposed scheme. Table 3.6 contains information regarding indirect employment creation due to the construction of the proposed scheme.

Table 3.6 Permanent- equivalent level of construction employment

Construction Year	Permanent years employment equivalent	Indirect employment creation	Total direct and indirect FTE
1	400	200	600
2	400	200	600
3	350	175	525
4	250	125	375
5	150	75	225

Overall, the construction of the proposed scheme will provide an annual average direct employment of 3,100 for the 5-year construction programme. This equates to 1,550 full-time equivalents, with a further 775 FTE arising as indirect impacts. Overall, the proposed scheme will result in positive impacts due to overall employment creation and this is a positive impact of low magnitude and Low significance.

Impacts due to traffic congestion and diversion
This impact is addressed in theTraffic chapters of this EIS (Volume 2, Chapter 7). However, a brief summary is provided below.

Generally there is an increase in journey times on most of the roads/routes assessed during the five year construction programme. Traffic modelling data (MVA, 2007) indicates that some routes experience significant journey time deterioration, particularly the R132 through Swords, Ballymun Road, N2, Collins Avenue, Church Street and Baggott Street. Overall the impact on journey time can be classified as moderate to significant on the routes assessed.

Traffic modelling results have shown that traffic speeds across the GDA will decrease by over 11%, or drop by $3kmh^{-1}$. This represents a situation where traffic movement for all modes will be very difficult with significant delays at key areas. Drivers will travel further distances to avoid construction areas compounding the congestion levels on other parallel routes and affecting the operation of buses through the city. Other traffic modelling statistics such as impact on bus speeds and journey time on key routes further demonstrate the significance of the construction impact. All of this means that there will be negative socio-economic impacts on the Greater Dublin Area's commuters and freight movements. These negative impacts are of medium to high magnitude and Medium to High significance, since the duration of these impacts ranges from temporary to short-term.

Localised socio-economic impacts
The localised socio-economic impacts will be a consequence of the landuse impacts (MN101 to MN107) and are addressed in the Landuse chapters of this EIS (Volume 2, Chapter 2). Similarly localised traffic disruption during construction is addressed in the Traffic chapters of this EIS (Volume 2, Chapter 7).

3.2.2 Project scenario: operational phase

3.2.2.1 General/scheme-wide impacts

Facilitating future development and employment creation
Overall the proposed scheme will facilitate a significant amount of future development along the whole alignment and across the wider northern part of the Greater Dublin Area. While the proposed scheme will not directly result in additional development in the proximity of the alignment the proposed scheme will, indirectly, allow the relevant planning authorities to plan for and grant consent for additional development at key locations.

Essentially, the proposed scheme will permit higher residential densities (planning policy in Dublin City and Fingal County Councils envisage higher-density development along key transport corridors and close to key transport nodes) thereby maximising the transport and socio-economic benefits of the scheme (Department of the Environment. Heritage and Local Government, 2008). The basis for higher density zoning adjacent to key transport corridors is that this will provide a realistic and attractive alternative to private-car based commuting, thereby resulting in great use of public transport (the proposed scheme in this case) with corresponding reductions in journey time and greater access to employment and other key destinations.

Fingal County Council commissioned a report titled 'Economic Development Strategy for the Metro North Economic Corridor (MNEC)' (Indecon International Economic Consultants, 2008) which outlines a long-term development strategy for a period up to 2025/2030. The Strategy has assumed that the MNEC is a 1km corridor on either side of the alignment of the proposed scheme (which corresponds to the width of Fingal County Council's Metro North Development Contributions Scheme) and extends from the terminus of the scheme in the townland of Belinstown to the Fingal County Council-Dublin City Council administrative boundary in the Santry area.

In summary, this Strategy envisages an increase in the MNEC population from 59,000 (2006 data) to 128,100 by the period 2025/2030. This represents an increase in residents within this 2km-wide corridor of 69,100, an increase of over 117% over 2006 levels. The basis for this proposed increase in MNEC population is that the attractiveness of the MNEC which will be greatly enhanced by the transport advantages provided by the proposed scheme.

The Strategy recommends that three specific locations within the MNEC be the focus of the majority of overall new development and growth. These three areas are: Swords-Lissenhall, Dublin airport (Eastlands) and Metropark. The proposed scheme is the key piece of infrastructure which will facilitate the implementation of the Indecon Strategy. Without Metro North many of the elements outlined in the Strategy will not arise. It should be noted that the various targets in the Strategy are acknowledged by Indecon as being ambitious and that they 'will be a major challenge and will require innovative policy initiatives' to ensure its implementation.

The overall objectives of the MNEC Strategy have been adopted by Fingal County Council and it is their intention to prepare a number of variations to the Fingal County Development Plan to facilitate implementing the MNEC Strategy. In May 2008, Fingal County Council published a document titled 'Your Swords: An Emerging City – Strategic Vision 2035'. This states (p.15) that 'the identification and promotion of Metro Economic Corridor(s) will be of strategic importance to the economy and well-being of the county's residential and business/ employment population'. Fingal County Council also intends to prepare additional planning policy documentation to support the implementation of the MNEC Strategy as required in future years.

Dublin City Council also sees Metro North as facilitating future development activity in their administrative area. However, those parts of Dublin City serviced by the scheme are different to the areas served in Fingal. In Dublin City Council's area, adjoining lands are predominantly already developed; whereas in Fingal, significant undeveloped sites existing, and it is these locations where the large quantum of future development (as envisaged in the MNEC) is likely to arise.

The proposed scheme will assist Dublin City Council with its development aspirations and objectives at key locations such as Ballymun (currently the focus of one of Europe's largest regeneration projects) and the north inner city. It will also assist with the implementation of the Phibsborough/Mountjoy Local Area Plan – which specifically refers to Metro North and the role it will play on future development patterns and landuses.

In conclusion, the proposed scheme is essential to the planning and development aspiration of both Dublin City Council and Fingal County Council and this is strongly reflected in both of their respective development and planning policies. The proposed scheme will facilitate and greatly assist future and more sustainable development pattern in future years and this is a positive impact of high magnitude and High significance.

The proposed scheme will also result in positive development and economic impacts for the Greater Dublin Area and beyond, through creating a positive image of the city – both for national and international markets – and result in wider economic benefits through assisting people move through and around the Greater Dublin Area. A report ('What Light Rail Can Do For Cities - A review of the evidence, prepared by Steer Davies Gleave, February 2005) for pteg (Passenger Transport Executive Group, based in the UK) noted that:

'there is real evidence that UK light rail schemes have provided business with better access for customers; giving better access to labour markets, supporting business expansion and providing the confidence to make investment decisions based on the evident commitment to improved public transport. Increased development activity has brought a 'buzz' to areas served by the tram schemes.'

DTO commissioned a study which surveyed household's attitudes to the Luas service (Millward Brown IMS, 2006). The survey was published in November 2006, over two years after the Luas service was introduced. The key findings of the survey were:

- Luas has contributed to people's overall satisfaction within their local area, with higher satisfaction levels in both Luas catchments.
- Luas is widely seen as a quicker way to travel than the car and, in particular, the bus. Many Luas users who have cars still opt for the Luas as the service offers speed and reliability (although the survey did highlight that there was a portion of car-users who were not willing to ‚give-up' car-based travel in favour of the Luas).
- Luas has contributed to increased shopping and employment opportunities. Luas also generated incremental shopping trips (i.e. shopping-related trips that would not normally have been made in the absence of Luas). This finding is also reported in another economic paper (Graham, 2003).

In 2006, the DTO commissioned another study ('LUAS 'After' Study: Employers & Retailers, Dublin Transportation Office: prepared by Millward Brown IMS, 2006) November 2006') which examined a range of public attitudes to the Luas light rail system. The study was undertaken from April to May 2006, approximately two years after the service was operational. The study had a number of key findings:

- Positive impact of the Luas on ease of travel around Dublin is widely acknowledged.
- The problem of staff punctuality as a result of inadequate public transport has been eased, in both the Red and Green line catchments.
- One in every four businesses, overall, and three in every ten located in the Luas catchments, believe Luas has been advantageous for their business. Businesses in the Green Line catchment are the most positive. Green Line businesses noted that improved staff access to work was the main advantage while Red Line businesses noted easier and better access for customers and clients.
- Significant satisfaction with improved access to and from the city centre.

Overall, the proposed scheme is likely to result in positive direct and indirect economic benefits for Dublin city, the Greater Dublin Region and the Irish economy through increasing accessibility to the city centre as well as induced/secondary/incremental economic and employment opportunities. However, it is noted by the pteg report that while it is difficult to quantify the wider economic impacts of rail schemes, 'there is clear empirical evidence of positive effects that light rail has had on the cities where it has been implemented in the UK'.

The proposed scheme will also go some way to reducing the wider costs of congestion and delays in commuting to work. The negative impacts of congestion to Dublin's (and thus, Ireland's) economy are significant: Dublin Chamber of Commerce estimates that 'the cost of congestion to the Greater Dublin Area in 2005 was €2.5bn' (Dublin Chamber of Commerce, 2005).

Overall, the proposed scheme will result in a positive impact to the wider economy in terms of development and reduced congestion of high magnitude, which is of High significance.

Improving accessibility to increased employment opportunities

Fingal County Council's MNEC Strategy will, through the Council's various planning policy documents, facilitate the creation of 37,000 additional jobs in the MNEC, up to the period 2025/2030. This represents an increase of 79% over the level of 2006 employment in the MNEC (which stands at 29,600 jobs). Additionally, the MNEC will have a resident population in excess of 128,000 and over 60% of these people will also work in the MNEC.

The Strategy envisages that most of these additional jobs will be within the services sector and target industries include corporate head offices, IT services, financial and business services, science and technology projects and environmental products and services. The strengths of MNEC, sourced from the MNEC Report, are:

- A high employment rate;
- A low dependency rate (i.e. retired, unable to work etc.);
- Large proportion of young population (25-44 age group);
- High educational attainment;
- Close proximity to Dublin Airport;
- Access to national and international markets via the national road network;
- Proximity to major seaports, including Dublin Port and the proposed Bremore Port;
- Existing base of foreign and indigenous firms;
- Access to major 3rd & 4th-level institutions in the Dublin area;
- A high quality of life.

The MNEC Strategy predicts that the majority of these jobs will be highly skilled in the Market Services sector (76%: 28,200 additional jobs), followed by Non-Market Services (13%: 4,900) and Industrial jobs (11%: 3,900). Market Services jobs will entail financial and other international services, transport and communications services, and distribution. Industrial jobs comprise manufacturing, utilities and building. The principal future employment areas will be: Swords-Lissenhall, Dublin airport (Eastlands) and Metropark.

In Dublin City Council, the proposed scheme will result in the creation of new employment opportunities, although not to the same extent as the potential additional employment creation in Fingal County Council. Additional employment creation is likely to be focused at Ballymun (as part of the ongoing regeneration) and in the suburban retail and office concentrations, such as Drumcondra and Phibsborough.

Overall, the proposed scheme will assist with the creation of major employment opportunities in the long-term and this is a positive impact of high magnitude and High significance.

Improving accessibility to community and social facilities
The proposed scheme will provide high-quality and frequent access to community and social facilities, such as typical city and town centre facilities (e.g. banking, post-offices, public sector services, retail, financial and professional services, medical and dental services and educational facilities). Examples of the key locations to which access will be provided include: Swords town centre, Airside Retail Park, Dublin Airport, Metropark, Ballymun Town Centre, Dublin City University, Mater Hospital, Drumcondra, Trinity College, Dublin city centre and Dublin Docklands. Additionally, access will be provided Dublin's wider rail and Luas network, thus opening up similar facilities all over the Greater Dublin Area, such as Dublin Docklands, Harcourt street business area, Dundrum Town Centre, Sandyford Industrial Estate, Heuston Station, Connolly Station and Tallaght Town Centre.

Overall, the proposed scheme will result in positive impacts with respect to access to the key social and community facilities in Dublin and this is a positive impact of high magnitude and High significance.

Assisting regeneration and social-improvement activities
The proposed scheme will greatly assist with the many ongoing regeneration initiatives in proximity the scheme's alignment. The largest regeneration project is Ballymun and this is being managed by Ballymun Regeneration Ltd, a company set up by Dublin City Council to oversee the overall project. The proposed scheme will greatly assist with all of the regeneration and renewal objectives for this area of Dublin which has suffered socially challenging conditions for generations. The proposed scheme will provide the resident population (significant percentages of who are unemployed and with minimal educational qualifications) with direct, high-frequency and regular transport options to the key employment and other landuse areas of the Greater Dublin Area, thereby assisting with the regeneration objectives. The proposed scheme will also greatly assist the development of Ballymun Town Centre through providing direct, high-frequency and regular transport connectivity to the planning and future employment opportunities and town centre landuses. Thus, Ballymun will become a key town centre, underpinning the future vitality and community of Ballymun.

The proposed scheme will also assist with other regeneration and social-improvement programmes. In total, there are five designated RAPID areas, four Integrated Action Plans (under the Urban Renewal Scheme), 16 primary schools and three post-primary schools in the Department of Education and Science's social inclusion programme, 'Delivering Equality of Opportunity in Schools' (DEIS). Many of these are located within the study area, as described in the Baseline Socio-Economic chapter of this EIS (Volume 1, Chapter 11).

Overall, the proposed scheme will greatly assist with current and future regeneration programmes, a positive impact of high magnitude and High significance.

Improved access to employment through commuting improvements
Metro North will deliver a fast, reliable, regular and efficient transport option through the north of Dublin city and on to Dublin Airport beyond Swords. The journey time from Dublin Airport to the city centre (St. Stephens Green) is estimated at approximately 20 minutes and the journey from city centre to the terminus north of Swords is estimated to be approximately 30 - 35 minutes. Annual patronage (total journeys) is estimate to be 34 million, in excess of an average of 94,000 journeys per day. The initial peak service (broadly 0700 – 1000 and 1530 – 1930) is expected to be a 90m LMV every four minutes, providing capacity for 10,000 passengers per direction per hour. The off-peak service will be less frequent and possibly with shorter vehicles (45m). Metro North has been specified to be capable of carrying 20,000 passengers per direction per hour, with LMVs up to 90m long running at frequencies up to every two minutes. The capacity specified is around four times the forecast peak demand on the line when it is expected to open in 2014, and around seven times the current peak demand on the Luas Green line.

In comparison to the other public transport option, which is primarily bus along the alignment, Metro North will provide substantial improvement in journey frequency and times. Currently, a sample bus journey from Swords to the city centre (bus number 41) takes approximately 75 minutes, with four such services per hour. This is predicted to increase to approximately 91 minutes in 2014 and 100.4 minutes in 2029, all without Metro North. When operational in 2014, Metro North will provide an average journey time of approximately 30 minutes with up to 15 services per hour during peak periods. In comparison to the current level of bus service, this represents a substantial improvement in the peak commuting journey times. Such bus versus Metro North journey time savings exist along the whole scheme.

Regarding improvements to car-based journeys, Metro North will positively impact on these, thus providing these car-based commuters with reduced journey times and improved quality of life (e.g. shorter and less-stressful commutes). The modal shift from car to Metro improves the average speed across the GDA by $2kmh^{-1}$ and $3kmh^{-1}$ in 2014 and 2029 respectively. Time spent queuing decreases, distance travelled decreases and also time spent travelling decreases. Journey time assessments (MVA, 2007) on key routes further demonstrate the positive nature of the impact as the majority in both 2014 and 2029 show decreases. In both operational years 2014 and 2029 there is a general reduction in journey times on most of the routes assessed.

Journey time reductions of note include on the R132, Ballymun Road, M1, N2, Collins Ave and Santry Avenue. There is a decrease in journey time of 19.8% on the R132 Northbound from the city centre to the airport. There is a decrease in journey time of 17.2% using the Port tunnel Northbound. There is a decrease in journey time of 14.3% using the South Quays – Georges Quay to O'Connell Bridge. There is a reduction on all routes on M1 and N2 north bound and southbound from Dublin city centre to Swords and on the M50 in both directions. The most significant increase in journey time is anticipated to be 8.9% on the North Quays – from Heuston to O'Connell Bridge. However the majority of journey times are reduced along the routes. The journey time assessment for the operational years illustrates the significance of the positive impact that the proposed scheme will have on traffic movement particularly in the vicinity of the alignment.

The result of the proposed scheme is that it will provide a significant improvement to transport options and accessibility to a large portion of the population along the alignment. The net result of the proposed scheme is that the quality of life for a large portion of the residents living along the commuting corridor of the proposed scheme will be significantly improved due to significantly reduced journey times, improved journey reliability, frequency, comfort and safety. This represents a positive impact of very high magnitude and Very high significance.

With the provision of three Park & Ride sites as part of the proposed scheme, improvements to the many commuters' quality of life will be extended to commuters living in the towns and villages of North County Dublin and Counties Louth, Meath and Longford (i.e. long-distance commuters). The current prevalence of long-distance commuting in the 'outer' counties of the Greater Dublin Area (and beyond) can be seen in the average distances of journeys travelled to work data from the 2006 Census. For Dublin City, the greatest percentage of journeys travelled (25.03%) is in the 2-4km distance. For Dun-Laoghaire, the greatest journey to work travelled is in the 5-9km category (25.24%). However, significantly fewer percentages of similar (i.e. shorter) journeys are travelled in the outer counties and proportionally a greater volume of longer journeys (15km+) are undertaken instead. For example, in Kildare and Meath, 15.28% and 17.44% respectively of journeys travelled are 25 - 49km, as against an average for Leinster of 7.4% for the same distance of journey.

While the proposed scheme will not reduce the commuting distances, it will reduce the commuting time and provide a more regular and improved commuting journey, resulting in an overall improvement to many long-distance commuters' quality of life. Overall, the proposed scheme will result in a positive impact to the quality of life of the commuters along the proposed scheme, and to those from the wider region who will use the Park & Ride sites. This positive impact is of high magnitude and is of High significance.

Direct employment creation

The proposed scheme will generate direct employment opportunities. RPA estimate that a total of 350 people will be required to operate the service in the first nine years of operation, with approximately 220 staff being employed in the operation of the service (vehicle drivers, customer service staff, Park & Ride attendants, station staff, management etc.) and approximately 130 staff being employed in the maintenance of the system and infrastructure.

The level of direct employment will increase in year 10 due to the increased frequency of service and greater capacity on the system. It is estimated that 420 staff will be directly employed for the operation and maintenance of the proposed scheme after year 10.

It is not possible to estimate where future employees will come from. However, it can be assumed that a portion will be from the Metro North catchment area. Given the higher unemployment levels in specific EDs (such as those in Ballymun and the north inner city of Dublin) within the proposed scheme study area, it is likely that employment of residents could be directly boosted in these EDs with some reduction of in unemployment rates.

The creation of this quantum of employment associated with the operation and management of the proposed scheme will also result in indirect socio-economic benefits, through expenditure of salaries by employees of the scheme. Additional job creation will also result. This is difficult to quantify, but it will result in some further socio-economic benefits to the Greater Dublin Area.

It should be noted that these jobs will be new jobs and will not be as a result of displacement of employment from other sectors of public transport. Thus, there will be no impact on existing levels of employment in public transport.

Overall, direct employment from the proposed scheme will result in a positive impact of very low magnitude and, coupled with the very high functional value, this results in a positive impact of Very low significance.

3.2.2.2 Localised (MN107) socio-economic impacts

Facilitating future development

While the proposed scheme will not directly result in increased population levels proximate to the proposed scheme it will, indirectly, allow the relevant planning authorities to plan for and grant consent for higher residential densities of development due to the greater public transport capacities provided by the proposed scheme.

Similar to MN106, MN107 is comparatively developed in comparison to the areas from MN101 to MN105. However, there are some planning documents prepared by Dublin City Council, the implementation of which will be assisted and promoted by the proposed scheme.

Phibsborough/Mountjoy Draft Local Area Plan (LAP) was published by Dublin City Council for public consultation in March 2008. The draft LAP makes reference to potential redevelopment of key sites and these include:

- Mountjoy Prison (once closed);
- Bohemians Football Club at Dalymount Park (once they relocate to the north of the city);
- Former Shandon bakery site at Cross Guns Bridge;
- Smurfit printworks on Botanic Road;
- Proposed develop of the Grangegorman campus (relocation of Dublin Institute of Technology (DIT)).

It should be noted that the closest stops (Mater and Drumcondra) and the alignment of Metro North are not within the boundary of the draft LAP, however, the proposed scheme is seen as an important element of the implementation of the Phibsborough/Mountjoy area in future years. The draft LAP notes (p.40) that:

'The delivery of new commercial and employment floorspace as part of an integrated mixed-use development strategy in the Phibsborough/Mountjoy LAP area will help drive the economic development of the area; reinforce the viability of Metro North; support investment in new retail development, community and social infrastructure; and deliver local employment which is in accordance with the best principles of sustainable development'.

It also notes that:

'The redeveloped Mountjoy Prison site also presents an opportunity for the development of associated ancillary medical, service industry, commercial and office employment floorspace and to create an important economic and employment cluster in the vicinity of the planned Metro North station.'

Thus, the proposed scheme is an important piece of infrastructure for the future planning and development of this part of central Dublin.

Dublin City Council also published a Framework Plan for Parnell Square in February 2005. In summary, this plan proposes a refurbishment and renewal of the urban and streetscape of this historic part of Dublin. The plan is unlikely to result in significant changes in residential populations as this location is dominated by non-residential uses.

In addition to assisting with the implementation of the Phibsborough/Mountjoy Draft Local Area Plan, the proposed scheme will also permit Dublin City Council to grant higher density planning permissions in the vicinity of the proposed scheme. Although much of the existing residential densities are already high in MN107 (and are typically high across much of inner-city Dublin), the proposed scheme is still expected to result in a considerable increase in future development patterns, and thus, future population levels (although this increase will not be as significant as MN101 and MN102).

MN107 consists of a predominately developed part of north Dublin. It is made up of twelve EDs, which are:

- Rotunda A;
- Arran Quay A;
- Mountjoy A;
- Rotunda B;
- Inns Quay C;
- North City;
- North Dock C;
- Mansion House A;
- Royal Exchange A;
- Mansion House B;
- Royal Exchange B;
- St. Kevin's.

Parts of Mountjoy A, Rotunda A and Arran Quay A are located within Area MN106 but they are described in this chapter because the majority of the area of these EDs is in Area MN107. There has been a small change in the population of Area MN107 over the period 2002-2006 (approximately 9%). In total the population of Area MN107 has grown from 35,817 in 2002 to 38,948 in 2006.

Two EDs experienced a reduction in population: Mansion House B (-12.2%) and North City (-1.9%) while the remaining ten had growth in population, the greatest being in Rotunda B (+22.0%), North Dock C (+14.1%) and Mountjoy A (+16.0%). In future years, the proposed scheme will assist with higher levels of population growth and development, primarily through assisting with the implementation of the Phibsborough/Mountjoy Local Area Plan.

Overall the proposed scheme is anticipated to have a positive impact on the future development patterns of MN107 of medium magnitude and Medium significance.

Employment creation

As with the future planning of economic development in Fingal, the proposed scheme will allow Dublin City Council to plan for a significantly greater level of employment along the corridor defined by the scheme. However, the segment of the scheme in the administrative area of Dublin City Council is more developed than the corresponding corridor in Fingal, which currently had large undeveloped areas (which, as noted in the impact assessment chapters for Areas MN101 to MN104 will be subject to future development as part of the Metro North Economic Corridor (MNEC) Strategy). Thus, the quantum of future employment creation to be indirectly created and assisted by the proposed scheme will be lower than the corresponding employment creation in Fingal.

The Phibsborough/Mountjoy Draft Local Area Plan does identify some specific area of future employment creation. The key sites include:

- National Children's Hospital on the Mater Hospital site– 'new employment opportunities';
- Mountjoy Prison – 'development of associated ancillary medical, service industry, commercial and office employment floorspace';
- The planned Mater Stop – 'important economic and employment cluster';
- The Phibsborough Shopping Centre/Dalymount Park site – 'a suitable location for office/ commercial floorspace given the current existence of a large office block on the site and its potential to enhance the economic vitality and viability of Phibsborough Village'

The proposed scheme will also greatly enhance the ongoing regeneration and renewal of the central and northern parts of O'Connell Street, especially the former Carlton Cinema and the Arnotts sites. Both of these development proposals (which have yet to receive planning consent) involve the creation a large-scale, mixed use developments comprising retail, commercial, public open spaces and additional public roads. The proposed scheme will provide direct access to the O'Connell Street area, which is currently a key retail centre of the Greater Dublin Area and will increase in importance in future years with the ongoing renewal and improvements to this key urban area.

While it is difficult to estimate the level of potential employment to be indirectly created within MN107, it is still likely that the positive impact of indirect employment creation will be of medium magnitude and Medium significance in the long-term for MN107.

Improving accessibility to and availability of employment opportunities

The rate of employment in the twelve EDs of MN107 is broadly average when compared to the averages for Dublin City, Greater Dublin Area, and the State. They range from 52.3% (Inns Quay C) to 65.6% (Mansion House B), as against an average in Dublin City Council's functional area of 56.9%, a Greater Dublin Area average of 59.9% and a State average of 57.2%. Unemployment rates are relatively low to average in MN107, ranging from 3.4% (Mansion House B) to 16.2% (Inns Quay C), although some EDs are well above the average for Dublin City Council. Some EDs in MN107 show evidence of particularly challenging socio-economic conditions, such as Mountjoy A and Inns Quay C.

The proposed scheme will improve access to employment opportunities across the Greater Dublin Area (especially the disadvantaged EDs within MN107) and it will also result in significantly positive employment impacts for MN107, through providing a high-quality, rapid and frequent mode of transport to the major employment areas of Dublin, especially for those commuting northwards (to current and future employment locations such as Dublin Airport, Ballymun, Metropark and Swords).

Regarding improving transport options for those with no access to a car, the proposed scheme will provide minor improvements to accessibility of EDs within MN107. However, it should also be noted that these high density areas of Dublin typically have higher percentages than normal level of no car ownership – a reflection of the fact that car parking availability can be limited coupled with the relatively good public transport options and proximity to Dublin City centre. MN107 also shows considerably above average proportion of commuting journeys which are made with non-car modes of transport. This is expected given the proximity of MN107 to the city centre and the relatively good-level of access to public transport options.

The proposed scheme will provide significant improvements regarding commuting times and journey quality for the residential population of MN107 (although it is noted that a lot of residents in this area are likely to walk to work, given their proximity to the city centre). This is evident in comparing comparable bus journeys to that of the proposed route for the proposed scheme. A relevant example for MN107 is the bus journey from Ballymun to the city centre (bus number 13). This currently takes approximately 56 minutes, with four such services per hour. This is predicted to decrease to 54.8 minutes in 2014 but increase to 73.2 minutes in 2029, all without the proposed scheme. When operational in 2014, the proposed scheme will provide an average journey time of approximately 15-18 minutes up to 15 services per hour during peak periods. In comparison to the current level of bus service, this represents a substantial improvement in the peak commuting journey, which is an impact of very high magnitude and Very high significance.

In relation to improving the type of employment opportunities, the proposed scheme will result in greater access to professional and technical employment for the population of MN107, especially the following EDs (which have significantly lower than average professional employment and higher than average unskilled employment): Rotunda A (16.3% professional occupations), Mountjoy A (15.3%), Rotunda B (17.8%) and Inns Quay C (15.9%) - against a Dublin City average of professional occupations of 30.4% and a State average of 32.9%.

Overall, the proposed scheme will increase access to more and better employment opportunities for MN107, a positive impact of very high magnitude and Very high significance.

Improving accessibility to community and social facilities

This section is focusing on the benefits that the proposed scheme will provide in relation to access to community and social facilities, such as typical city and town centre facilities (e.g. banking, post-offices, public sector services, retail, financial and professional services, medical and dental services and educational facilities).

The proposed scheme will provide significantly faster and direct access to some key community and social facilities along the alignment, such as Swords town centre, Airside Retail Park, Dublin Airport, Metropark, Ballymun Town Centre and Dublin City University. Additionally, access will be provided Dublin's wider rail and Luas network, thus opening up similar facilities all over the Greater Dublin Area.

Overall, the proposed scheme will improve access to community services, a positive impact of high magnitude and High significance.

Assisting regeneration and social-improvement activities

Rotunda A, Mountjoy A and North Dock C are included in Dublin City North East Inner City RAPID Area. Inns Quay C is included in Dublin City North West Inner City RAPID Area. Mansion House A, Mansion House B, St. Kevin's, Royal Exchange A and Royal Exchange B are included in Dublin City South East Inner City RAPID Area. Area MN107 also contains the North East Inner City Integrated Action Plan (IAP), O'Connell Street IAP and the HARP IAP (Heritage Area Rejuvenation Project Integrated Area Plan) areas under the Urban Renewal Scheme. Located within Area MN107, within 500m of the alignment, are 4 primary schools and 2 post-primary schools included in the Delivering Equality of Opportunity in School (DEIS) programme. The proposed scheme will greatly assist with these regeneration and social improvement programmes, as well as greatly assisting Dublin City Council in its long term objective of the regeneration of the inner city areas with considerable social issues and disadvantages.

Overall, the proposed scheme will greatly assist with current and future employment development objectives, a positive impact of very high magnitude and Very high significance.

3.3 DERIVATION OF MITIGATION MEASURES

3.3.1 Construction phase

Construction activities within Area MN107 are proposed at Parnell Square, O'Connell Street, Westmoreland Street and St. Stephen's Green environs. As a result there is likely to be disruption to the retail and businesses within these areas. The disruption may take the form of temporary diversion to property/office access, potential nuisance factors associated with the nearby construction activities and potential traffic diversions within these areas. However, access to all businesses will be maintained at all times and all members of the business community around these locations will be kept fully informed of major works and activities. The construction site boundaries will be kept in good, clean condition and appropriate signage will be used to ensure that safe access for residents, shoppers, workers and commuters is maintained to and through the surrounding area. This collaborative community approach will be central to the management of the construction of the proposed scheme.

Appropriate information and management procedures will be introduced before and during the construction phase for the resident, working and visitor populations. This will include traffic management and access measures. A Construction Team representative will be available during the construction phase for consultation with local residents and businesses.

3.3.2 Operational phase

All of the operational impacts are positive and, thus, no mitigation is proposed.

3.4 ASSESSMENT OF RESIDUAL IMPACTS

A summary of the residual impacts associated with the scheme is provided in Table 3.7.

Table 3.7 Summary of residual impacts

	Magnitude of impact taking into account mitigation	Functional value of area affected	Significance of impact
General/scheme-wide impacts: Construction phase			
Direct economic impacts	very low	very high	Very low
Indirect economic impacts	low	very high	Low
Impacts due to traffic congestion and diversion	high	very high	High
General/scheme-wide impacts: Operational phase			
Facilitating future development and employment creation	high	very high	High
Improving accessibility to employment opportunities	high	very high	High
Improving accessibility to community and social facilities	high	very high	High
Assisting regeneration and social-improvement activities	high	very high	High
Improved access to employment through commuting improvements	very high	very high	Very high
Improved commuting journeys for long-distance commuters	high	very high	High
Direct employment creation	very low	very high	Very low
Localised (MN107) impacts: Construction phase			
Refer to respective Landuse and Traffic chapters of this EIS (Volume 2, Chapters 2 and 7 respectively)			
Localised (MN107) impacts: Operational phase			
Facilitating future development	medium	very high	Medium
Employment creation	medium	very high	Medium
Improving accessibility to and availability of employment opportunities	very high	very high	Very high
Improving accessibility to community and social facilities	high	very high	High
Assisting regeneration and social-improvement activities	very high	very high	Very high

04 HUMAN BEINGS: NOISE

This chapter of the EIS evaluates the potential noise impacts arising from the construction and operation of the proposed scheme in Area MN107.

4.1 INTRODUCTION

This chapter of the EIS evaluates the potential noise impacts arising from the construction and operation of the proposed scheme in Area MN107. Groundborne noise and vibration impacts are reported in the Vibration chapter of this EIS (Volume 1, Chapter 5).

4.2 STUDY AREA

The study area for this assessment is defined in the baseline chapter and comprises the nearest noise sensitive receptors to the alignment corridor, construction compounds and adjacent roads where traffic flows may be changed up to 500m from the alignment.

4.3 IMPACT ASSESSMENT METHODOLOGY

The source and type of all potential impacts is described in Section 4.4.1. Mitigation measures to be put in place are defined in Section 4.4.2. The extent to which mitigation is needed increases as the magnitude of the impact increases. Unmitigated impacts and residual (mitigated) impacts are evaluated in Section 4.4.3. Annex C, Noise Assessment Details (Volume 3, Book 2 of 2), provides details of the noise modelling methods and results, including predicted levels of noise without mitigation for both the construction and operational phases.

4.3.1 Prediction of noise magnitude

4.3.1.1 Construction

The magnitude of construction noise impacts is predicted by considering noise emissions data for typical construction equipment based on the expected methods of construction for each phase of work on each worksite. The plant teams used are listed in Section 6 of Annex C Noise Assessment Details (Volume 3, Book 2 of 2). The prediction method follows that recommended in BS 5228 Noise and vibration control on construction and open site, part 1, 2, 3, 1997.

Noise from road traffic

For road traffic noise on the surrounding roads a similar approach to that described for Light Metro Vehicles (LMVs) is used. Significant changes in road traffic noise have been identified by analysis of the available road traffic modeling results. Changes in noise levels have been predicted using CRTN (the Calculation of Road Traffic Noise, (CRTN) (UK DoE, 1988) based on the traffic flows, speeds and percentage of the flow which is Heavy Goods Vehicles (HGVs) in the do minimum and do something scenarios for 2014 (year of opening) and 2029 (operation year). These have then been compared. Also, where junction realignments take place that will bring road elements closer to receptors and will lead to increases in noise these have been calculated. Where an increase is expected, the functional value of the receptor is considered as described in the following section.

4.3.2 Assessment methodology

4.3.2.1 Construction

The predicted levels are compared to the assessment criteria given in Table 4.1. Any predicted noise levels exceeding the criteria given in Table 4.1 at a noise sensitive receptor are deemed to be an impact, unless they occur for very short periods of time. Where exceptions occur in this regard, they are discussed on a case by case basis.

The National Roads Authority (NRA) has published construction noise targets guidelines for L_{Aeq} in 'Guidelines for the Treatment of Noise and Vibration in National Roads Schemes'. The NRA guidelines are based on UK guidance which describes daytime noise levels for rural areas or areas away from major roads.

These criteria are summarised in Table 4.1. As shown in the table, the evening targets are taken as 10 dB lower than the daytime levels based on guidance given in BS5228. The daytime criteria given in Table 4.1 may be appropriate for interurban road schemes undertaken by the NRA, but are not necessarily appropriate for the urban situation through which the majority of the proposed scheme is to be constructed. For the urban area, or near to main roads, the 75 dB value is used, taken directly from the UK guidance and common practice.

In addition, a level of 65 dB is used specifically for schools, again drawn from common practice in the UK for urban developments.

The criteria given in Table 4.1 have been applied to all areas with a functional value of ≥ medium. Areas with a functional value of <medium are not considered to be sensitive to noise.

Table 4.1 Noise criteria during the construction phase (at 1m from the façade)

Period over which criterion applies	Noise Impact Criterion ($L_{Aeq, period}$)
- Monday to Friday: Urban areas or near main roads; Day: 07.00 to 19.00 Rural areas away from main roads Day: 07.00 to 19.00	 75 dB 70 dB
- Monday to Friday: Evening: 19.00 to 22.00	65 dB
- Monday to Friday: Night: 22.00 to 07.00	The higher of 45 dB or the ambient level.
- Saturday: Day: 08.00 to 16.30 (work outside these hours will be subject to Monday to Friday night time noise levels i.e. the higher of 45dB or the ambient level)	65 dB
- Sundays and Bank Holidays: Day: 08.00 to 16.30 (work outside these hours will be subject to Monday to Friday night time noise levels i.e. the higher of 45dB or the ambient level)	60 dB

Table 4.2 defines the impact ratings that are used in this assessment.

Table 4.2 Definition of noise magnitude ratings

Extent of Noise Impact (Exceedance of Assessment Criteria)	Noise Impact Magnitude	Magnitude Rating
>10dB	Severe	very high
5 to 10dB	Substantial	high
3 to 5dB	Moderate	medium
1 to 3dB	Slight	low
<1dB	No Impact	very low

4.3.2.2 Operation

When judging noise impact, the functional value of each receptor is considered. In terms of noise assessment, the functional value relates primarily to the noise sensitivity of the activity taking place in the building. Most receptors will fall into two groups: those that are sensitive at all times to noise and those that are only sensitive during the day. However, there are also receptors that have unique sensitivities. Areas with a functional value of ≥ (III) have been considered. Areas with a functional value of <(III) have not been assessed because they are not considered to be sensitive to noise.

For road traffic the significance of noise impact has been assessed with reference to the change in noise. The magnitude ratings used in the assessment are summarised in Table 4.3. 3dB is generally the smallest change in environmental noise that would be noticeable under typical listening conditions. A change of 10dB is generally considered to be a doubling in loudness.

Table 4.3 Definition of noise magnitude ratings

Extent of Noise Impact (Exceedance of Threshold Criteria or Increase in Baseline Levels When Above Threshold)	Noise Impact Magnitude	Magnitude Rating
>10dB	Severe	very high
5 to 10dB	Substantial	high
3 to 5dB	Moderate	medium
1 to 3dB	Slight	low
<1dB	No Impact	very low

Traffic noise impacts are assessed using this methodology. Noise from fixed plant is considered in the same manner; however, it has been assumed insignificant if noise is less than NC25 inside neighbouring buildings at night (to avoid sleep disturbance) or to not exceed the existing L_{A90} background noise. Noise Criteria (NC) curves are used to specify sound levels across a range of frequencies, and NC25 dB is an acceptable level for internal areas. Since all fixed plant is to be designed to meet these standards, it has not been necessary to define magnitudes of impact since no significant residual effects are expected.

4.4 IMPACT ASSESSMENT

4.4.1 Impact identification

4.4.1.1 Construction

The key airborne noise sources during construction are likely to be from the construction of the underground stops i.e. Parnell Square, O'Connell Bridge and St. Stephen's Green, which will be constructed by cut-and-cover techniques. A temporary working deck and a Bailey bridge is to be constructed over the River Liffey. The key activity in terms of construction noise is likely to be drive piling associated with the installation of approximately 14 tubular steel piles for each structure.

To assess the construction noise impacts in this section of route, noise predictions have been carried out at 14 noise sensitive receptors around these works areas. These receptors are illustrated on maps (Noise Impact) included in Volume 3 Book 1 of 2. Each receptor represents the group of properties most likely to be affected by the works nearby. Annex C, Noise Assessment Details (Volume 3, Book 2 of 2), provides details of the noise modelling methods and results, including predicted levels of noise without mitigation for both the construction and operational phases.

4.4.1.2 Operation

During operation of the scheme, noise sources will include testing of emergency ventilation fans and changes in traffic noise.

Noise impacts from traffic may result due to modal shift from the private car may help to reduce the number of vehicles on the highway network. It is noted that substantial changes in road traffic flow, speed, and/or composition are required to produce noise changes greater than 3dB.

People accessing the underground metro stops may cause additional noise, but in general stops are located in busy areas where ambient noise levels are relatively high, and any such affects will be small.

4.4.2 Mitigation measures

4.4.2.1 Construction

Mitigation will include the following measures:

Best practical means will be used to minimise construction noise through implementation of BS 5228. In particular, the following noise mitigation measures will be implemented:

- Proper use of plant with respect to minimising noise emissions and regular maintenance will be required. All vehicles and mechanical plant will be fitted with effective exhaust silencers and will be maintained in good efficient order.
- The use of inherently quiet plant where appropriate - all major compressors and generators will be 'sound reduced' models fitted with properly lined and sealed acoustic covers, which will be kept closed whenever the machines are in use, and all ancillary pneumatic percussive tools will be fitted with mufflers or silencers of the type recommended by the manufacturers.
- Machines in intermittent use will be shut down in the intervening periods between work or throttled down to a minimum.
- All ancillary plant such as generators and pumps will be positioned so as to cause minimum noise disturbance, and where necessary, acoustic enclosures will be provided.
- Where practicable the use of noisy plant will be limited to core daytime periods.
- Channels of communication will be established between the contractor/ developer, local authority and residents.
- A site representative will be appointed responsible for matters relating to noise.
- Typical levels of noise will be monitored during critical periods and at sensitive locations.
- A 2m high solid site hoarding along the site boundaries will be erected where practical and feasible.
- Localised noise barriers will be erected as necessary around items such as generators or high duty compressors.
- Construction compounds will be laid out so as to minimise noise impacts to neighbouring noise sensitive receptors, by locating noisy operations well away from receptors and using on-site structures and materials to screen noise where practicable and necessary.

Additionally, all contractors will be required to comply with S.I. No 632 of 2001 European Communities (Noise Emission by Equipment for Use Outdoors) Regulations 2001, amended by S.I. No 241 of 2006.

4.4.2.2 Operation

LMV Noise
The alignment is in bored tunnel in this area, no airborne noise impacts will occur. No noise mitigation measures are required to mitigate noise from the LMVs.

Emergency tunnel exhaust vents
The emergency tunnel exhaust vent fans will be fitted with exhaust silencers. The sound power limits for the ventilation shaft fans and the minimum performance for their silencers will be:

(a) Sound Requirements

(i) in relation to emergency ventilation axial fans the total sound power generated by the fan shall not exceed the following decibel ratings at source when operating in the normal mode at rated speed

(ii) it is proposed that attenuation shall be included after the fans in the form of a silencer with the appropriate fire/heat rating. The sound attenuation shall be able to achieve a minimum noise reduction of NR 20 decibel reduction compared with the ratings in Table 4.4 in the nearest openable window of any habitable space.

Table 4.4 – Sound at Source – axial fans

Hz	63	125	250	500	1000	2000	4000	8000
Sound Power Level at fan (dBA) (referred to 10-12 watts)								
dB(A)	96	102	103	98	97	95	91	87

This indicates that the fan noise levels immediately outside the discharge opening of the emergency tunnel exhaust vents will be no higher than 70-75dB(A).

In addition the following noise limit inside buildings near emergency tunnel exhaust vents is specified:

> 'The fans will be attenuated to ensure that the noise levels in adjacent buildings will not exceed Noise Criteria level NC25'.

This will preferably be achieved by increasing the fan silencer performance, but if necessary other measures including providing noise insulation to affected buildings if necessary (see below) will be applied.

4.4.3 Assessment of residual impacts

4.4.3.1 Project scenario: construction phase

Structures
The noisiest activity associated with construction of the temporary working deck and the temporary bridge over the River Liffey is driven tubular piling. The nearest residential properties to the north of the proposed bridge are at 15-17 Eden Quay, which are approximately 24m from the driven piling plant. The nearest noise sensitive property to the south of the proposed Bailey bridge is the Corn Exchange, which is 23m from the nearest pile. The predicted noise levels were (13dB) above the 75dB criterion at both locations which applies to these properties resulting in a Very high impact. No noise reduction has been assumed for mitigation, but it is likely that once the detailed ground conditions and piling rig type are known further reductions could be achieved.

Stops
The predicted noise levels for these activities are shown in Table 7.30 of Annex C Noise Assessment Details (Volume 3, Book 2 of 2). Predicted noise levels were 1 to 17dB above the 75dB criterion which applies to ten residential and commercial receptors and 9 to 24dB above the 65dB criterion that applies to three buildings with educational uses that are close to the Parnell Square, O'Connell Bridge and St. Stephen's Green Stops.

There are residual impacts of 7dB (High) at Parnell Square / Gardiner's Row (MN1071-C2), 7dB (High) Parnell Square East (MN107-C4) and 5dB (Medium to High) at O'Connell St Lower (East) (MN107-C7).

Impacts are also expected at receptors that are used in part for educational purposes including 9dB (High) at Findlater's Church (MN107-C1), 14dB (Very high) at Gate Theatre (MN107-C3).

Construction compounds
Construction compounds 17, 18 and 19 are located in area MN107. Compounds 17 and 19 provide for offices and storage, and are therefore not expected to result in significant noise impacts. At 18 the construction of the permanent works determines the noise impact.

Works at night
Concrete pours outside of core hours may be required for the underground stops. It may be necessary to carry these out at night. This activity is not likely to be standard practice and the assessment therefore represents a worst case scenario. However, where required there will be liaison with the local community and agreement with the relevant local authority in advance of this works proceeding.

At locations that are sensitive to night-time noise Very High residual impacts of 12dB at Westmoreland St (MN107-C10) and 15dB at Fitzwilliam Hotel (MN107-C11) are predicted.

Baseline noise levels at city centre locations are likely to be above the 45dB assessment criterion. Measurements at night around St. Stephen's Green indicate baseline noise levels in of approximately 50 to 55dB. The level of impact will depend on the baseline noise levels at specific receptors at the time that work will be carried out, but High to Very high residual impacts are likely.

Construction traffic
Changes in traffic flows are expected to occur along Parliament Street (from Dame Street to Wellington Quay), increasing traffic noise levels by approximately 3dB. Parliament Street consists mainly of commercial properties, which are expected to experience a Medium impact lasting for up to approximately 31 months.

4.4.3.2 Project scenario: operational phase

Introduction
The route runs in tunnel through this area, and no airborne noise impacts are predicted.

Emergency tunnel exhaust vents
Noise from testing of emergency tunnel exhaust vent fans may be at levels of up to 70-75dB immediately next to the vent. Testing will take place for about 30 minutes once every two weeks. In general where the shaft discharges are on busy streets the noise will be audible above ambient noise, but given its short duration will not constitute a significant noise impact. The specific effects at three stops are discussed below.

At the Parnell Square and O'Connell Bridge Stops the nearest noise sensitive receptors are within approximately 20m of the proposed vents. Noise from fan testing during the day should be below ambient noise at these receptors. Additional noise attenuation may be necessary to achieve the NC25 standard within buildings. If additional fan silencers cannot achieve this it will be possible to restrict testing to daytime. This will ensure disturbance and hence significant impacts are avoided.

At the St. Stephen's Green Stop the shaft discharge will be within the gardens and approximately 75m from the nearest noise receptor building. Noise levels close to the discharge may cause some local disturbance during testing. Additional measures will be taken to reduce this, and given the duration and infrequency of the noise, the impact of this will be Low.

4.4.4 Summary of residual impacts

A summary of the residual impacts associated with this section of the scheme is provided in Table 4.5.

Table 4.5 Summary of residual impacts

	Magnitude of impact taking into account mitigation	Functional value of area affected	Significance of impact
Construction phase			
Construction Noise During Day	very high at the Gate Theatre (MN107-C3), at receptors close to the working deck and the Bailey bridge (15-17 Eden Quay, and the Corn Exchange) high at Parnell Square / Gardiner's Row (MN107-C2), Parnell Square East (MN107-C4) and Findlater's Church (MN107-C1) medium to high at O'Connell St Lower (East) (MN107-C7) medium Road traffic noise affecting properties on Parliament Street. Other impacts are not significant.	very high	Significant
Construction Noise During Night	very high over periods when concrete pours cannot be completed during the day at Westmoreland St (MN107-C10) and Fitzwilliam Hotel (MN107-C11)	very high	Significant
Operational phase			
Airborne Noise from LMVs	very low	Not applicable	Not significant
Emergency Tunnel Ventilation Fans	very low	very high	Not significant

05 HUMAN BEINGS: VIBRATION

This chapter of the EIS evaluates the potential vibration impacts arising from the construction and operation of the proposed scheme within Area MN107.

5.1 INTRODUCTION

This chapter of the EIS evaluates the potential vibration impacts arising from the construction and operation of the proposed scheme within Area MN107.

5.2 STUDY AREA

The study area for this assessment is set out in Table 5.1.

5.3 IMPACT ASSESSMENT METHODOLOGY

5.3.1 Construction phase methodology

The source and type of all potential impacts is described in Section 5.4.1. Mitigation measures to be put in place are defined in Section 5.4.2 for any adverse impacts that are deemed to be of Medium or greater significance prior to mitigation. The extent to which mitigation is needed increases as the significance of the impact increases. The residual impact is then evaluated in Section 5.4.3 in terms of magnitude and significance.

Table 5.1 Study area

Criteria	Width of study area (on both sides of the alignment)
Construction Groundborne Noise – human perception	50m
Construction Groundborne Noise – effects on sensitive facilities	100m
Construction Vibration – building damage	50m
Construction Vibration – human perception	80m
Construction Vibration – effect on sensitive equipment	1,000m
Operational Vibration – human perception	50m
Operational Vibration – effect on sensitive equipment	100m
Operational Groundborne Noise – human perception	50m
Operational Groundborne Noise – effects on sensitive facilities	100m

5.3.1.1 Magnitude

The criteria used to assess the different impacts associated with this scheme are discussed below and summarised in Table 5.2.

Groundborne Noise
The metric which is widely used for the assessment of groundborne noise is the maximum A-weighted sound level using 'slow' time response, $L_{Amax,S}$.

The symbol 'L' indicates a value expressed in decibels (abbreviated dB). The dB scale measures relative magnitudes of sound power or intensity (sound power per unit area) a property proportional to the mean squared value of the amplitudes of the air pressure oscillations that cause sound. Every doubling of intensity is a 3dB increase and every tenfold increase in intensity is a 10dB increase. A standard reference level (0dB = 20μPa of root mean square sound pressure) is used so that the dB scale can measure absolute levels as well as relative levels. The symbol 'A' signifies that the measured sound pressure has been subjected to frequency weighting using the standard 'A-weighting scale', to approximate the frequency response of the human ear—relatively insensitive at low frequencies and very high frequencies. Every 10dB increase in A-weighted sound level is perceived as approximately a doubling of loudness—slightly more than a doubling for sound of low frequency. The symbol 'S' specifies a method of averaging the oscillating sound pressure, by exponential averaging as defined in IEC 61672 (2002), using the standard 'slow' time constant of one second—the alternative being the 'F' or 'fast' time constant of 1/8 second. 'S' has a greater smoothing effect on sound that varies in level. The symbol 'max' means the highest averaged value reached during an event such as the passage of a train. The value of $L_{Amax,S}$ nearly equals the value of $L_{Amax,F}$ for a steady sound that lasts for one second or more, otherwise $L_{Amax,F}$ levels exceed $L_{Amax,S}$ levels by an amount dependent on the rapidity and magnitude of the variations. For groundborne noise from a modern underground railway $L_{Amax,S}$ levels are typically 2dB lower than $L_{Amax,F}$ levels. $L_{Amax,S}$ can alternatively be written as L_{Asmax} and is defined in IEC 61672 (2002).

During the construction phase, vibration will relate principally to the passage of the tunnel boring machine (TBM) and will be experienced by humans as groundborne noise. The fact that the TBM will only be heard in each tunnel for the short period of its passage means that impact thresholds are higher than for the permanent effect of the operating scheme. In limestone, the TBM is likely to advance at the rate of about 75m per week, operating 5 days per week. In the case of the Dublin Port Tunnel noise from the TBM was sometimes audible for up to three weeks before, and three weeks after, reaching the closest point to a receiving location. The Dublin Port Tunnel is approximately 11m in diameter. The Metro North tunnels will be 6.7m in diameter so groundborne noise levels will be less than those for the Dublin Port Tunnel with consequently shorter durations. Passage through the overburden above the limestone is likely to be faster. In locations between the two tunnels, this experience will be repeated with a delay of the order of two months between the two tunnel drives.

Because of the finite duration of this effect, the night-time impact thresholds have been set 5dB higher than those for the operation of the proposed scheme. Separate day-time thresholds (not relevant to operation as there is no difference between $L_{Amax,S}$ for a passing tram by day or night) have been used which are 5dB above the night-time thresholds (i.e. 10dB above the thresholds for operation).

Vibration
The metric which is used for the assessment of vibration is the KB value from DIN 4150-2, which is assessed using three different criteria, A_u, A_o and A_r. The KB value is a frequency weighted measure of vibration velocity in units of mm/s, using the 'F' time constant, obtained for each 30-second cycle in a sequence of contiguous 30-second cycles. Two types of parameters are defined based on the KB value:

- KB_{Fmax} the maximum value for the time varying KB value during the evaluation period;
- KB_{FTr} an evaluation parameter that is weighted according to the number of vibration events and the duration of these events during the evaluation period.

For daytime vibration other than blasting, if KB_{Fmax} is lower than or equal to Au DIN 4150-2 states that 'the requirements of the standard have been met'. If KB_{Fmax} is greater than Ao 'the requirements of the standard have not been met'. In other cases, where the KB_{Fmax} value is between A_u and A_o, KB_{FTr} is calculated as the root-mean square of the 30-second KB values, and if it does not exceed A_r the 'requirements of the standard have been met'.

For construction vibration three levels are defined by DIN 4150-2:

Level I: With vibration below this level, it can be assumed even without any previous knowledge, that there will be no considerable discomfort.

In this assessment daytime vibration impact above Level I and not above Level II is classed as Low.

Level II: Vibration below this level is also not likely to produce considerable discomfort, as long as the measures specified in items a) to e) (and if necessary, item f) of DIN 4150-2 are taken. As this level is exceeded, the probability increases that there will be considerable discomfort. According to DIN 4150-2 'If it is expected that level II will be exceeded, an attempt shall be made to use construction methods that produce less vibration'.

In this assessment daytime vibration impact above Level II and not above Level III is classed as High.

Level III: The effects produced by vibration above this level are unacceptable. In this case, special measures that go beyond those specified in items (a) to (f) of DIN 4150-2 shall be agreed upon.

In this assessment daytime vibration impact above Level III is classed as Very high.

For construction vibration at night, the same guideline values used for operational vibration apply. In this context DIN 4150-2 defines criteria for five receptor types and the most stringent criteria have been used to define the Very low impact category. The criteria for less sensitive receptors defined in DIN 4150-2 have been used to define the higher impact magnitudes in the absence of other guidance. All impact magnitudes above 'very low' are defined as significant at night.

For assessment of vibration from blasting, the metric conventionally used is peak particle velocity (PPV). The Irish EPA recommends that to avoid any risk of damage to properties in the vicinity of a quarry, the vibration levels from blasting should not exceed a peak particle velocity of 12mm/s as measured at a receiving location when blasting occurs at a frequency of once per week or less. In the rare event of more frequent blasting, the peak particle velocity should not exceed 8mm/s.

DIN 4150-2 uses KB_{Fmax} for the assessment of human exposure to vibration from blasting, using only the A_o values from the set of limits (A_o, A_u and A_r) used for general vibration assessment.

For human response, a relationship between PPV and KB_{Fmax} is required. The relationship depends on the frequency spectrum and the duration of the blast. The KB frequency weighting is almost flat between 16Hz and 63Hz, between which limits it is effectively an F-weighted exponential average of velocity in mm/s. While blasting vibration can occur significantly outside this range, often the dominant frequency is between 16Hz and 63Hz. The ratio of PPV to KB_{Fmax} in the example given in DIN 4150-2 is 2:1. Based on typical examples from blast monitoring of the Dublin Port Tunnel this would appear to be very conservative, and the ratio may be higher. However, the relationship $PPV = 2 \times KB_{Fmax}$ is used in this assessment.

A daytime PPV of 12mm/s, taken as $A_o = 6$, is equated in this assessment to the threshold of High impact. The threshold of Medium impact is $A_o = 5$ and Low impact is $A_o = 3$, being the daytime A_o value given in DIN 4150-2 for the two most sensitive classes, 'Buildings which are predominantly or purely residential' and 'Buildings in specially protected areas'.

Vibration from construction plant operating on above-ground worksites is assessed in the same way as vibration from the tunnelling, based on measured PPV levels for the relevant plant, converted to KB_{Fmax} using the same ratio of 2:1.

Table 5.2 Criteria for assessment of impact magnitude during construction

Criteria		Impact magnitude
Dwellings, Offices, Hotels, Schools, Colleges, Hospital Wards, Libraries		
Groundborne noise (TBM)	Night $L_{Amax,S}$ >50dB Day $L_{Amax,S}$ >55dB	very high
	Night 45dB >$L_{Amax,S} \leq$ 50dB Day 50dB >$L_{Amax,S} \leq$ 55dB	high
	Night 40dB >$L_{Amax,S} \leq$ 45dB Day 45dB >$L_{Amax,S} \leq$ 50dB	medium
	Night 35dB >$L_{Amax,S} \leq$ 40dB Day 40dB >$L_{Amax,S} \leq$ 45dB	low
	Night $L_{Amax,S} \leq$ 35dB Day $L_{Amax,S} \leq$ 40dB	very low
Vibration effect on people (TBM and construction plant)	Night $A_u > 0.2$, $A_o > 0.4$, $A_r > 0.1$ Day $A_u > 1.6$, $A_o > 5$, $A_r > 1.2$	very high
	Night $A_u \leq 0.2$, $A_o \leq 0.4$, $A_r \leq 0.1$ Day $A_u \leq 1.6$, $A_o \leq 5$, $A_r \leq 1.2$	high
	Night $A_u \leq 0.15$, $A_o \leq 0.3$, $A_r \leq 0.07$ Day $A_u \leq 1.2$, $A_o \leq 5$, $A_r \leq 0.8$	medium
	Night $A_u \leq 0.1$, $A_o \leq 0.2$, $A_r \leq 0.05$ Day $A_u \leq 0.8$, $A_o \leq 5$, $A_r \leq 0.4$	low
	Night $A_u \leq 0.1$, $A_o \leq 0.15$, $A_r \leq 0.05$ Day $A_u \leq 0.4$, $A_o \leq 3$, $A_r \leq 0.2$	very low
Vibration effect on people (blasting)	Night $A_o > 0.4$ Day $A_o > 6$	very high
	Night $A_o \leq 0.4$ Day $A_o \leq 6$	high
	Night $A_o \leq 0.3$ Day $A_o \leq 5$	medium
	Night $A_o \leq 0.2$ Day $A_o \leq 3$	low
	Night $A_o \leq 0.15$ Day $A_o \leq 2$	very low
Vibration – building damage	>50mm/s ppv	very high
	≤ 50mm/s ppv	high
	≤ 12mm/s ppv	medium
	≤ 5mm/s ppv	low
	≤ 3mm/s ppv	very low

Criteria		Impact magnitude
Places of meeting for religious worship, courts, lecture theatres, small auditoria – Sensitive During Daytime Only		
Groundborne noise (TBM)	$L_{Amax,S} > 55dB$	very high
	$50dB > L_{Amax,S} \leq 55dB$	high
	$45dB > L_{Amax,S} \leq 50dB$	medium
	$40dB > L_{Amax,S} \leq 45dB$	low
	$L_{Amax,S} \leq 40dB$	very low
Vibration effect on people (TBM and construction plant)	$A_u > 1.6, A_o > 5, A_r > 1.2$	very high
	$A_u \leq 1.6, A_o \leq 5, A_r \leq 1.2$	high
	$A_u \leq 1.2, A_o \leq 5, A_r \leq 0.8$	medium
	$A_u \leq 0.8, A_o \leq 5, A_r \leq 0.4$	low
	$A_u \leq 0.4, A_o \leq 3, A_r \leq 0.2$	very low
Vibration effect on people (blasting)	$A_o > 6$	very high
	$A_o \leq 6$	high
	$A_o \leq 5$	medium
	$A_o \leq 3$	low
	$A_o \leq 2$	very low
Vibration – building damage	>50mm/s ppv	very high
	≤ 50mm/s ppv	high
	≤ 12mm/s ppv	medium
	≤ 5mm/s ppv	low
	≤ 3mm/s ppv	very low
Sensitive Equipment		
Vibration	Computer equipment 0.25g peak acceleration	Must not exceed
	Mater Hospitals: agreed vibration limit at the centre span of any floor 12 μm/s rms in any third octave of frequency within the overall range 4 to 80Hz	Must not exceed
	Rotunda Hospital: Advised vibration limits 3μm displacement at 5Hz, 6 μm displacement at 10Hz and 15Hz,	Must not exceed

5.3.1.2 Significance

The significance of all impacts is assessed by considering the magnitude of the impact and the functional value of the area upon which the impact has an effect. The functional value of the receptor relates to its sensitivity which has been taken account of in the assessment criteria that have been adopted.

5.3.2 Operational phase methodology

5.3.2.1 Magnitude

The criteria used to assess the different impacts associated with the operation of the metro are shown in Table 5.3.

Table 5.3 Criteria for assessment of impact magnitude during operation

Criteria		Impact magnitude
Dwellings, Offices, Hotels, Schools, Colleges, Hospital Wards, Libraries		
Groundborne noise	$L_{Amax,S}$ >45dB	very high
	40dB > $L_{Amax,S}$ ≤ 45dB	high
	35dB > $L_{Amax,S}$ ≤ 40dB	medium
	30dB > $L_{Amax,S}$ ≤ 35dB	low
	$L_{Amax,S}$ ≤ 30dB	very low
Vibration	Night A_u = <0.2, A_o = <0.4, A_r = >0.1 Day A_u = 0.4, A_o = 6, A_r = 0.2	very high
	Night A_u = 0.2, A_o = 0.4, A_r = 0.1 Day A_u = 0.3, A_o = 6, A_r = 0.15	high
	Night A_u = 0.15, A_o = 0.3, A_r = 0.07 Day A_u = 0.2, A_o = 5, A_r = 0.1	medium
	Night A_u = 0.15, A_o = 0.2, A_r = 0.05 Day A_u = 0.15, A_o = 3, A_r = 0.07	low
	Night A_u = 0.1, A_o = 0.15, A_r = 0.05 Day A_u = 0.1, A_o = 3, A_r = 0.05	very low
Places of meeting for religious worship, courts, lecture theatres, small auditoria – Sensitive During Daytime Only		
Groundborne noise	$L_{Amax,S}$ >40dB	very high
	35dB > $L_{Amax,S}$ ≤ 40dB	high
	30dB > $L_{Amax,S}$ ≤ 35dB	medium
	25dB > $L_{Amax,S}$ ≤ 30dB	low
	$L_{Amax,S}$ ≤ 25dB	very low
Vibration	A_u = 0.3, A_o = 0.6, A_r = 0.15	very high
	A_u = 0.2, A_o = 0.4, A_r = 0.1	high
	A_u = 0.15, A_o = 0.3, A_r = 0.07	medium
	A_u = 0.15, A_o = 0.2, A_r = 0.05	low
	A_u = 0.1, A_o = 0.15, A_r = 0.05	very low

Criteria		Impact magnitude
Theatres, Large Auditoria and Concert Halls – Sensitive During Daytime Only		
Groundborne noise	$L_{Amax,S} > 30dB$	very high
	$25dB > L_{Amax,S} \leq 30dB$	high
	$20dB > L_{Amax,S} \leq 25dB$	medium
	$15dB > L_{Amax,S} \leq 20dB$	low
	$L_{Amax,S} \leq 15dB$	very low
Vibration	Day $A_u = 0.4, A_o = 6, A_r = 0.2$	very high
	Day $A_u = 0.3, A_o = 6, A_r = 0.15$	high
	Day $A_u = 0.2, A_o = 5, A_r = 0.1$	medium
	Day $A_u = 0.15, A_o = 3, A_r = 0.07$	low
	Day $A_u = 0.1, A_o = 3, A_r = 0.05$	very low
Sensitive Equipment		
Vibration	Dublin Airport: The most sensitive equipment reported at the Airport is a ceilometer with a vibration criterion stated as a limit of ± 1mm displacement in the range 5-13.2Hz, and ± 0.7g in the range 13.2-100Hz.	Must not exceed
	Mater Hospitals: agreed vibration limit at the centre span of any floor 12 μm/s rms in any third octave of frequency within the overall range 4 to 80Hz	Must not exceed
	Rotunda Hospital: Advised vibration limits 3μm displacement at 5Hz, 6 μm displacement at 10Hz and 15Hz,	Must not exceed

5.3.2.2 Significance

The significance of all impacts is assessed by considering the magnitude of the impact and the functional value of the area upon which the impact has an effect. The functional value of the receptor relates to its sensitivity which has been taken account of in the assessment criteria that have been adopted.

5.4 IMPACT ASSESSMENT

5.4.1 Impact identification

5.4.1.1 Construction Phase

Vibration in the construction phase will be of three main kinds:

- Vibration due to the excavation of underground works, particularly cross-passages. It is likely that impact breakers will be used initially if the ground permits and then other methods may have to be used which could include chemical breaking, hydraulic splitting, Low VoD (velocity of detonation) pyrotechnics or drill and blast. The assessment has been based on the use of drill and blast, with other methods considered as mitigation through the use of alternatives causing lower vibration.
- Vibration due to the operation of the TBMs
- Vibration due to other construction work, including percussive breaking of rock and concrete, piling and diaphragm walling.

Drilling and Blasting
The principal source of vibration from drilling and blasting is the detonation of explosive charges underground. Vibration is a well known effect of blasting and the relationship

$PPV= K W^d R^{-b}$

is commonly used to predict peak particle velocity as a function of distance and charge weight per delay. In this expression K is the Ground Transmission Constant, depending on the nature of the rock or soil and other parameters such as confinement. It will also be dependent on the blasting method, with specialist techniques used in tunnelling such as Penetrating Cone Fracture likely to give different results from conventional explosives. W is the charge weight per delay in kilogrammes, and R is the distance in metres, with d and b being empirical exponents. Blasting normally involves a sequence of detonations of small charges, separated by delays of 50 milliseconds or more. W relates to the mass of the explosive detonated after each delay. W and R are often combined in a parameter called scaled distance $S=R/\sqrt{W}$, in which case the express becomes

$PPV=K S^{-b}$

This effectively sets the value of d as 0.5b.

This relationship was originally derived for quarry blasting, and has been extended for use in drill and blast operations.

Values for K range from 200 to 1200 (for results in mm/s), the latter being for granitic and volcanic rocks, with soft rocks being in the range 500-600. A figure of 1.6 is commonly used for b.

Vibration monitoring carried out at 27 locations in volcanic rock in San Diego county, California gave values for K for 95% confidence of 200-5000 with the mean lying on a line represented by K=714.

In limestone, the value of K can be expected to be less than in volcanic rock.

Monitoring of drilling and blasting for the Dublin Port Tunnel gave results from which parameters can be derived. The charge weights are not known, but a best fit for PPV in terms of KS^{-b} results from an assumption of 10kg per delay, and a value of K of 1,000 with a standard deviation of 9.6mm/s. The mean is used as the basis of this assessment, but it must be recognised that there will be a distribution of results about the mean. The Dublin Port Tunnel sample is too small, and the blasting took place too far from Metro North blasting locations, to make a reliable estimate of confidence intervals (e.g. 95%), and it will be necessary to carry out trials of the proposed drill and blast method to evaluate more specific local values for K and to determine the associated confidence intervals.

Tunnel boring
The principal sources of vibration from tunnel boring are probe drilling (if undertaken) and the cutting action of the TBM.

The Dublin Port Tunnel was bored through bedrock that is similar to that which is expected to be experienced by the TBMs involved in the proposed scheme. During the course of the construction of the Dublin Port Tunnel, the project carried out extensive monitoring of the groundborne noise and vibration that occurred at specific locations along the scheme.

A numerical model of the Dublin Port Tunnel project has been created as part of the Metro North studies. The results of this model have been backfitted to the groundborne noise and vibration results that were measured when the port tunnel was being built in order to obtain a source term for the tunnel face. A comparative modelling exercise has then been carried out to create a model for Metro North taking into account the fact that the Metro North tunnel will have a significantly smaller diameter (approximately 6.7m) than that of the Dublin Port Tunnel (approximately 11m). The output of the modelling exercise provides an indication of likely ground vibration and associated groundborne noise at various depths and geological conditions, as well as a prediction of the decay of vibration and groundborne noise with distance, both laterally and ahead and behind the TBM.

The predictions were carried out using the Rupert Taylor Finite Difference Time Domain model FINDWAVE®.

The model used for this study predicts, in the time domain, the three-dimensional vibration velocity of the tunnel face and surrounding lithology. The time-domain results are transformed into the frequency domain to give 1/3 octave frequency spectra, and overall sound levels in dB(A) and vibration units.

The approach has been to set up a generic model in an unbounded soil (i.e. with no ground surface in the model) and produce cross-sectional plots of vectored vibration velocity from which, subject to the application of transfer functions to buildings, ground surface predictions can been made.

Above ground works
Most construction plant is not likely to generate vibration that will be perceptible at off-site locations. Therefore, vibration impacts have been considered from the particular plant items that have the potential to generate perceptible levels of vibration. The activities that are most likely to fall into this category are driven piling for the Bailey Bridge in the Liffey, and bored piling and vibratory rollers at stops. These activities are unlikely to take place outside of daytime working hours.

The vibration levels typically decay rapidly from these activities and meet the DIN standards for construction within 10m from bored piling and 15m from vibratory rollers (resulting in Low or Very low impacts beyond this point). Higher levels are predicted in the assessment section below for driven piling. The standards that have been adopted apply to construction work carried out for up to 26 days. However, the operation of these plant is not likely to be sustained throughout the scheduled construction period and is likely to be limited to periods of less than this.

Effect of variations in geotechnical parameters

The ground conditions of the scheme vary along the alignment. These variations affect the predictions of groundborne noise and vibration from the TBM.

The effects are of three main kinds. The first is that the impedance of the rock in which the TBM is working affects the level of vibration generated. Impedance is the product of rock density and the speed of sound of compression waves in the rock. For constant face pressure, the power transmitted away from the face as vibration is inversely proportional to the rock impedance, i.e. less vibration for harder rock. For constant TBM power, the power transmitted away from the face as vibration is independent of the rock impedance. If the power is increased to compensate for harder rock, then the power transmitted away from the face as vibration is proportional to the rock impedance. The last assumption has been made in this assessment, namely that the power transmitted away from the face as vibration is proportional to the rock impedance.

The second effect relates to the influence of the overburden layer of clay, sand or gravel between the rockhead and the foundations of buildings founded on the surface. The impedance of the overburden is less than that of limestone. There is a reduction in transmission of vibration out of the limestone into the overburden, but the nature of this effect depends not only on the impedance of the overburden relative to the limestone, but also on the thickness of the overburden. A reduction in the impedance of the overburden causes a broad reduction across the spectrum, but this can be less important than the fact that the peak frequency at which vibration is transmitted shifts downwards, which in the region of the new peak causes an increase in vibration around that frequency.

The third effect is that lower impedance results in lower wave speed and shorter wavelength, and as loss due to material damping is inversely proportional to wavelength this results in greater material damping in the overburden layer.

The geotechnical properties continually change along the alignment, as does the depth of the tunnel, sometimes being in the overburden and sometimes in the limestone. The estimates of vibration and groundborne noise made in this assessment have been based on the numerical modelling results, adjusted according to the local geotechnical conditions in each location.

5.4.1.2 Operational Phase

Vibration and groundborne noise are aspects of the same phenomenon, perceived differently or in different media. Vibration is movement of a surface or structure perceived by humans by the tactile sense or which directly affects the function of an item of equipment such as an electron microscope. Groundborne noise is vibration of a surface or structure perceived by humans by the sense of hearing, or by equipment such as microphones in, for example, recording studios, as a result of radiation of the vibration into air between the surface and the ear, causing sound.

Sources of vibration and groundborne noise in the operation of the scheme are:

- Wheel/rail interaction during the movement of LMVs
- over plain line
- over switches and crossings
- Operation of equipment such as escalators and mechanical services plant at stops

Escalators and mechanical services plant will be designed to ensure that they do not give rise to significant effects at offsite receptors. This will involve ensuring that mitigation will be incorporated to avoid exceeding significant impact levels as defined above. Mitigation measures will include well established techniques such as vibration isolating bearings to control vibration from this type of source if required. Therefore, it has not been necessary to consider these in detail in this assessment.

5.4.2 Mitigation measures

5.4.2.1 Construction

Drilling and Blasting
Blasting will not take place in residential areas at night and suitable advanced warning will be given to anyone who may experience noise or vibration. Additional mitigation measures assumed include monitoring of vibration from each blast to enable blasting parameters to be optimised and to ensure that damaging levels of vibration are not reached. For conventional explosives the parameters concerned are charge weight per delay, and length of delay. PPV is proportional to the charge weight to the power of 0.8, so halving the charge weight reduces the PPV by about 40%. However, the parameters in the scaled distance formula are all empirical, and have to be determined by experimental measurements on site.

Alternatives to conventional explosives are capable of achieving significantly lower PPV values, including penetrating cone fracture (PCF) methods, chemical breaking, hydraulic splitting and Low VoD pyrotechnics. Use of road headers (excavating equipment fitted with a boom-mounted rotating drum cutting head) also results in much lower vibration than blasting.

Tunnel boring machine
Two principal methods of mitigation are available. The first is to limit hours of operation to avoid the more sensitive night period. The second method is optimisation of TBM characteristics including face pressure and selection of cutters and teeth.

The following incorporated mitigation measures have been assumed;

The following incorporated mitigation measures have been assumed

Work may only be carried out between 07h00 and 23h00, Monday to Saturday but excluding bank holidays ("core permitted underground working hours") except that work may be carried out at times outside the core permitted underground working hours in the following cases:

(i) groundborne noise levels are not in excess of 40dB $L_{Amax,s}$ (where $L_{Amax,s}$ is as defined in IEC 61672, 2002) as measured near the centre of any occupied sensitive room of an inhabited building.

or

(ii) groundborne noise levels are in excess of 40dB $L_{Amax,s}$ (where $L_{Amax,s}$ is as defined in IEC 61672, 2002) as measured near the centre of any occupied sensitive room of an inhabited building provided that that work does not cause noise disturbance, where noise disturbance is defined as any complaint made by any person who is the occupant of a sensitive room in an inhabited building

or

(iii) the full extent of the tunnel drives under the airport as well as for the Airport Stop where working hours of 24 hours per day seven days per week will be permitted without restriction.

Above Ground Works
Bored piling and vibratory rollers have been identified as the plant most likely to create vibration impacts in the form of disturbance to the occupiers of adjacent properties. Bored piling is a low vibration piling method, so where piling is necessary there may be limited scope to use alternative methods. Possible mitigation measures for driven piling include pre-drilling, using reduced energy piling plant and avoiding noise sensitive times. Vibration will be monitored and advanced warning will be given of the relevant activities.

5.4.2.2 Operation

A particular feature of the operation of a newly designed railway is that the incorporation of resilient rail support and the use of welded rail have the result that significant effects due to vibration and groundborne noise are completely avoided provided that the appropriate form of track support is selected, and an adequate maintenance regime is followed. Resilient rail support has been established as the standard trackform for non-ballasted track on Luas and is the normal method of standard rail support for modern urban underground railways throughout the world. While resiliently embedded rail is used for street-running, resilient baseplates or other rail support systems, or booted blocks are typical modern designs.

The assessment of vibration and groundborne noise from a new railway therefore consists entirely of a consideration of the likely nature of incorporated mitigation in the design and operation (including maintenance) of the system. The Description of the Scheme chapter of this EIS (Volume 1, Chapter 6) states that a floating trackbed system will be provided in the twin bore running tunnels between St. Stephen's Green and Albert College Park.

It is assumed that the following specification will be imposed:

It is assumed that the following specification will be imposed:

(a) To ensure that noise disturbance during operation of Metro North is minimised, InfraCo shall ensure that the maximum permissible level of groundborne noise that may be generated during operation does not exceed 40dB $L_{Amax,S}$ determined near the centre of any occupied sensitive room of an inhabited building, except at the following locations:

(i) Between Parnell Street and Albert College Park the maximum permissible Groundborne noise that may be generated during operation does not exceed 25dB $L_{Amax,S}$ determined near the centre of any occupied sensitive room of an inhabited building.

(b) An inhabited building is a building which is in whole or in part lawfully used either temporarily or permanently as a dwelling, hospital, hostel or hotel. An occupied sensitive room is a room in an inhabited building that is a hospital ward, living room, or bedroom which is not a kitchen, bathroom, WC or circulation space that is in use as a living room or bedroom at the time the works are being carried out.

Mitigation measures primarily consist of the design of the track support system, and the choices available broadly fall into two categories, namely resilient rail support and floating slab track. Generally speaking, the parameter that controls the isolation performance of the system is the mass-spring natural frequency of the effective mass of the rail plus bogie unsprung mass on the spring provided by the resilience of the support system below the rail. Limitations on allowable dynamic rail deflection place a lower bound on the achievable dynamic stiffness of the support.

Resilient rail support means support of the rail from the second stage concrete by a system with a vertical dynamic stiffness below about 20MN/m (systems are available with vertical dynamic stiffnesses as low as 7MN/m). This may be in the form of a resilient baseplate supporting the rail foot, a resilient support for the rail web instead of the rail foot, or the provision of a resilient boot to a concrete block to which the rail is fastened.

Floating slab track (FST) means the support of the rail from a concrete slab which is mounted on resilient bearings. FST achieves greater isolation of vibration and groundborne noise largely because the mass of the concrete slab enables a lower natural frequency to be achieved without excessive dynamic deflection. Some of the vibration is also stored and dissipated in the slab and components above the slab.

5.4.3 ASSESSMENT OF RESIDUAL IMPACTS

5.4.3.1 Project scenario: construction phase

The results of this assessment are as follows. For each group of receptors the potential impact with no mitigation has been predicted. The extent of committed mitigation is described and the resultant residual impact expected with that mitigation adopted is reported. The depth of the tunnel may reduce somewhat due to the proposed limits of deviation. In each case, this is not expected to change the predicted impact categories.

At Mater Stop the bored tunnels are in the glacial till (boulder clay) overlying the limestone, and the stop box is founded on the limestone which is at a depth of about 20m. The existing Mater Private Hospital has piled foundations. The proposed future Mater Adult Hospital will have a raft foundation. The depth of the tunnel here is dependent on the choice of two options for the Mater Stop.

During construction, the nearest operational part of the Mater Misericordiae University Hospital will be approximately 75m to the west of the stop box. Vibration transmission from the stop site would be through the made ground which is a layer approximately 10m thick above a layer of about 15m of boulder clay above the limestone. The base of the stop box is in the limestone. The proposed future extension to the Adult Hospital will be partially supported from the structure of the Mater Stop. For this reason the Mater Stop box is expected to be constructed as advance works, and at this time construction vibration impacts on the neighbouring Mater Private Hospital will arise both from the construction of the Metro stop box and from the construction of the Adult Hospital. The advanced works involved will consist of the insertion of a contiguous/secant bored pile retaining wall, the insertion of diaphragm walls for the stop box, the excavation of soil and rock between the walls and the concreting of the floor and roof slabs to the box. The principal potential cause of significant vibration would be the excavation of bedrock at the base of the stop box. For this reason, a slightly raised vertical alignment is under consideration that will minimise the need for rock excavation. There is no equivalent construction activity involved in the Adult Hospital construction, and the cumulative effect of the co-existence of the two construction projects is therefore no greater than the effect of the construction of the stop box.

The Mater Private Hospital will be in normal use during the construction of the Mater Stop and the tunnel drive. The southern headwall of the stop is proposed at approximately 2m from the Mater Private Hospital. Vibration will be transmitted into the foundations from the excavation of the limestone at the base of the stop box, from concreting of the headwall which may include breaking out a soft eye in the headwall to admit the TBM. Vibration from the passage of the TBM will be transmitted through the ground to the hospital foundations. Vibration, once it has entered the hospital structure, will decay only slightly with distance, although it would require on-site tests to establish the effect of distance within the structure.

The limit for sensitive equipment in the Mater Hospitals of 12 μm/s will be significantly exceeded in the Private Hospital, by a factor of the order of 25, during the passage of the TBM, and the limit will not be achieved until the TBM is of the order of 350-400m from the hospital. This amounts to some 10 weeks for each tunnel at a progress rate of 75m per week, although in the overburden the progress rate may be faster. Unless alternative tunnelling methods are found to be possible for some 400m, temporary alternative arrangements will be required for the most sensitive equipment in the hospital. The existing Mater Adult Hospital also lies within this distance.

Depending on the vertical alignment, rock breaking may be required for the construction of Mater Stop, and assuming this is done using a hydraulic rock breaker, groundborne noise levels of approximately 49dB(A), assuming four breakers in simultaneous operation, are likely in buildings above the stop, with vibration at 0.2 KB_{FTR}, resulting in Medium impact on humans by day, High impact by night, but some 17 times the sensitive equipment limit of 12 μm/s.

There are no cross-passages in the vicinity of Mater Stop, the nearest being at St. Joseph's Place 380m to the south at the bottom of the glacial sands and gravels and the top of the limestone, and Kenmare Parade 190m to the north, in the limestone.

Blasting for the Kenmare Parade cross-passage will occur about 280m from the Mater Private Hospital is likely to give a PPV of 0.75mm/s at the hospital. This would interfere with the operation of sensitive equipment, and mitigation in the form of liaison between the site and the hospital will be required to ensure that blasts and critical use of the equipment do not occur simultaneously. The equivalent value of KB_{Fmax} = 0.4 is in the Very low category for day; High for night.

There are residential buildings immediately above the cross-passage at St. Joseph's Place where there is approximately 25m of ground cover. It is likely that the PPV be of the order of 37mm/s, KB_{Fmax} = 19, will exceed the building damage threshold of 12mm/s, and be in the Very high impact category for human response. The Low impact threshold of KB_{Fmax} = 3 will be exceeded within a radius of 73m and the building damage threshold of 12mm/s will be exceeded within a radius of 44m. With a dominant frequency of 25Hz, this would be equivalent to approximately 0.6g, in excess of the damage threshold for computer equipment. To limit the PPV to the Low impact category for daytime the charge weight per delay would have to be restricted to 0.8 to 1.0kg depending on the final tunnel alignment.

During the passage of the TBM in this area, the groundborne noise level is likely to be 47dB $L_{Amax,S}$, High impact if tunnelling takes place at night, Medium impact if tunnelling does not occur at night. Vibration is likely to be 0.09 KB_{FTr} High impact at night, Very low impact by day.

South of Mater Stop, the bored tunnels enter the limestone at approximately St. Joseph's Parade and pass under residential areas north of Parnell Square. The educational, institutional and community facilities in the area are sensitive to structure-radiated noise and vibration. There are various protected monuments and structures included throughout the area, mainly Georgian buildings. The area also includes the Rotunda Hospital including the HARI Clinic, Ambassador Theatre, the Temple Theatre and the Gate Theatre in Cavendish Row. The depth of the tunnel at Parnell Square is approximately 22m.

During the passage of the TBM in this area, the groundborne noise level is likely to be 48dB $L_{Amax,S}$, High impact if tunnelling takes place at night, Medium impact if tunnelling does not occur at night. Vibration is likely to be 0.09 KB_{FTr} High impact at night, Very low impact by day. The effect of 48dB $L_{Amax,S}$ in the theatres will depend on the nature of the production. During quiet moments in a production, this will be clearly audible and intrusive. The main mitigation possible is liaison with the theatre managements, with as much advance warning as practicable. Reduction in face pressure and/or cutter speed may be an option although the effect on ground settlement must also be taken into account.

There is a planned cross passage opposite Hardwicke Street, just south of Telecom Eireann. Ground cover is approximately 26m and a PPV of some 35mm/s, KB_{Fmax} = 18, can be expected. With a dominant frequency of 25Hz, this would be equivalent to approximately 0.5g, in excess of the damage threshold for computer equipment. This cross passage is approximately 300m from the HARI clinic to give a PPV of 0.7mm/s at the clinic. This would be close to the limit advised for the operation of sensitive equipment at the Rotunda Hospital/HARI clinic, and mitigation in the form of liaison between the site and the hospital together with vibration monitoring will be required to ensure that use of the equipment is not adversely affected. The Low impact threshold of KB_{Fmax} = 3 will be exceeded by blasting in the Hardwicke Street cross-passage within a radius of 72m and the building damage threshold of 12mm/s will be exceeded within a radius of 43m.

The HARI/Rotunda vibration threshold for sensitive equipment of 6μm displacement at 15Hz is equivalent to a velocity of 565μm/s. Based on the modelling carried out for the Mater Private Hospital, it is not likely that vibration from the passage of the TBMs will exceed this threshold. The groundborne noise level is likely to be 48dB $L_{Amax,S}$ high impact if tunnelling takes place at night, Medium impact if tunnelling does not occur at night. Vibration is likely to be 0.09 KB_{FTr} High impact at night, Very low impact by day. Groundborne noise at 48dB $L_{Amax,S}$ is likely to have a High impact in the Gate Theatre during performances.

Baseline monitoring showed vibration less than the limit for sensitive equipment for the Mater and Rotunda Hospitals.

Rock breaking will be required for the construction of Parnell Square Stop, and assuming this is done using a hydraulic rock breaker, groundborne noise levels of approximately 39dB(A), assuming four breakers in simultaneous operation, are likely in buildings above the stop, with vibration less than 0.16 KB_{FTR}, resulting in Low impact by night, Very low impact by day.

There is a proposed cross-passage below O'Connell Street Upper which is approximately 170m from the HARI clinic to give a PPV of 1.7mm/s at the clinic. This would interfere with the operation of sensitive equipment, and mitigation in the form of liaison between the site and the hospital will be required to ensure that blasts and critical use of the equipment do not occur simultaneously.

From Parnell Square to O'Connell Street the tunnel is in glacial sands and gravels, re-entering the limestone for the remainder of the route.

From Parnell Street to O'Connell Bridge the sensitive receptors are the hotels in O'Connell Street. The proposed cross-passage below O'Connell Street Upper with approximately 21m of ground cover (26m slant distance to the nearest building). The likely PPV will be 34mm/s, KB_{Fmax} = 17, in excess of the building damage threshold and in the Very high impact category for people in the building. The Low impact threshold of 3mm/s will be exceeded within a radius of 74m and the building damage threshold of 12mm/s will be exceeded within a radius of 45m. With a dominant frequency of 25Hz, this would be equivalent to approximately 0.5g, in excess of the damage threshold for computer equipment. To limit the PPV to the Low impact category for daytime the charge weight per delay would have to be restricted to 1.1kg.

Drill and Blast may be necessary for the construction of O'Connell Bridge Stop beneath the Liffey. The likely PPV will be 48mm/s, KB_{Fmax} = 24, in excess of the building damage threshold and in the Very high impact category for people in the building. The Low impact threshold of 3mm/s will be exceeded within a radius of 74m and the building damage threshold of 12mm/s will be exceeded within a radius of 45m. With a dominant frequency of 25Hz, this would be equivalent to approximately 0.75g, in excess of the damage threshold for computer equipment. To limit the PPV to the Low impact category for daytime the charge weight per delay would have to be restricted to 0.75kg.

During the passage of the TBM in this area, the groundborne noise level is likely to be 48dB $L_{Amax,S}$, High impact if tunnelling takes place at night, Medium impact if tunnelling does not occur at night. Vibration is likely to be 0.09 KB_{FTr} High impact at night, Very low impact by day.

There is a proposed cross passage near Princes Street North, which has approximately 23m of ground cover (25m slant distance to the nearest building). The likely PPV will be 37mm/s, KB_{Fmax} = 19, in excess of the building damage threshold and in the Very high impact category for people in the building. The Low impact threshold of KB_{Fmax} = 3 will be exceeded within a radius of 73m and the building damage threshold of 12mm/s will be exceeded within a radius of 44m. With a dominant frequency of 25Hz, this would be equivalent to approximately 0.6g, in excess of the damage threshold for computer equipment. To limit the PPV to the Low impact category for daytime the charge weight per delay would have to be restricted to 0.6 to 1.0kg depending on the final tunnel alignment.

From O'Connell Street to St. Stephens Green there are buildings with residential use and the academic buildings in Trinity College. There is a proposed cross passage near College Green, which has approximately 23m of ground cover (27m slant distance to the nearest building). The likely PPV will be 32mm/s, KB_{Fmax} = 16, in excess of the building damage threshold and in the Very high impact category for people in the building. The Low impact threshold of KB_{Fmax} = 3 will be exceeded within a radius of 73m and the building damage threshold of 12mm/s will be exceeded within a radius of 44m. The cross passage is close to the northern end of the crossover step-plate junction in which drill and blast may also be used. With a dominant frequency of 25Hz, this would be equivalent to approximately 0.4g, in excess of the damage threshold for computer equipment. To limit the PPV to the Low impact category for daytime the charge weight per delay would have to be restricted to 0.75 to 1.5kg depending on the final tunnel alignment.

During the passage of the TBM in this area, the groundborne noise level in the nearest buildings of Trinity College is likely to be 45dB $L_{Amax,S}$, High impact if tunnelling takes place at night Medium impact if tunnelling does not occur at night. The noise will be clearly audible in Trinity College and intrusive in quiet rooms occupied by people engaged in activities requiring concentration or relaxation. Vibration is likely to be 0.07mm/s KB_{FTr} Medium impact at night, Very low impact by day.

There is a proposed cross passage near Wicklow Street, which has approximately 24m of ground cover. The likely PPV will be 39mm/s, KB_{Fmax} = 20, in excess of the building damage threshold and in the Very high impact category for people in the building. The Low impact threshold of KB_{Fmax} = 3 will be exceeded within a radius of 73m and the building damage threshold of 12mm/s will be exceeded within a radius of 44m. With a dominant frequency of 25Hz, this would be equivalent to approximately 0.6g, in excess of the damage threshold for computer equipment. To limit the PPV to the Low impact category for daytime the charge weight per delay would have to be restricted to 1.0kg.

During the passage of the TBM in this area, the groundborne noise level is likely to be 47dB $L_{Amax,S}$, High impact if tunnelling takes place at night, Medium impact if tunnelling does not occur at night. Vibration is likely to be 0.09 KB_{FTr} High impact at night, Very low impact by day.

The Gaiety Theatre is in King Street South and Groundborne noise at 47dB $L_{Amax,S}$ will cause a High impact during performances. The effect of 47dB $L_{Amax,S}$ in the theatre will depend on the nature of the production. During quiet moments in a production, this will be clearly audible and intrusive. The main mitigation possible is liaison with the theatre managements, with as much advance warning as practicable. Reduction in face pressure and/or cutter speed may be an option although the effect on ground settlement must also be taken into account.

At St. Stephen's Green, blasting is likely to be used for the excavation of the turnback loop. There is approximately 17m of ground cover, and the shortest slant distance to the nearest property is 50m. The PPV is likely to be 13mm/s, KB_{Fmax} = 7, at the limit of the building damage threshold and in the High impact category for people in the building. The Low impact threshold of KB_{Fmax} = 3 will be exceeded within a radius of 74m. To limit the PPV to the Low impact category for daytime the charge weight per delay would have to be restricted to 3 to 4kg depending on the final tunnel alignment.

The nearest residential properties to the north of the proposed Bailey bridge over the Liffey, 15-17 Eden Quay, lie within 24m of driven piling plant. Vibration levels (KB_{Fmax}) of approximately 4.4mm/s are expected here, resulting in a Very high impact. The nearest vibration sensitive property to the south of the proposed Bailey bridge if the Corn Exchange, which lies at a distance of 23m. Vibration levels due to driven piling (KB_{Fmax}) of 4.5mm/s are expected here, resulting in a Very high impact.

The north and south banks of the Liffey lie within approximately 2m of the nearest driven pile from the proposed Bailey bridge. Vibration levels (ppv) of 19mm/s are expected. Assessing these levels according to the criteria set out for building damage due to vibration, gives a High impact.

The Abbey Theatre and Peacock Theatre lie within approximately 50m of the proposed Bailey bridge piling. Groundborne noise may be audible at times as a result of driven piling. If this occurs at audible levels, it will be mitigated. Possible mitigation measures include pre-drilling, using reduced energy piling plant and avoiding noise sensitive times.

5.4.3.2 Project scenario: operational phase

For the purposes of this assessment the vibration performance of the track and vehicles have been assessed by numerical modelling, in two ways. For the most demanding cases, namely the achievement of the limits for sensitive equipment at the Mater hospitals, detailed numerical models of the stops, tunnels and the hospital buildings have been created, and the results have shown that with the use of floating slab track the vibration limits can be achieved. These vibration limits are equivalent to levels of groundborne noise below the most stringent Very low impact magnitudes in Table 5.2, and it follows that in any location where mitigation better than resilient rail support is required, floating slab track will provide mitigation sufficient for the most demanding case.

For track laid without rail joints (except at switches and crossings) and with modern standards of rail alignment, groundborne noise is the determining impact, and tactile vibration is normally at levels below the threshold of human perception. Vibration only requires special consideration in the case of highly sensitive equipment as further explained below.

For the standard case of resilient rail support, three generic models have been created, one for the case of the tunnel in limestone with glacial till (boulder clay) above, one for the case of the tunnel in the clay above the limestone and one for cut-and-cover tunnel sections. The basic models are unbounded, and a further model was created including a ground surface to determine the effect of multiple reflections between the ground surface and the limestone rockhead. This was found to increase dB(A) levels by an average of 5dB(A), and this has been added to the unbounded results. The results are speed dependent at the rate of approximately 1dB per 8% change in speed. It is noted that the highest levels are not directly above the tunnel.

Because it will be for the appointed contractor to select the trackform at a future stage in the programme, and the procurement process for the vehicles will take place after the writing of this Environmental Impact Statement, it is not possible to model the performance of the actual track and vehicles. The approach that has been taken is to model the rail support dynamic stiffnesses for resiliently supported rail as 13MN/m per metre run of rail, to yield the likely significant effect of the scheme The vehicle characteristics used have been those for the vehicle with the highest unsprung mass among those likely to be offered by the contractor, and an allowance of 5dB(A) for vehicle and rail support stiffness uncertainty has been added to the results.

The results of the modelling are shown in Figure 5.1 to Figure 5.3. These figures illustrate that generally the groundborne noise will reduce for higher depths of ground cover. They also show that the groundborne noise is dependent on transverse distance from the tunnel, and that it does not follow a simple linear decay.

In any case where either a Medium, High or Very high significant impacts for groundborne noise are identified in this way, or where 'not to exceed' limits for sensitive equipment would be exceeded, incorporated mitigation in the form of floating slab track is assumed.

The results of this assessment are as follows:

At Mater Stop the bored tunnels are in the glacial till (boulder clay) overlying the limestone, and the stop box is founded on the limestone which is at a depth of about 20m. The existing Mater Private Hospital has piled foundations. The proposed future Mater Adult Hospital will have a raft foundation. The depth of the tunnel here is dependent on the choice of two options for the Mater Stop.

Because of the presence of scientific equipment of very high sensitivity to vibration at Mater Misericordiae University Hospital and the Mater Private Hospital a detailed study has been carried out which indicates that the installation of floating slab track will be required through the Mater Stop and the bored tunnels past the Mater Private Hospital. The extent of the floating slab track is likely to extend beyond the end of each hospital building.

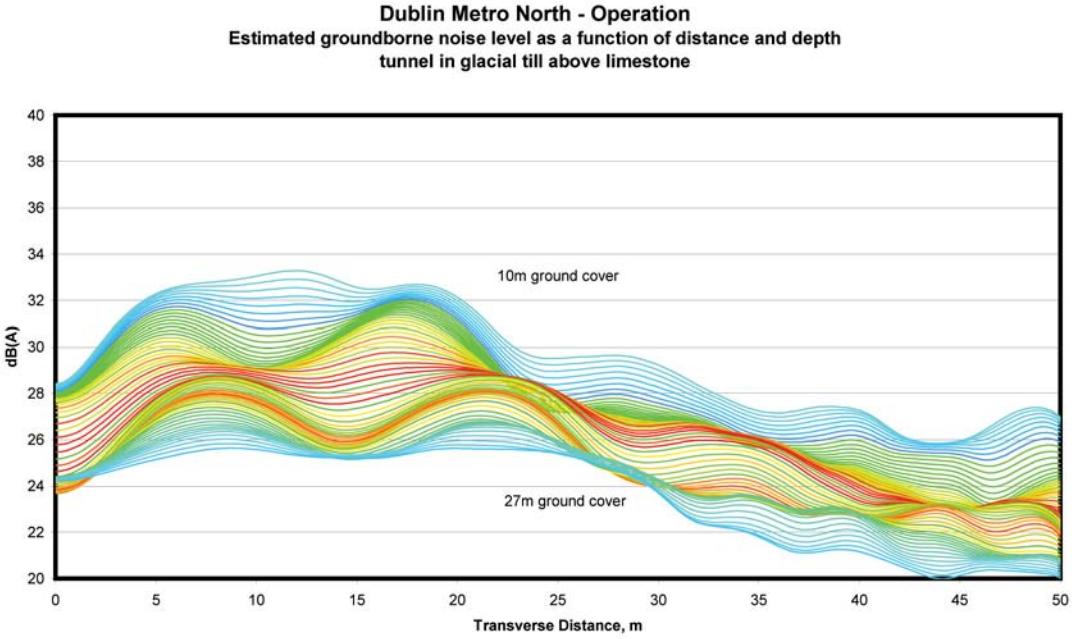

Figure 5.1 Groundborne noise from LMV in bored tunnel in glacial till above limestone

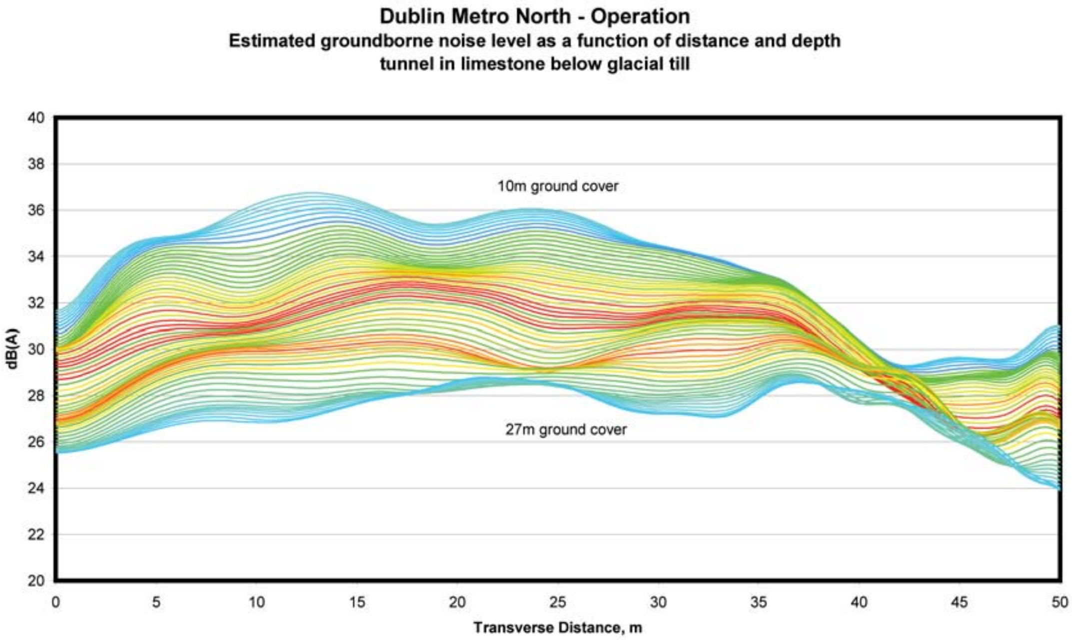

Figure 5.2 Groundborne noise from LMV in bored tunnel in limestone below glacial till

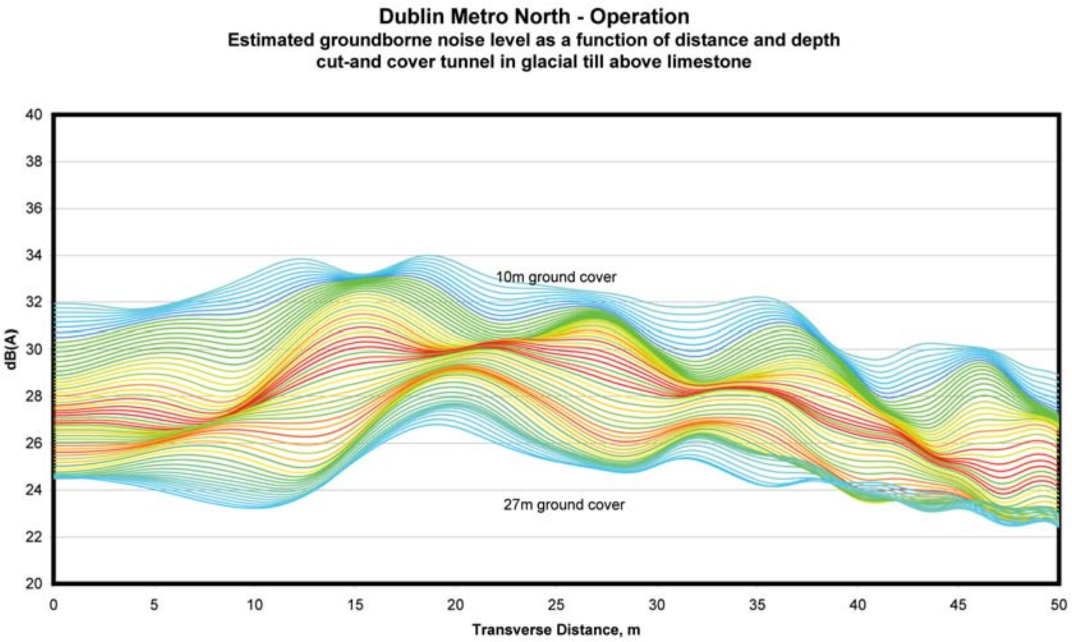

Figure 5.3 Groundborne noise from LMV in cut-and-cover tunnel in glacial till above limestone

South of Mater Stop, the bored tunnels enter the limestone at approximately St. Joseph's Place and pass under residential areas north of Parnell Square. The educational, institutional and community facilities in the area are also sensitive to structure-radiated noise and vibration. There are various protected monuments and structures included throughout the area, mainly Georgian buildings, the Rotunda Hospital including the HARI Clinic, Ambassador Theatre, the Temple Theatre and the Gate Theatre in Cavendish Row. The depth of the tunnel at Parnell Square is approximately 22m, and the presence of these receptors will require the installation of floating slab track as far as Parnell Street in order to avoid a significant groundborne noise or vibration effect.

From Parnell Square to O'Connell Street the tunnel is in glacial sands and gravels, re-entering the limestone for the remainder of the route.

From Parnell Street to O'Connell Bridge the sensitive receptors are the hotels in O'Connell Street. The depth of the tunnel is approximately 24m and resiliently supported rail will provide adequate mitigation to avoid a significant effect, giving an $L_{Amax,S}$ value of up to 30dB. Very low vibration or groundborne noise impacts are likely with standard resilient rail support.

From O'Connell Street to St. Stephen's Green there are buildings with residential use and the academic buildings in Trinity College. There is a crossover proposed close to Trinity College, and the added effect of the passage of wheels over the frogs in the switches will potentially increase the level of groundborne noise above the threshold of High impact for the uses of the spaces within Trinity College. The recommended mitigation measures will either be the use of swing-nose points or the installation of floating slab track, which will be sufficient to avoid significant noise or vibration impacts.

The Gaiety Theatre is in King Street South. The tunnel depth is approximately 25m (increasing towards St. Stephen's Green). Resiliently supported rail will provide adequate mitigation to avoid a significant effect, giving an $L_{Amax,S}$ value of up to 30dB. A detailed study will be required to establish whether the predicted $L_{Amax,S}$ would have fallen to no more than 20dB at the Gaiety Theatre, the threshold above which floating track slab would be required. If floating track slab is necessary it will ensure that no significant impacts occur.

Baseline monitoring showed vibration less than the limit for sensitive equipment for the Mater and Rotunda Hospitals.

5.4.4 Summary of residual impacts

The potential noise and vibration effects from construction and operation of Metro North have been assessed. An assessment of the requirements for mitigation has been undertaken. A summary of the residual impacts associated with the scheme is provided in Table 5.4.

Table 5.4 Summary of residual impacts

	Magnitude of impact taking into account mitigation	Functional value of area affected	Significance of impact
Construction phase			
Goundborne noise (TBM)	medium by day high by night	very high	Significant Significant
Vibration affecting humans (TBM)	very low by day high by night	very high	Not Significant Significant
Vibration affecting buildings (TBM)	high	very high	Significant
Vibration affecting sensitive equipment (TBM)	very high	very high	Significant
Vibration affecting humans (drill and blast)	very high	very high	Significant
Vibration affecting buildings (drill and blast)	high	very high	Significant
Vibration affecting sensitive equipment (drill and blast)	very high	very high	Significant
Operational phase			
Goundborne noise	low or very low	very high	Not significant
Vibration affecting humans	very low	very high	Not significant
Vibration affecting sensitive equipment	very low	very high	Not significant