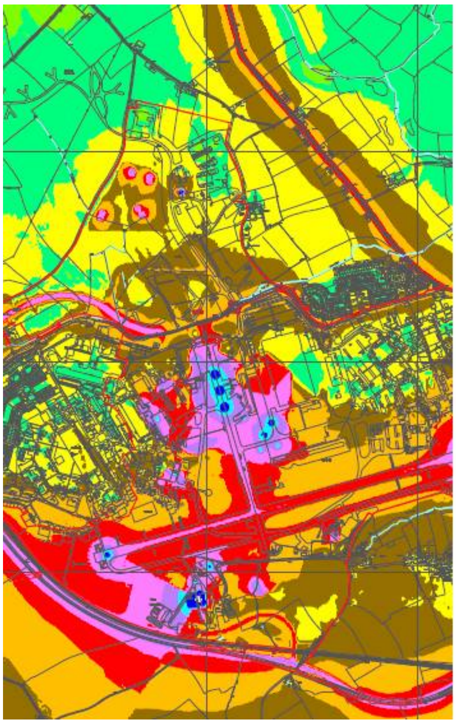
Department of Environment Northern Ireland

Provision of Second Round Noise Maps for Northern Ireland

Railway Noise Mapping – Final Report



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Department of Environment Northern Ireland

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Railway Noise Mapping – Final Report

27 July 2012

AMEC Environment & Infrastructure UK Limited

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Executive Summary

This document outlines the processes which have been adopted to develop the railway noise dataset used within Round Two of noise mapping within Northern Ireland under the Environmental Noise Regulations (Northern Ireland) 2006. The results of the noise mapping process are also presented.

This document aims to give the Northern Ireland Department of the Environment (DoE) and Translink an understanding of the model development process including data capturing and processing, development of the railway noise dataset and related QA procedures.

The report begins with providing an introduction to the requirements of the mapping exercise (Section 1) and outlining the extents of the Round Two (R2) data capture areas (Section 2). This provides the setting for the specific calculation methods used to develop the R2 railway noise maps (Section 3) and the data requirements needed to develop the final noise model maps (Section 4).

The report then outlines the work which has been undertaken to review the datasets used during the Round One mapping exercise and to identify new data for use within Round Two (Sections 5 and 6). This includes preparation of input data covering the geographical location of the railway centrelines; number of overall rail movements; number of diesel locomotives on full power; location and configuration of bridges and elevated tracks; type of rolling stock; overall train and line speeds; track types and support structures.

The processes used to QA the final railway source and emission datasets produced are discussed in detail in Section 7 of the report. These includes highlighting the automated and manual checks which were completed to ensure that the final datasets are both ‘fit for purpose’ and optimised for the final modelling exercise.

In Section 8 of the report, the discussion covers the final calculation and processing settings which have been used to run the LimA modelling environment. This includes providing further details of the efficiency settings, calculation settings; and computational environment used in the modelling processes. The section concludes by outlining the post-processing steps which have been adopted to produce the final modelling outputs.

The final sections of the report (Section 9 -11) detail the preliminary results of the railway noise exposure analysis. This includes providing area analysis of the different noise levels with the more detailed analysis of population and dwelling noise exposure (Sections 9 and 10). This provides the context for the final Section (Section 11) which provides an assessment of the key differences between the outputs of Round 1 and Round 2 mapping exercises.

Contents

Glossary

Term	Definition
Agglomeration	Major Continuous Urban Area as set out within the Regulations
AMEC	AMEC Environment and Infrastructure UK Limited
ArcGIS	GIS software package produced by ESRI
ASL	Above Sea Level
Attribute Data	A trait, quality, or property describing a geographical feature, e.g. vehicle flow or building height
Attributing (Data)	The linking of attribute data to spatial geometric data
BCA	Belfast City Airport
BIA	Belfast International Airport
CORINE land cover 2000	Coordination of Information for the Environment (CORINE) land cover dataset last produced the UK in 2000
CRN	The Calculation of Railway Noise 1995. The railway prediction methodology published by the UK Department of Transport.
CRTN	The Calculation of Road Traffic Noise 1988. The road traffic prediction methodology published by the UK Department of Transport.
Data	Data comprises information required to generate the outputs specified, and the results specified
dB	Decibel
DEM	Digital Elevation Model
DoE	Department of Environment
DSM	Digital Surface Model
DTM	Digital Terrain Model
DWG/DXF	Autodesk Autocad Drawing (DWG) or Data Exchange File (DXF) format
EC	European Commission
EEA	European Environment Agency
EIONET	EIONET is a partnership network of the European Environment Agency (EEA) and its member and cooperating countries. The network supports the collection and organisation of data and the development and dissemination of information concerning Europe's environment
END	Environmental Noise Directive (2002/49/EC)
ENDRM	Environmental Noise Directive Reporting Mechanism
ENDRM DF8	Environmental Noise Directive Reporting Mechanism Data Flow 8
ESRI	Environmental Systems Research Institute
FDMI	Final Modified Data Inputs
GIS	Geographic Information System

Term	Definition
INM	Integrated Noise Model
Irish National Grid (ING)	The official spatial referencing system of Ireland
ISO	International Standards Organisation
KML/KMZ	Keyhole Markup Language (KML) is is used to express geographic annotation and visualization within Internet-based, two-dimensional maps and three-dimensional Earth browsers. The file format is used within Google Earth and many GIS software packages.
Land Cover Map 2007 / LCM2007	CEH Land Cover Map 2007 depicting 23 individual land use classes across the UK.
LimA	Software product produced by Stapelfeldt for calculating noise levels
Metadata	Descriptive information summarising data
NTF	Ordnance Survey National Transfer Format
NISRA	Northern Ireland Statistics and Research Agency
Noise Bands	Areas lying between contours of the following levels (dB): L_{den} <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_d <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_e <55, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >74 L_n <50, 50 – 54, 55 – 59, 60 – 64, 65 – 69, >69
Noise Levels	Free-field values of L_{den} L_d, L_e, L_n, and $L_{A10,18h}$ at a height of 4m above local ground level
Noise Level - L_d - Daytime	L_d (or L_{day}) = $L_{Aeq,12h(07:00 \text{ to } 19:00)}$
Noise Level - L_e - Evening	L_e (or $L_{evening}$) = $L_{Aeq,4h(19:00 \text{ to } 23:00)}$
Noise Level - L_n - Night	L_n (or L_{night}) = $L_{Aeq,8h(23:00 \text{ to } 07:00)}$
Noise Level - L_{den} – Day/Evening/Night	A noise rating indicator based upon Ld. Le and Ln as follows: L_{den} = 10 * lg 1/24 {12 * 10^((L_{day})/10) + 4 * 10^(($L_{evening}$+5)/10) + 8 * 10^((L_{night}+10)/10)}
Noise Level – $L_{A10,18h}$	$L_{A10,18h}$ = $L_{A10,18h}$ (06:00 to 24:00)
Noise Mapping (Input) Data	Two broad categories: (1) Spatial (e.g. road centre lines, building outlines). (2) Attribute (e.g. vehicle flow, building height – assigned to specific spatial data)
Noise Mapping Software	Computer program that calculates required noise levels based on relevant input data
Noise Model	All the input data collated and held within a computer program to enable noise levels to be calculated.
Noise Model File	The (proprietary software specific) project file(s) comprising the noise model
Output Data	The noise outputs generated by the noise model
OSNI	Ordnance Survey of Northern Ireland
Processing Data	Any form of manipulation, correction, adjustment factoring, correcting, or other adjustment of data to make it fit for purpose. (Includes operations sometimes referred to as 'cleaning' of data)
QA	Quality Assurance
Round One	Round One noise modelling for the European Noise Directive (Northern Ireland) - 2007

Term	Definition
Round Two	Round Two noise modelling for the European Noise Directive (Northern Ireland) - 2012
Shapefile	ESRI proprietary GIS dataset format. Contains both geometry to define features, and associated alphanumeric attribute information.
Spatial (Input) Data	Information about the location, shape, and relationships among geographic features, for example road centre lines and buildings.
Translink	The main public transport service provider for Northern Ireland
WG - AEN	Working Group – Assessment of Exposure to Noise

1. Introduction

1.1 Background

The Environmental Noise Regulations (Northern Ireland) 2006 (referred hereon in as the “Regulations”) set out the requirements and responsibilities associated with the production of strategic noise maps and action plans as defined by European Directive 2002/49/EC (referred hereon in as the “Directive”). The Regulations set out the Competent Authorities who have been made responsible for producing noise maps and action plans. Under the Regulations, the Department of Environment (DoE) is named as the Authority responsible for overseeing the implementation of the Regulations. As the overseeing Authority, DoE decided that the noise mapping should be undertaken in a consistent manner and has therefore let a single contract for the preparation of noise maps on behalf of the Competent Authorities.

AMEC Environment and Infrastructure UK Limited (AMEC) were commissioned to prepare noise maps for the Competent Authorities reporting directly to DoE. As part of the commission, AMEC have prepared noise maps, all associated population exposure data and supplementary reports as required under the Regulations and the Directive. The maps and reports will enable Northern Ireland to report the results of the mapping to the European Commission.

This project relates to the second round of noise mapping. Under the Regulations, noise maps and noise action plans must be prepared over a 5-year rolling cycle. The first round of noise mapping in Northern Ireland was undertaken and completed in 2007 using data representative of 2006. For reporting in 2012, the second round of mapping is being undertaken using data representative of 2011.

For the first round of mapping in 2007, the Regulations required the preparation of noise maps for the following:

- All major roads with more than 6 million vehicle passages per year;
- Major railways with more than 60,000 passages per year;
- Major airports; and
- All agglomerations with more than 250,000 inhabitants.

Within agglomerations, the Regulations require the mapping of all road, railway, industry and airport noise sources regardless of the thresholds outlined above. For the second and subsequent rounds of mapping, the Regulations reduce the thresholds for which noise mapping and action planning should be prepared and reported to the following:

- All major roads with more than 3 million vehicle passages per year;
- Major railways with more than 30,000 passages per year;
- Major airports; and

- All agglomerations with more than 100,000 inhabitants.

Under the Regulations, this project aims to establish estimates of the total number of people (in hundreds) living in dwellings that are exposed to major transportation noise sources and all transportation and industrial noise sources within agglomerations. The exposure estimates are for the L_{den} noise indicator calculated 4 metres above the ground and on the most exposed façade of a residential dwelling.

The L_{den} noise exposure statistics are required in the following bands: 55-59, 60-64, 65-69, 70-74 and >= 75. The total area (in km2) exposed to values of L_{den} higher than 55, 65 and 75 dB respectively, along with the estimated total number of dwellings (in hundreds) and the estimated total number of people (in hundreds) living in each of these areas must also be given and reported to the European Commission.

The same information is also required for the L_{night} indicator except reporting is necessary for noise level bands 5 dB lower than for L_{den}. Under this contract, noise level exposure statistics are also required for other supplementary noise indicators which are incumbent within national noise policy guidance.

The contract has been delivered in two stages which are described below. This report documents work undertaken by AMEC for both stages of the contract.

Stage 1 of this contract was undertaken to the following scope:

- Appraisal and quality assurance of the data provided by DoE and the Competent Authorities;
- Identification of gaps in order to define any further information requirements;
- Modifying and/or collecting further information through contractor survey. This includes any data cleaning and manipulation required to prepare the dataset for Stage 2;
- Collation of the data into relevant datasets; and
- Preparation of Stage 1 report.

Stage 1 of the contract also included delivery of the following specific elements of work:

- Descriptions of the processes and approaches adopted for the collection, collation, validation, verification, integration and creation of the noise model;
- Description of the datasets to be generated;
- Detailed description of the noise modelling methodology to be applied to each noise source;
- Acceptable approximations and simplifications where appropriate;
- Software to be used (notably noise model and GIS software environments);
- Efficiency settings; and
- Storage and backup of electronic data.

Stage 2 of the contract was undertaken to the following scope:

- Interrogation of the final datasets produced in Stage 1;
- Creating the digital model in an appropriate format;
- Calculating the defined noise data level outputs;
- Completing modelling, generating maps and reports;
- Presenting the final modified data, metadata and a technical manual for the modelling of railway noise sources; and
- Provision of a report in a suitable format specified by the Electronic Noise Data Reporting Mechanism as preferred by the Commission and suitable for uploading to EIONET.

1.2 Purpose of this Report

This report details the processes used to develop the Round Two railway noise modelling datasets for the mapping of noise levels for railways across Northern Ireland. The aim of this report is to provide Translink and DoE with an understanding of the processes involved in the development of these datasets which have been used to support the assessment of noise for the second round of mapping.

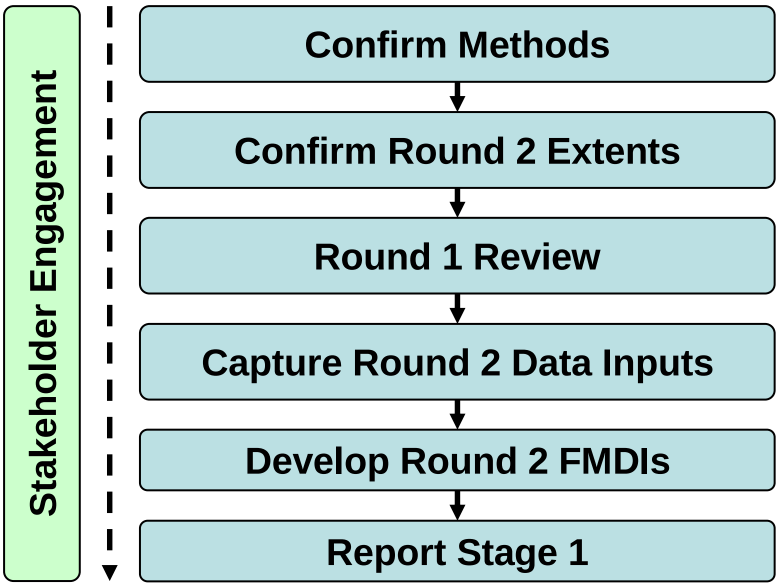
1.3 Overview of the Second Round Approach

Under the contract let by DoE, the second round of mapping was split into two stages as outlined below.

1.3.1 Stage 1

The primary aim of Stage 1 was to develop the Final Modified Data Inputs (FMDIs) needed to facilitate the noise mapping and reporting of noise exposure under the Regulations. Plate 1.1 presents an overview of Stage 1.

Plate 1.1 Overview of Stage 1



Stage 1 was structured to identify and ensure that data inputs and information gathered and processed during the first round of mapping were where possible retained and utilised in the production of noise maps for the second round.

The process was initiated through confirming the methods to be used for the mapping and confirmation of the second round extents. This was followed by a review of the first round datasets and the information used in their development with respect to the project extents and methods. Following this review and where necessary, additional data capture exercises were undertaken.

This report does not explicitly report the findings of the Round One review. Instead the report outlines the results of the Round One review alongside all other relevant sections. For example, noise calculation environments and the preparation of various elements of the railway noise datasets are discussed in this report in relation to both the approach undertaken in Round One and the methodology adopted for Round Two.

1.3.2 Stage 2

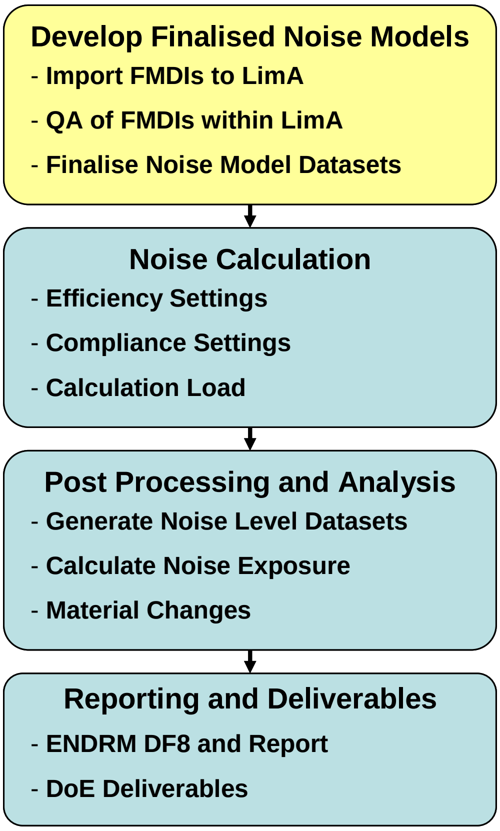
The key aims of Stage 2 of the contract were:

- the development of digital noise models based upon the FMDIs developed during Stage 1;
- the production of second round noise maps including consolidated noise maps of road, rail, airport and industrial noise within the Belfast Agglomeration;
- generation of datasets identifying the total areas and populations within noise level bands as required by the Regulations and the Directive;

- provision of suitable Environmental Noise Directive Report Mechanism (ENDRM) Data Flow 8 (DF8) reporting and associated technical reports for submission to the Commission through the EIONET.

Plate 1.2 presents an overview of the Stage 2 process.

Plate 1.2 Overview of Stage 2



2. Data Capture Extents

Under the Environmental Noise Regulations (Northern Ireland) 2006, Round Two noise maps in relation to railway noise must encompass:

- Major railways with more than 30,000 passages per year;
- All agglomerations (including road, railway, industrial and airport noise sources) with more than 100,000 inhabitants.

The remainder of this section details the extent of the Round Two data capture area under the Regulations for railway noise sources in Northern Ireland. Maps showing the geographical extent of the areas are also provided in Plates 2.1 – 2.2.

2.1 Agglomeration Modelling Extent

The only agglomeration in Northern Ireland considered in Round Two is the Belfast agglomeration, as defined in the Regulations. The Belfast agglomeration is presented in Plate 2.1 and has an approximate area of 198km^2. Data currently available for 2008 shows the Belfast Urban Metropolitan Areas has a total population of 267,742. The Agglomeration was considered in Round One due its population exceeding the Round One threshold of 250,000. The extents of the Agglomeration for Round Two are the same as for Round One.

A review of potential agglomerations qualifying for Round Two has also been undertaken for completeness. Data obtained from the Northern Ireland Statistics and Research Agency (NISRA) for 2008 shows that the second largest urban area in Northern Ireland is the Derry Urban Area. The Derry Urban Area has a population of 85,016 and therefore falls below the 100,000 threshold.

Using the Belfast agglomeration as a basis, a Round Two data capture extent was created. This was developed by applying a 3km corridor to the boundary of the Belfast agglomeration and subsequently clipped against the Northern Ireland coastline. The resulting data capture area of 596km^2 is shown in Plate 2.1.

2.2 Major Railway Modelling Extent

At the start of the Round Two, Translink confirmed that there had been no major changes to the railway network in Northern Ireland since 2006 and that all of Northern Ireland’s major rail network falls within the Belfast Agglomeration. As a consequence the stretches of rail network mapped and considered during the first round have been used as the basis for the data capture process. Following railway movement data obtained from Translink, the major railway extents have been confirmed and differ to those expected as part of Northern Ireland’s submission to the Commission in 2008. This has however confirmed that Northern Ireland’s major railways are located in and around the Belfast Agglomeration. The extent of Northern Ireland’s major railway network is shown in Plate 2.1.

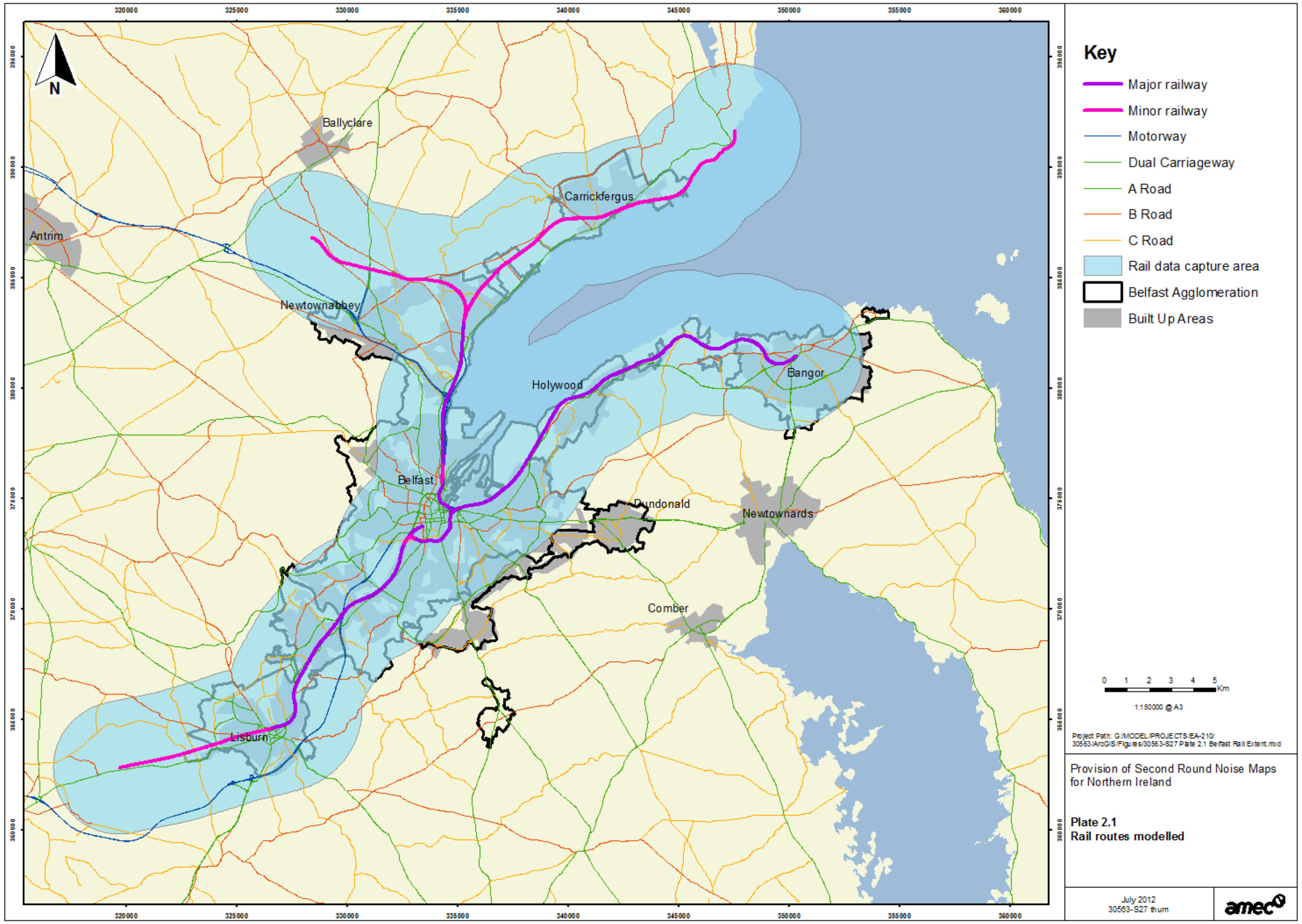
2.3 Round One and Round Two Data Capture Extents

Table 2.1 provides a summary of the extent of railways and data capture areas used for the Round One and Round Two mapping exercises.

Table 2.1 Railway – Length of Railway mapped and the Extent of the Data Capture Area

Length of Railways Mapped (km)	Round One	Round Two
Minor railways	148.4	59.2
Major railways	0	89.2
Total	148.4	148.4
Data Capture Area (km^2)	**Round One**	**Round Two**
Total area	No information available	455.4

Plate 2.1 Belfast Agglomeration showing Location of the Major and Minor Railway Routes Modelled during Round Two



3. Confirmation of Calculation Methods

3.1 Noise Calculation Method

Under the Regulations the assessment method prescribed for the mapping of railway noise sources is outlined in Table 3.1. It is confirmed from a review of Round One that the same methods were adopted and applied during Round One. For Round One, the methods outlined in Schedule 2 were adopted and/or supplemented by additional guidance.

Table 3.1 Methods of Assessment as Outlined in Schedule 2 of the Regulations (Rail)

Assessment method for railway noise indicators
7. For railway noise indicators the assessment methods—
(a) "Calculation of railway noise" (Department of Transport, 13th July 1995, HMSO)(d); and
(b) (in relation to railways to which it is expressed to apply) "Calculation of railway noise 1995 Supplement No. 1 Procedure for the calculation of noise from Eurostar trains class 373" (Department for Transport, 20 October 1996, Stationery Office)(e);
shall be used, adapted as shown in Figure 6.5 of the report "Rail and wheel roughness – implications for noise mapping based on the Calculation of Railway Noise procedures" (DEFRA March 2004)(f).

For railway noise, the assessment for Round One was undertaken with reference to the following:

- Railways: Calculation of Railway Noise (CRN) (UK) - adapted version comprising:
  - Calculation of Railway Noise (Department of Transport, 13th July 1995, HMSO);
  - Calculation of Railway Noise 1995 Supplement No. 1 Procedure for the calculation of noise from Eurostar trains class 373" (Department for Transport, 20th October 1996, Stationery Office);
  - "Rail and wheel roughness – implications for noise mapping based on the Calculation of Railway Noise procedure" (Defra, March 2004);
  - "Additional railway noise source terms for "Calculation of Railway Noise 1995" (Defra, May 2004); and
  - Supplementary information regarding noise emissions and railway roughness corrections for the Northern Irish rail fleet as provided by DeltaRail during Round One.

For Round Two, there is no requirement to alter the method adopted for Round One. It was also concluded that the adopted method outlined above remains relevant to the delivery of the strategic noise maps under the Regulations.

For Round Two, the noise calculation assessment method described in this section has been used to inform data requirements and identify any additional data capture requirements.

3.2 Software Methods

For Round One, noise mapping of railway noise sources were prepared using the LimA version 5.2 noise modelling package with geo-processing and analysis undertaken with the ESRI ArcGIS software environment.

For Round Two both software environments have been retained. The LimA version that has been adopted for Round Two is version 8.1. Following discussions with Stapelfeldt Ingenieurgesellschaft mbH, developers of the LimA noise mapping software, it is understood that there have been no modifications to the implementation of the CRN methodologies between versions 5.2 and 8.1.

4. Dataset Specifications

The development of the railway noise source emission model dataset has been undertaken with the aim of developing and finalising "Final Modified Data Inputs" (FMDIs) in accordance with a data specification satisfying the requirements of the assessment method and software environments.

To calculate noise levels at a specific location or receptor, the following must be established:

i. The level of noise being generated at source (i.e. the noise emissions)

ii. The attenuation of noise levels during propagation from source to receiver (i.e. the propagation)

This report concentrates on the development of the railway noise emission dataset. Development of the noise propagation dataset is discussed in the accompanying Northern Ireland Round 2 Noise Mapping 3D modelling report. It is recommended that this report is read in conjunction with the Round 2 3D modelling report.

For Round One, a dataset specification was developed for the railway noise emission dataset which was designed to function with the selected software environments. As there has been no change in the calculation methods or software environments employed in Round Two, the FMDI dataset specifications have been retained from Round One. The dataset specification is provided in full in Appendix A.

In order to populate this dataset, a list of data requirements was developed. These data requirements are outlined in Section 4.1.

4.1 Data Requirements

A number of specific data requirements were required to develop a 'fit for purpose' railway noise emission dataset which could be used as an input for the Round 2 mapping exercise. These data requirements are identical to those developed in Round One and include:

- Rail centreline
  - between the two railheads
  - one per rail line
  - plan accuracy to within 1.5m in urban areas
  - plan accuracy to within 3.0m in rural areas
  - in any case should not cross the "top of embankment" or "bottom of cutting" polylines
  - section accuracy to within 0.5m

- Total vehicle volume of all vehicles along centreline
  - Annual average day, evening and night 18 hours and 6 hours traffic flow
- Diesel Locomotives on Full Power
  - Locations where diesel locomotives are normally on full power
- Bridges and elevated tracks
  - Location and type of bridge or track support
- Type of rolling stock
  - Matched to CRN categories
- Train speed
  - For each type of rolling stock
- Track type and support
  - Where jointed ,slab or continuously welded
  - How supported
- Maximum line speed
  - Per track
- Acoustic Track Quality (ATQ)
  - Per track.

Table 4.1 Railway Noise Emission Dataset Requirements

Input		Spatial Reference	Object Type	Unit	Validated Range
Rail centre line geometry		Vector	Polylines	Metre (m)	n/a
Train flow		n/a	n/a	n/a	n/a
Track type/track support structure		n/a	n/a	n/a	n/a
Rolling Stock		n/a	n/a	n/a	n/a
Speed	Diesel locomotive on full power	n/a	n/a	n/a	n/a
	Rail Vehicle Speed				
Number of vehicles comprising train		n/a	n/a	Number Integer	*1-50 Vehicles
Bridge/ballast correction		n/a	n/a	NA	n/a
Rail roughness / ATQ		n/a	n/a	dB(A)	n/a
Rail grinding		n/a	n/a	n/a	n/a

* Range of values displaced within the tables and charts of Calculation of Railway Noise (Department of Transport, 13th July 1995, HMSO);

5. Round Two Dataset Development

5.1 Reviewing the Round One Data Sources

Prior to the development of the Round Two railway noise emission dataset, the project team undertook a review of the Round One dataset which was provided to AMEC by DoE. The review was undertaken through a study of the GIS FMDIs and the final Round One railway noise mapping report produced by the previous contractor. The review process set out to identify the following:

- The data sources used to create the Round One datasets;
- Availability of Round One data sources for Round Two over required extents;
- Where any added value or editing was present within the Round One dataset; and
- Whether or not the data source could be improved upon or further refined for Round Two.

This first deliverable of this review was the preparation of a data review questionnaire which was submitted to Translink. This purpose of this questionnaire was to understand whether there had been any changes in the agglomeration and major railway networks in Northern Ireland that may influence Round Two data capture and results; and also to assist with the review process. Table 5.1 presents a summary of the key outcomes of this data review.

Table 5.1 Reviewing the Round One Datasets

Data Input	Round One Data Source	Round One Coverage relevant for Round Two Mapping	Value Adding/ Editing	Potential Improvement?
Rail Centrelines	OSNI LargeScale	Yes	Yes	No
Total Movements	Schedules	Yes	No	No
Diesel Locomotives on Full Power	Train Drivers	Yes	No	No
Elevated Track Locations/ Bridges	Various	Yes	Yes	No
Rolling Stock	Schedules / Engineering	Yes	No	No
Train Speed	Speed Limits and Recorded Tran Speeds	Yes	Yes	No
Track Type and Support	Various	Yes	Yes	No
Rail Roughness	Informed Assumption	Yes	No	Yes

The review identified that most of the data obtained and available during Round One were also available for Round Two mapping over the required extents. The review also identified that much of the information used within Round One was already in a format which could readily transferred in to Round Two from the Round One FMDIs.

The following sections outline the development of the Round Two rail source emission dataset. Where relevant, the results of the Round One review and the relevance of the Round One datasets to the development of the Round Two dataset are discussed in further detail.

5.2 Railway Centrelines

For Round One, railway centrelines were derived from the OSNI LargeScale digital mapping product. An initial review of the railway line features within the OSNI LargeScale digital mapping product showed that there had been no fundamental changes to the location and extent of the railway network in Northern Ireland between 2006 and 2011. The data questionnaire responses by Translink also confirmed that:

- There has been no additional rail lines laid in Northern Ireland since 2006;
- No disused or closed railway lines had reopened;
- There had been no light rail schemes in Northern Ireland which may affect noise levels in the Belfast Agglomerations or could be considered as Major Railway; and
- No new stations had opened since 2006.

Based on these responses, it was determined by the project team that the derived Round One railway centrelines could be used as basis for modelling Round Two noise emissions as there has been no fundamental changes to the extents under consideration between rounds.

5.3 Rail Movements

Rail movement data is required by the assessment method in order calculate noise emission levels from the total number and type of rail vehicles operating on a section of the rail network. The total number of rail passages, in terms of trains, is also required in order to determine whether a rail route qualifies above the major railway threshold of 30,000 passages per annum.

In order to be compliant with the Regulations, vehicle movements are required for the following five separate time periods:

- Day (0700 – 1900hrs)
- Evening (1900 – 2300hrs)
- Night (2300 – 0700hrs)
- 18 Hour UK Day (0600 – 0000hrs)

- 6 Hour UK Night (0000 – 0600hrs)

For the first round, Translink derived annual passenger vehicle movements for each route on the Northern Ireland rail network from timetables representative of 2006. Vehicle passenger movements were provided in two directions and were assigned to a specific rolling stock with further details of the typical train make up i.e. number and type of vehicle units comprising the train. Additional information regarding the number of engineering movements to and from Translink's York Road depot, and for the number of 'out of service' passenger trains were also provided and modelled.

As part of the review process, the project team raised the following queries with Translink.

- Has there been any change in timetabling between 2006 and 2011 that would materially affect the number of rail movements?
- Are there any new or additional services from 2006 which are now effective in 2011?
- Has there been any change in train services since 2006 which are now effective in 2011 which may affect the number of stopping and terminal services?
- Has there been any change in the rolling stock services that are operated on any of the services identified modelled in Round One i.e. are new trains operating the services?
- Are all of the passenger services in Round One still operating?
- Has there been any change in the engineering movements and rail engineering vehicles since 2006?

Following these queries, Translink issued a set of revised rail vehicle passenger movements representative of 2011, as outlined in Appendix B. These vehicles movements were based on schedules and took into considerations developments throughout 2011, notably the introduction of the Class 4000 on the Larne line. Following review of the 2011 passenger movement data, further clarifications regarding terminating passenger services were sought to more accurately model stations and to confirm with a greater a level of confidence the extents of major railway to the south of Lisburn.

From the review process, Translink confirmed that the 'out of service' passenger train movements and engineering movements used in Round One were applicable to Round Two. The only exception was the insistence on the inclusion of the Fortwilliam Depot which was not considered in Round One.

5.4 Diesel Locomotives on Full Power

For Round One, the location of where diesel locomotives are on Full Power was provided by Translink. This information was sourced from information recorded/provided by individual locomotive drivers. Two locations in the Lisburn area were identified as being where full power was required. These locations were apparent from the Round One FMDI GIS railway noise emission dataset as being locations where the L_FP attribute was set to a value of 1.

For the Round 2 exercise, Translink confirmed that there had not been any change to signalling or rolling stock which would potentially require further review of these locations or identify any further locations. As such the locations obtained from the Round One FMDI's were adopted for Round Two.

5.5 Bridges and Elevated Tracks

For Round One, bridges and elevated tracks were identified from a variety of sources including analysis of digital mapping data, aerial photography, the Translink Bridge Inventory and a field survey used to verify the locations of bridges from other sources of data.

As part of the 3D-modelling work, the project team reviewed the location of bridges by intersecting railway features within the OSNI LargeScale dataset with other features such as water and roads.

Through the data review questionnaire, the project team also asked Translink whether:

- There have been any new bridges constructed on the Northern Irish rail network since 2006?; and
- Any bridges have been replaced since 2006?

Translink confirmed that there had been no new or replaced bridges since 2006. As such, bridge information including bridge construction type, as found within the Round One FMDI railway noise emission dataset was accepted as being relevant and was adopted for Round Two.

5.6 Type of Rolling Stock

A key data requirement of the CRN calculation methodology is the consideration of the noise emissions from the various train vehicles making up movements on a section of track. For Round One, information regarding rolling stock was provided by Translink in the form of movements schedules. As part of the data review questionnaire, the project team asked Translink whether there had been any new rolling stock that had entered service on their network in 2011 in comparison to Round One.

Tranlink confirmed that a new Class 4000 train had entered service part way through 2011 and was replacing the existing Class 400 trains which operate on the Larne Line. The Class 4000 is technically very similar to the Class 3000 trains already operating on the network and a made by the same manufacturer, CAF. Translink also confirmed that the Class 110 locomotive hauled Mark IIf/IIb carriage trains operating between GVS and Newry had been retired.

Table 5.2 presents a summary of the technical details of each train operating on the Northern Irish rail network.

Table 5.2 Overview of Northern Ireland Rail Fleet

Rail Vehicle	Maximum Speed	Horse Power	Propulsion	Braking System	Used Between (R1)	Used Between (R2)
Class 110 Locomotive	90mph (144kmh)	2475bhp	Diesel	Tread	GVS – Newry	Retired
Class 201 Locomotive	90mph (144kmh)	3200bhp	Diesel	Disc	Belfast – Dublin	Belfast – Dublin
Mark IIf/IIb Coaches	70mph (112kmh)	n/a	n/a	Tread	GVS – Newry	Retired
Enterprise Loco Hauled Carriage	90mph (144kmh)	n/a	n/a	Disc	Belfast - Dublin	Belfast – Dublin
Class 450	70mph (112kmh)	560bhp	Diesel-Electric	Tread	Belfast – Bangor Belfast – Portadown Belfast – Larne	Belfast – Larne
Class 3000	90mph (144kmh)	Unknown	Diesel	Disc	Bangor – Portadown Belfast – Londonderry	Bangor – Portadown Belfast – Londonderry
Class 4000	90mph (144kmh)	530hp	Diesel	Disc	-	Belfast – Larne
Class 80	70mph (112kmh)	560bhp	Diesel-Electric	Tread	All lines (maintenance)	All lines (maintenance)
Tampers: Plasser 07-16 Plasser 08 Plasser 08-16 SP4	- - -	402 hp 402 hp 805 hp	Diesel	Tread	All lines (maintenance)	All lines (maintenance)
Ballast and Hopper Wagons: HTA Wagons	75 mph (121 kmh)	n/a	n/a	-	All lines (maintenance)	All lines (maintenance)

5.7 Train and Line Speeds

Train speed is a critical input for calculating railway noise emissions. The CRN calculation method requires that train speed is provided per train and rail vehicle and that this speed is provided at all locations along the railway line.

For Round 1, train speed information was captured from:

- Permanent speed restrictions which obtained from annotated paper maps marked against mileposts; and
- Actual train speed obtained from the data recorder of a Class 3000 train.

During Round 1, Translink confirmed that the speed of Class 3000 trains on any of its routes would provide a good representation for other train movements due to operational procedures. Where the data obtained from the Class 3000 did not cover sections of the rail network, Translink confirmed that speed restrictions should be used instead. From reviewing the Round 1 FMDIs, actual speeds obtained from the Class 3000 trains were present within the L_VEL attribute whereas speed restrictions were identified within the L_VAD attribute.

The project team raised the approach adopted during R1 with Translink through the data questionnaire and Translink confirmed that this data would be applicable for R2 mapping. The L_VAD and L_VEL values and spatial locations from R1 have therefore been subsequently adopted for R2.

5.8 Track Type and Support Structure

CRN allows for railway noise emissions to be corrected depending upon track type and support structures. Different railway track types and supports can comparatively enhance and indeed reduce noise emissions. Understanding the location and type of track, bridges, points and switches is therefore a key requirement when calculating railway noise emissions.

During R1, this information was captured through a series of meetings with Translink and from information held within their bridge inventory. Virtual techniques including aerial imagery was also employed to confirm the location and type of various support structures.

For R1, all railway lines were modelled as Continuous Welded Rail (CWR) on a Ballast track bed. This followed confirmation from Translink that the majority of the rail network in the vicinity of Belfast is, if not all, CWR laid on ballast. This characteristic was confirmed by Translink at the start of R2.

As part of the data questionnaire, the project team also asked Translink to identify any new or replacement bridges on the Northern Irish network. Translink confirmed that there had been no new or replaced railway bridges on the network since R1. On this basis, the project team identified that the content of the L_TT (track type) and L_TS (track support) was still current for R2 mapping and on this basis, the content of the L_TT and L_TS attributes was adopted.

The location of tunnels was also reviewed, and the R1 FMDI checked to ensure that the tunnels were modelled appropriately by disabling noise emissions.

6. Development of R2 Rail Emission Dataset

This section of the report presents the development of the R2 railway noise emission dataset using the information captured and adopted as outlined in Section 5. The calculation of railway noise emissions has been undertaken using a specially developed railway noise emission geo-processing and database script developed in the Python programming environment. The follow section details specific information which is relevant to the calculation of railway noise emissions using this script.

6.1 Rail Centrelines Emission Objects

The R1 FMDIs were adopted as the R2 rail centreline emission objects. No modifications were made to these objects with the exception of including an additional source emission line running into and out of the Fortwilliam depot. This was inserted by digitising between the railheads presented within the OSNI Largescale dataset. The adoption of the R1 FMDIs ensured that railway noise emissions in Northern Ireland continue to be modelled at track level rather than route level. Track level modelling is more accurate than route level modelling as a track level model considered all railway lines within a given rail corridor or route. This approach is also compliant with CRN. Route level modelling simplifies the railway by assuming that all railway movements within a given route occur on a single rail centreline. This approach has also been adopted in England, Wales and Scotland and can result in uncertainties where rail corridors are wide.

6.2 Assigning Rail Movements to Rail Centrelines

The assignment of rail movements to the rail centrelines was undertaken using relational database techniques. For each rail movement provided by Translink, a unique ID was assigned in terms of a 'J_ID' or 'Journey ID'. The unique J_ID for the rail movements is presented in Appendix B and is incorporated within the information provided by Translink.

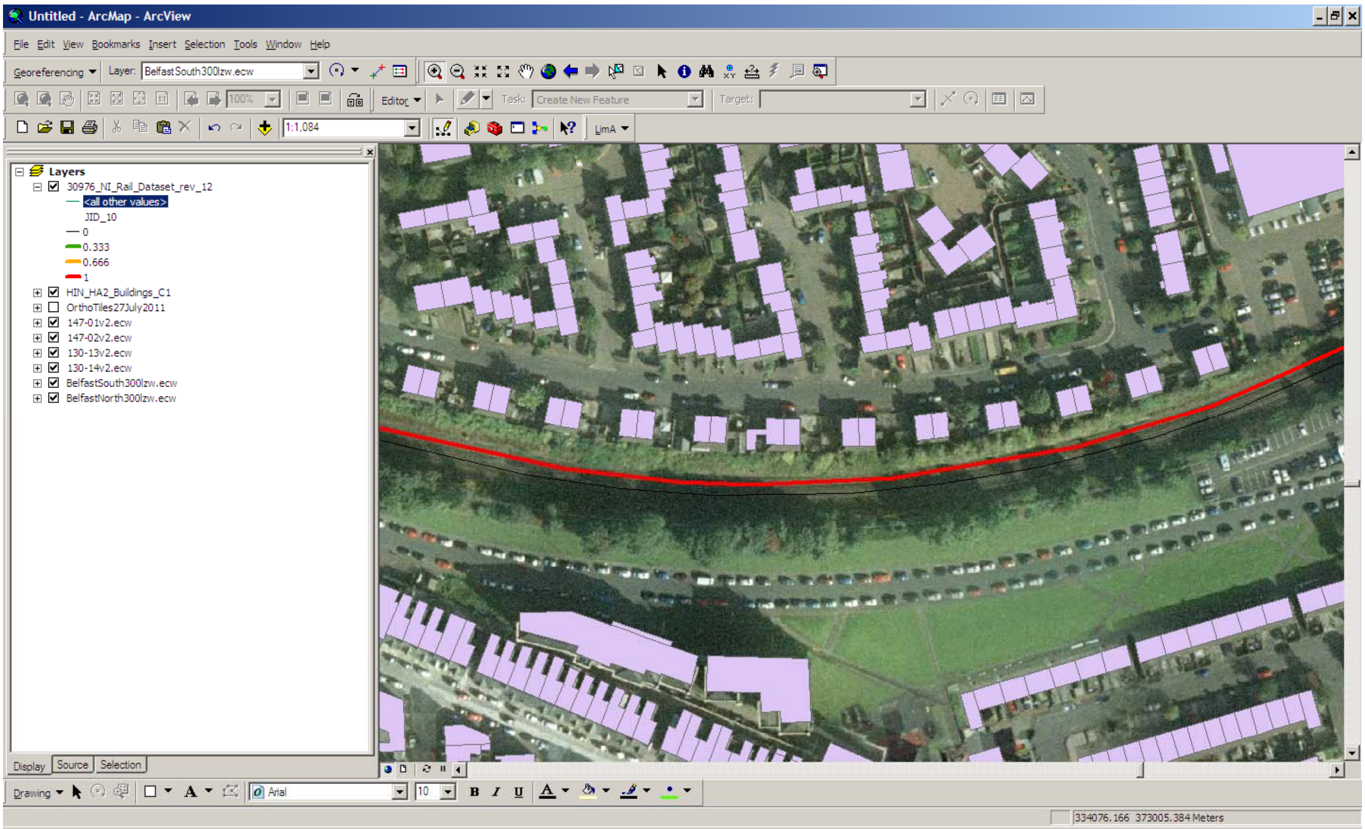
Using GIS, each rail centrelines was assigned a 'J_ID' value between 0 and 1 to reflect the proportion of movements of a journey operating on a certain track. For majority of cases, this J_ID was assigned to either 0 or 1. In some instances, such as stations, the J_ID was set to reflect a spread of movements across tracks and platforms. Using a database scripting, details of the journey, including the number of movements and rail vehicle details could be obtained for the purposes of rail emission calculations.

The assignment of movements, and any associated assumptions, in terms of the J_ID is discussed in the following sections for general sections of railway; stations and depots.

6.2.1 General Rail Movements

For general rail movements between stations, the assignment process adopted a default assumption that trains run on the left hand track in their direction of travel. Plate 6.1 presents an example of this assumption for a passenger service movement between Great Victoria Street and Belfast Central.

Plate 6.1 Example of Left Hand Direction of Travel



Red line shows the modelled rail emissions between Great Victoria Street and Belfast Central. The red line is modelled on the left hand track assuming that the direction of travel is always on the left hand line.

It should be noted that for the majority of the railway lines considered by the mapping, the J_ID was assigned to either 0 or 1 to reflect all or none of the movements operating on the line. In some scenarios, notably beyond terminating stations, the J_ID has been set to a value reflecting the number of trains carrying on past a station and the number that terminate at the station. This is discussed further in the following section.

6.2.2 Stations

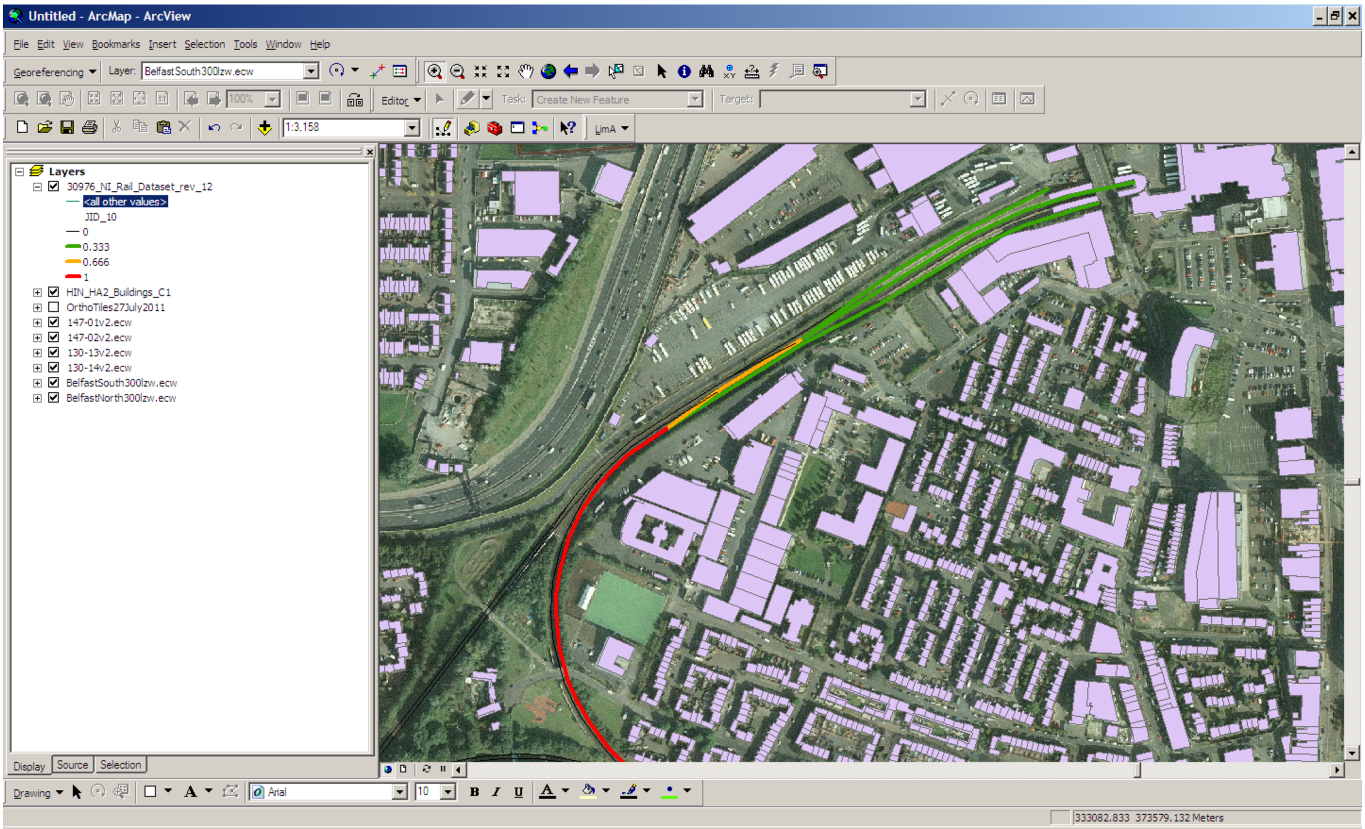
For R1, three options were considered for the modelling of train movements into and out of stations:

- Option 1 – model only two centrelines into and out of stations;

- Option 2 – Proportion movements into and out of stations by service type; and
- Option 3 – average total services across all available platforms into and out of stations.

Following discussions with Translink, it was decided that Option 2 was most appropriate for the modelling of the railways in Northern Ireland. Subsequent guidance was provided by Translink relating to the allocation of railway movements across platforms. This guidance has been reviewed and confirmed by Translink as appropriate for modelling in R2. An example of the application of the Option 2 approach is provided below in Plate 6.2.

Plate 6.2 Example of J_ID Attribution at Great Victoria Street Station



Example shows the distribution of railway movements by J_ID into platforms at Great Victoria Street Station. The green lines assume that 33% of the movements will be allocated across these platforms. The orange line assumes that 66% of the movements will be allocated. The red line assumes that 100% of the movements will be allocated to the line.

Due to the lowering of the major rail threshold for R2, it has also been necessary to carefully review the modelling process for stations outside of the Belfast agglomeration and specifically to confirm the extent of major rail. This has involved consideration of the number of trains terminating and continuing past Carrickfergus and Lisburn stations.

Further information regarding the number of terminating trains at these stations has been used in combination with information regarding the modelling of platforms. This appends the information provided by Translink during R1 and is presented in Appendix C.

6.2.3 Depots

In R1, the York Road Depot was modelled using guidance provided by Translink on the allocation of movements to and from the depot. Following queries between the project team and Translink, it was identified that the Fortwilliam depot should have also been modelled in R1 but was ignored. Translink confirmed that the movements to and from the Fortwilliam depot should be modelled for R2 and provided indicative movements. The project team have modelled the movements in and out of the Fortwilliam depot as a single route in and out of the depot. The approach to modelling routes in and out of the York Road depot has been retained from R1.

Further details of modelling the approaches to modelling movements in and out of the York Road depot are outlined in Appendix C.

6.3 Modelling of Rail Vehicles

6.3.1 Total Vehicle Movements

The CRN method requires that all train movements be considered in terms of railway vehicles (or ‘bogies’) in order to calculate noise emissions. This means, for example, that a single train comprising of a locomotive and eight carriages is modelled in terms of noise emission from the locomotive and each of its eight carriages. In the case of multiple unit trains, a single multiple unit train is modelled in terms of number of units it comprises.

Movement data provided by Translink for passenger movements, out-of service passenger trains, engineering movements and terminating services were provided in terms of trains. This approach is appropriate for determining the extent of major rail as the Regulation requires the consideration of the ‘number of train passages’ which must be considered at route level. For the mapping of railway noise in Northern Ireland, the approach adopted by the project team and the methodology outlined in CRN requires railway vehicles to be modelled at track level. To this end, Translink provided details of the typical composition of the trains outlined in the movements provided. In addition, Translink also outlined the routes which the trains are operating.

Using the information provided, the project team developed a look-up table which linked the trains provided in the movement data to the number of various vehicles they comprised. This look-up table was expanded to contain additional information relevant to the calculation of railway noise emissions that is intrinsic to the type of railway vehicles. This is discussed further in the following sections.

6.4 Railway Vehicle Noise Emission Data

As discussed in Section 6.4, the project team developed a look-up table which linked the various trains outlined in the movements provided by Translink to the number of railway vehicles they each comprised. This look-up table was extended to include details relevant to the calculation of noise emissions from each rail vehicle. These details included:

- Maximum vehicle speed;
- Rail vehicle emission factors for rolling noise, fan noise and diesel on-power noise; and
- Railway roughness.

6.4.1 Maximum Vehicle Speeds

Maximum vehicles speeds were taken from technical specification for each of the rail vehicles identified within the data provided by Translink. The importance of maximum speeds is to ensure that rail vehicles are not modelled above their maximum operating speed. In the calculation of noise emissions, the speed obtained from the rail centreline is cross checked against the maximum operating speed. Where the speed obtained from the line is higher than the operating speed, the trains maximum speed is used within the calculation of the noise emissions.

6.4.2 Rail Vehicle Noise Emission Factors

The adapted version of CRN used within the mapping considered noise emissions from three noise sources on a train. Each rail vehicle considered has emission factors for the sources that change between vehicles to differentiate their noise emission characteristics. These sources are as follows:

- **Rolling Noise** – this is noise from the rail-wheel interface and is modelled at the railhead;
- **Diesel Locomotive (Full Power)** – this is noise generated at the exhaust of a diesel locomotive when at full power. This noise source only applies for diesel locomotives when at full power and is modelled at 4m. When this source is modelled, the rolling noise from the diesel locomotive is excluded from the calculation;
- **Fan Noise** – this is the noise source generated by the fans from Class 373 Eurostar trains and was included for the purposes of modelling a specific characteristic of the Eurostar as part of the Channel Tunnel Rail Link (CTRL). This source is modelled at a height of 2m above the railhead. The specific nature of this source means that it not relevant to the noise mapping exercises undertaken for Northern Ireland.

During R1, emission factors for Rolling Noise and Diesel Locomotive (full power) noise sources was obtained from Deltarail. This information has been retained for R2 with the addition of new data for Class 4000 trains which are new to R2.

The Class 4000 is a development of the existing Class 3000 train manufactured by CAF. Although both trains are of similar length and have similar transmission and braking systems; the trains are fitted with different engines. As the train does not require the consideration of a Diesel Locomotive (Full Power) emission source, only emission factors for the rolling noise source are required. Rolling noise is highly dependent upon a train’s breaking system and transmission. The Class 3000 and Class 4000 are very similar in this respect and therefore it is reasonable to adopt the same Class 3000 rolling noise emission factors for the modelling of the Class 4000.

For R1, the modelling of wagons and hoppers associated with engineering movements was undertaken with the assumption that half of these vehicles would be full and the other half empty. This is due to the emission factors for rolling noise for these vehicles differing due to loading. This assumption has been retained for R2.

6.4.3 Railhead Roughness

Rolling noise is the dominant component of railway noise over a large speed range. Railhead roughness is a significant factor in the rolling noise emissions from by the railways. The core calculation methodology within CRN assumes that trains are operating on smooth, unperforated lines. Railway roughness occurs when a train vehicles wheel locks during breaking and flat spots. Rail vehicles with tread brakes are much more prone to flat spotting than disc-braked vehicles and for this reason, rolling noise emissions tend to be much lower for disc-braked vehicles. Flat spotting is generally associated with cast-iron tread brakes rather than the latest composite types which tend result in similar rolling noise components as disc-braked vehicles.

In general, flat spotting results in two effects:

- increased rolling noise emissions due to the flat spot interacting with the railhead; and
- general increases in rolling noise emissions for rail vehicles with smooth wheel interacting with resultant perforations in the railhead.

Research has indicated that railhead roughness can account for increases of up to 20 dB(A) in rolling noise emissions in comparison to the methodology outlined in CRN. The adapted version of CRN used for the mapping Northern Ireland accounts for Railhead Roughness using guidance provided by Deltarail.

As outlined above, railway roughness affects rolling noise emission at the railhead and through the wheel-railhead interaction. When considering emissions factors for railhead roughness, the wheel roughness characteristics of the rail vehicles must be considered in combination with the railhead roughness of the track. To this end, it is necessary for rail vehicles to be considered in terms of whether their wheels are ‘rough’ or ‘smooth’ and to what extent their wheels interact with the roughness of the track, otherwise known as gradient. This information has been adopted from R1. For the Class 4000 trains, these characteristics have been adopted from the Class 3000.

6.4.4 Final Railway Noise Emission Look-up Table

Table 6.1 presents the railway vehicle noise emission data adopted for the mapping. The table presents the railway vehicle emission data described in the previous sections for each railway vehicle modelling in R2.

Table 6.1 Final Railway Noise Emission Look-up Table

V_ID (Vehicle ID)	Train Vehicle	Maximum Vehicle Speed	Wheel Condition	Gradient	Rolling Noise Emission Factor	Diesel Locomotive (Full Power) Emission Factor
01	Class 110 Locomotive	90mph (144kmh)	Smooth	0.64	13.0 dB	-5.0 dB
02	Class 201Locomotive	90mph (144kmh)	Smooth	0.64	13.0 dB	-13.0 dB
03	Mark IIf/IIb Coaches	70mph (112kmh)	Rough	0.73	14.8 dB	n/a
04	Enterprise Loco Hauled Carriage	90mph (144kmh)	Smooth	1.00	6.0 dB	n/a
05	Class 450	70mph (112kmh)	Rough	0.40	16.1 dB	n/a
06	Class 3000	90mph (144kmh)	Smooth	0.90	7.6 dB	n/a
07	Class 4000	90mph (144kmh)	Smooth	0.90	7.6 dB	n/a
08	Class 80	70mph (112kmh)	Rough	0.40	16.1 dB	n/a
Tamper & Liner:						
09	Plasser 07-16	n/a	Rough	0.70	12.0 dB	n/a
10	Plasser 08					
11	Plasser 08-16 SP4					
Ballast and Hopper Wagons:						
12	HTA Wagons (Loaded)	75mph (121kmh)	Smooth	0.90	7.1 dB	n/a
13	HTA Wagons (Empty)	75mph (121kmh)	Smooth	0.68	10.4 dB	n/a

6.5 Diesel Locomotives on Full Power

As discussed earlier in this section, CRN considers a separate noise source and set of emission factors for diesel locomotives that are on full power. For the purposes of noise mapping, an understanding of where diesel locomotives are at full power is required. As discussed earlier in this section, Translink confirmed that the location of diesel locomotives using full power remains the same as that in R1 and as such the locations obtained from the R1 FMDIs as outlined in the L_FP attribute have been adopted.

For the purposes of calculation railway noise emissions, where the L_FP attribute stored on the railway centrelines is set to 1, diesel locomotives are considered as being on full power and railway noise emissions for these vehicles are calculated accordingly.

6.6 Track Type and Support Structure

As discussed earlier in this section, Translink have confirmed that track type and support structures have not changed from R1 and therefore the information held within the L_TT and L_TS attributes in the R1 FMDIs can be retained for R2.

Track type and support only effects rolling noise emissions. The L_TT and L_TS attributes are indexed to lookup tables for the various rolling noise source corrections offered by CRN for the track type and support structures considered by the method. Table 6.2 and Table 6.3 presents these lookup tables for track support and type respectively as considered by CRN.

Table 6.2 Support Structure Rolling Noise Correction Look-up Table

L_TS	Material	Structure Type[1]	Correction to Rolling Noise Emissions (dB)
01	Concrete	Bridge	+1 dB
02		Viaduct	+1 dB
03	Steel	Generic	+4 dB
04		Box Girder (with rails fitted directly girder and orthotropic slab). Rail Bearer and cross and lattice girder	+9 dB

[1] Descriptions from CRN

Table 6.3 Track Type Rolling Noise Correction Look-up Table

L_TT	Track Type Description[1]	Correction to Rolling Noise Emissions (dB)
01	Continuously Welded Rail (CWR) on Concrete Sleepers and Ballast	0 dB
02	Continuously Welded Rail (CWR) on Timber Sleepers and Ballast	0 dB
03	Jointed Track (18.3m lengths).	+2.5 dB
04	Points and Crossings	+2.0 dB

[1] Descriptions from CRN

For the purposes of calculating noise emissions, the corrections outlined in Table 6.2 and 6.3 are obtained from the L_TS and L_TT attributes on the rail centrelines and then applied to rolling noise emissions. It should be noted that corrections for support structure and track type are arithmetically summed before being applied to rolling noise emissions.

6.6.1 Crossings, Points and Switches

Crossings, points and switches were considered in R1 by setting the L_TT attribute to a value of 4 in the location of these features. Although the location of these features has not changed since R1, these were reviewed prior to the calculation of emissions.

6.7 Train and Line Speeds

Train vehicle speed is a key component in the modelling of railway noise emissions. This is reflected in CRN models where rolling noise emissions increase with increasing rail vehicles speeds. In the case of diesel locomotive (full power) noise sources, emissions decrease within increasing speeds.

Using information provided by Translink, it was confirmed that the same rail vehicle and line speed assumptions adopted for R1 were applicable for R2. This information is held within the L_VEL and L_VAD attributes within the R1 FMDIs. Additional information relating to speed, in the form of maximum rail vehicle speeds, is also stored in the railway vehicle noise emission look-up table outlined in Table 6.1.

For the purposes of calculating noise railway noise emissions, speed has been handled as follows:

- The calculation script checks for an entry in the L_VEL and L_VAD attributes. Where a speed is present within the L_VEL attribute, this indicates a measured train speed for the line is available and is adopted. Where no L_VEL speed is available, this indicates that no measured speed information is available and the line speed stored within the L_VAD attribute is adopted;

- The L_VEL or L_VAD speed is checked against the maximum speeds of the rail vehicles. Where the maximum speed of the rail vehicle is lower than L_VEL or L_VAD, the speed adopted for the calculation of emissions is set at the maximum rail vehicle speed otherwise the L_VEL or L_VAD speed is adopted for the calculation.

This approach is compliant with the approaches and guidance outlined in the WG-AEN GPG2 Toolkit 9 from Defra research project NANR 208 as outlined in Plate 6.3 below.

Plate 6.3 WG-AEN GPGv2 Toolkit 9 Guidance for the Modelling of Train Speeds

Toolkit 9: Train (or tram) speed			
Method	complexity	accuracy	cost
Reliable train speeds are **available from the owner of the tracks**		< 0.5 dB	
Reliable train speeds are **available from the operators of the trains**		< 0.5 dB	
Measure train speeds		< 0.5 dB	
Use timetables and distances to calculate an average speed (may not be possible for freight trains)		2 dB	
Take the minimum of the following two values: • maximum train speed • maximum track speed		2 dB	

It should be noted that this approach within the calculation of emissions reflects the accuracy and hierarchy of the methods outlined in Toolkit 9.

6.7.1 Assumptions and Rules within L_VAD and L_VEL Attributes

The L_VAD attribute considered maximum line speeds as provided by Translink during R1. The data considered within this attribute is subject to rules and assumptions. This includes a minimum modelling speed of 20 kmh^{-1} as this speed is the lowest permissible within the CRN method. This assumption mainly effect stations and platforms and has been retained for R2. For completeness, it should also be noted that the measured speeds stored within L_VEL attribute as taken from the Class 3000 data recorders during R1 have also been restricted to a minimum speed of 20 kmh^{-1}.

6.8 Rail Roughness

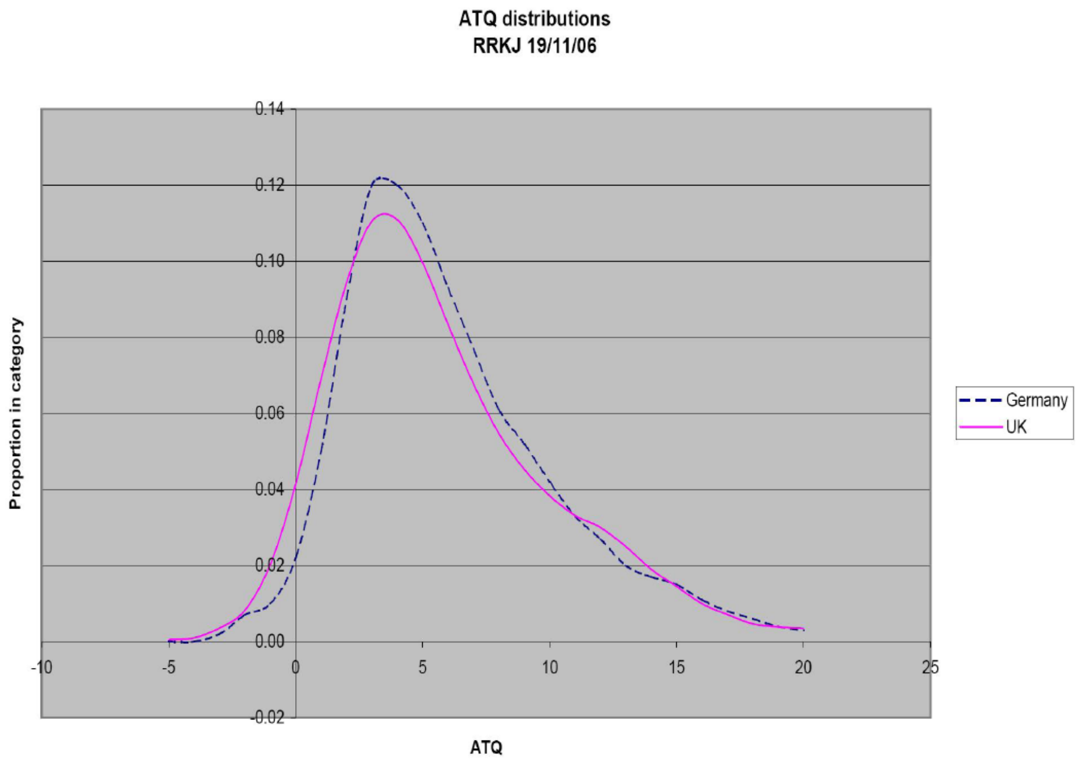
As discussed in Section 6.5, railhead roughness is a combination of direct and indirect effects through the flat-spotting of rail vehicle wheels. Although railhead roughness is considered for rail vehicles, some consideration must also be given to the roughness of the rail. This consideration is given through the concept of Acoustic Track Quality (ATQ).

ATQ was developed by Deltarail through their study of the influence of railway roughness upon railway noise levels and emissions. ATQ aims to quantify railway roughness against the core assumption within CRN that a railhead is smooth. The ATQ is measured in decibels (dB). Where ATQ is equal to 0 dB, this reflects the core assumption of CRN. Where the ATQ of a track is higher than 0 dB, this reflects a track which produces more noise that the core CRN assumption. Conversely, where the ATQ is less than 0 dB, this reflects a track which performs better than the core assumption in CRN and produces lower noise emissions.

Through measurements undertaken by Deltarail, ATQ has been found to vary from around -5 dB for very smooth track to around +20 dB for rough perforated tracks. For a smooth wheeled vehicle this results in changes in rolling noise emissions directly proportional to the ATQ of the track i.e. rolling noise are increased or decreased by value of the ATQ. For rough wheeled vehicles, the relationship between rolling noise emissions and ATQ is more complex in that the effects of wheel roughness upon noise emission become more dominant when the railhead is smooth. Deltarail have developed equations to calculate the correction due to railhead roughness for rough wheeled vehicles.

To fully consider railhead roughness, it is preferable to determine the ATQ of all modelled tracks. However this information was not available in R1 and required the development of an assumption relationship based upon a measured distribution of ATQ obtained from Deltarail. This distribution is shown in Plate 6.4.

Plate 6.4 Measured Distribution of ATQ as reviewed in R1



Based upon the information presented in Plate 6.4, a ATQ value of 4 dB was applied for all rail lines in Northern Ireland. during R1.

As part of the data review questionnaire, Translink confirmed that ATQ has not been captured prior to the R2 mapping exercise and that assumptions used during R1 should be applied to R2. Although the project team are aware of companies who can directly measure ATQ, capture of this data would be extremely costly to undertake and was therefore ruled out as a possibility in the R2 mapping exercise. The ATQ value of 4 dB during R1 was therefore applied for R2 within the L_ATQ attribute field.

6.9 Source Segmentation

To calculate railway noise emissions, it was necessary to segment the railway noise centrelines to reflect changes in the input parameters that lead to changes to in railway emission levels. Much of this segmentation was already present within R1 FMDIs however, in some locations, additional segmentation has been required. Plate 6.5 presents the concept of source segmentation with respect to the various input parameters required for the calculation of emissions. The project team have undertaken this segmentation within the ArcGIS environment.

Plate 6.5 Railway Emission Source Segmentation

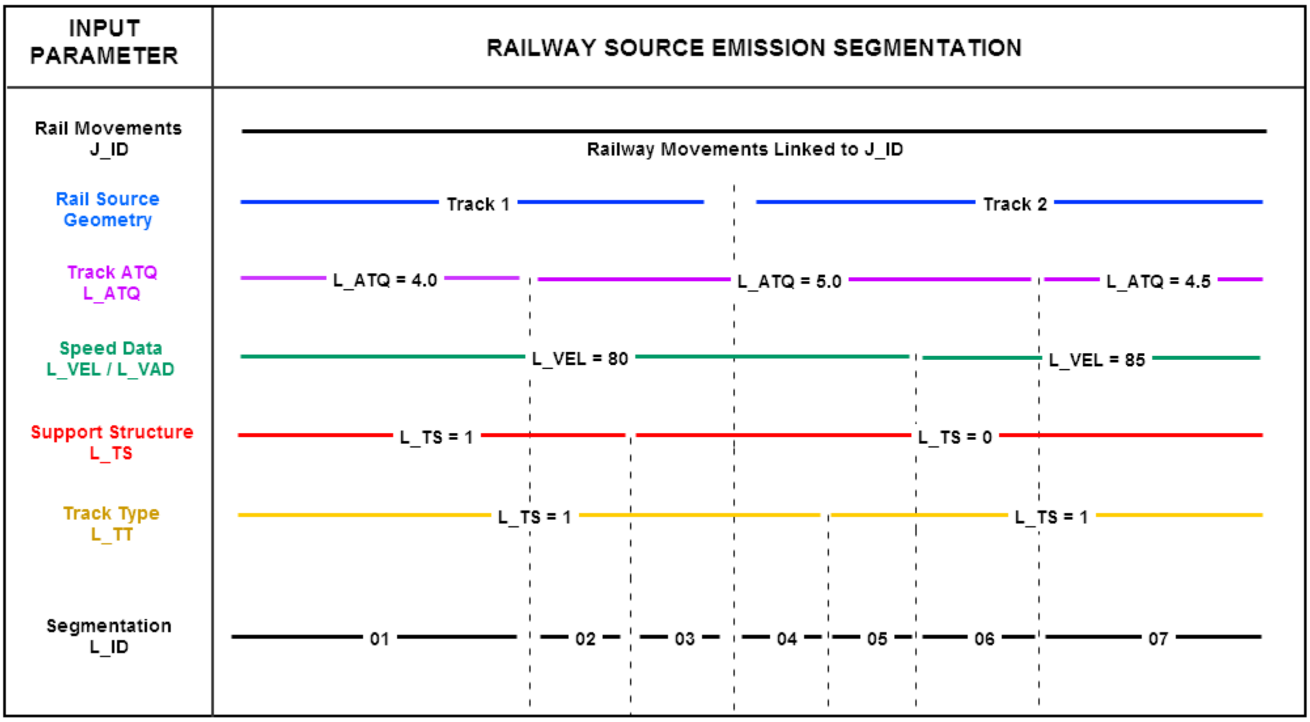
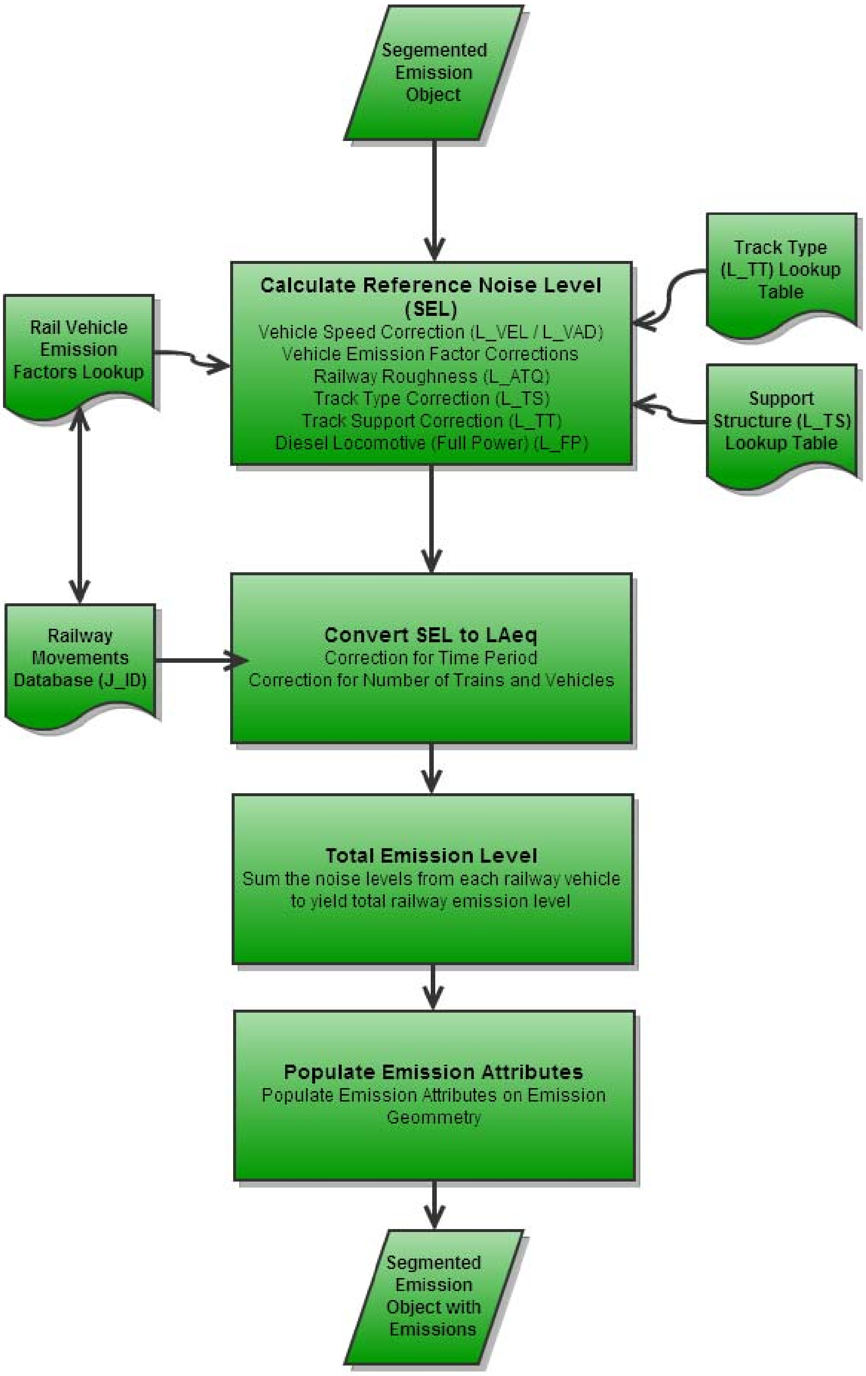


Plate 6.5 shows that the resultant emission source segmented according to the changes in the emission input data is referenced against a unique ID stored within the L_ID attribute. The resulting segmented railway noise emission line can then be used to calculate railway noise emissions.

6.10 Calculation of Railway Noise Emissions

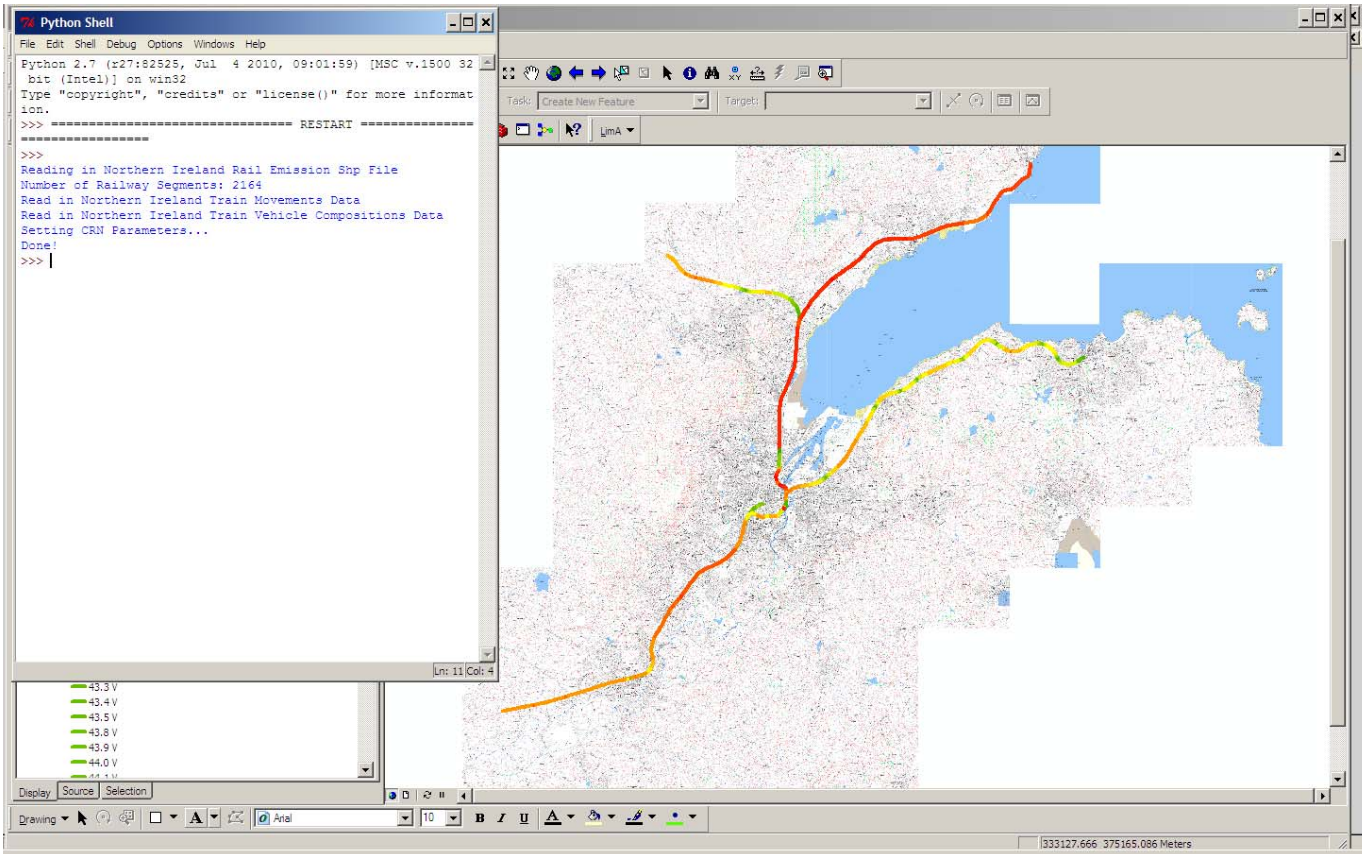
As stated previously, the calculation of railway noise emissions has been undertaken using a geo-processing and database script developed in the Python programming environment. This script is designed to read in the segmented source emission geometry and source emission attributes, perform the calculation of railway noise emission in accordance with adapted CRN and populate the emission attributes on the rail emission geometry. As part of the process the script reads data from the lookup tables outlined in this section to ensure that each rail vehicles, track type and support structure is handled correctly within the calculation. Plate 6.6 presents an overview of the process of calculating the railway noise emissions using the script.

Plate 6.6 Process Diagram for the Calculation of Railway Noise Emissions



As part of the scripting process, information regarding the total number of train passages is also reported against routes to allow the extent of major rail to be confirmed and determined. The script also checks for inputs which do not match values in any of the look-up tables. Any blank or missing values are also reported so that any potential errors are identified before the calculation commences. Plate 6.7 presents an illustration of the populated emission objects and the Python scripting.

Plate 6.7 View of the Emission Calculation in ArcGIS and Populated Rail Emission Objects



Upon completion of the calculation of emission, the BRT source emission dataset was reviewed before being signed off as complete.

7. R2 Railway Noise Model Development with the LimA Environment

7.1 Introduction

This section details the Quality Assurance procedures implemented upon the R2 railway noise model dataset. All railway noise emission datasets and 3D modelling datasets were developed in the GIS environment in accordance with the various LimA object dataset schemas associated with each model layer. This approach aims to reduce the processing required within the LimA software environment and seeks to ensure that datasets are compliant with the LimA software.

The Quality Assurance of the Round Two datasets marks the transition from the GIS environment to the LimA software environment and marks the beginning of Stage 2 of the project. The QA procedures aim to identify whether the various GIS datasets comprising the railway noise model have been developed to specification. It also aims to ensure that calculations will run without error and that any issues encountered with any of the noise model layers are identified before calculation and corrected as required.

The QA procedures adopted by the project team broadly reflect those implemented for Round One. However, developments within the LimA software itself has allowed many of these procedures to become automated and further refined. Like the approach adopted in Round One, all QA procedures have been undertaken with the assistance of electronic proformas. These proformas ensure that all steps within each stage of the QA procedures are adhered to in sequence and are correctly implemented. The proformas also allow version control, file paths and corrective actions to be formally issued between the noise calculation and GIS teams. Plate 7.1 presents an example proforma.

Plate 7.1 Example QA Proforma

Stage 3A QA - Integrity Checks in LimA Modelling Env.

Project Title	Northern Ireland Second Round Noise Mapping
Project Number	30563
Project Sub-Area	A2
LimA Server Project Path	\\emanlima1\LimAjobs\30563\DATA_TESTING

Note: Scroll over the QA Check to review checking requirements. Perform Checks from Left to Right

Shapefile Data Inputs								
Data Layer	File	CHECK 1 OK?	CHECK 2 OK?	CHECK 4 OK?	CHECK 7 OK?	Renumber ELEs	SAVE	Pass / Fail?
~~HIN_HA1~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
HIN_HA2	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\MODEL\HIN_HA2\A2_HIN_HA2_03.BN	Yes	Yes	Yes	n/a	Yes	Yes	Pass
HIN_HA4	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\MODEL\HIN_HA4\A2_HIN_HA4_02.BN	Yes	n/a	Yes	n/a	Yes	Yes	Pass
HIN_HA7	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\MODEL\HIN_HA7\A2_HIN_HA7_02.BN	Yes	Yes	Yes	Yes	Yes	Yes	Pass
GEL	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\MODEL\GEL\A2_GEL_01.BNA	Yes	n/a	Yes	n/a	Yes	Yes	Pass
~~BRL~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
~~RDL~~	~~No Data Layer for Project Sub-Area~~		n/a		n/a			
~~IND~~	~~No Data Layer for Project Sub-Area~~				n/a			

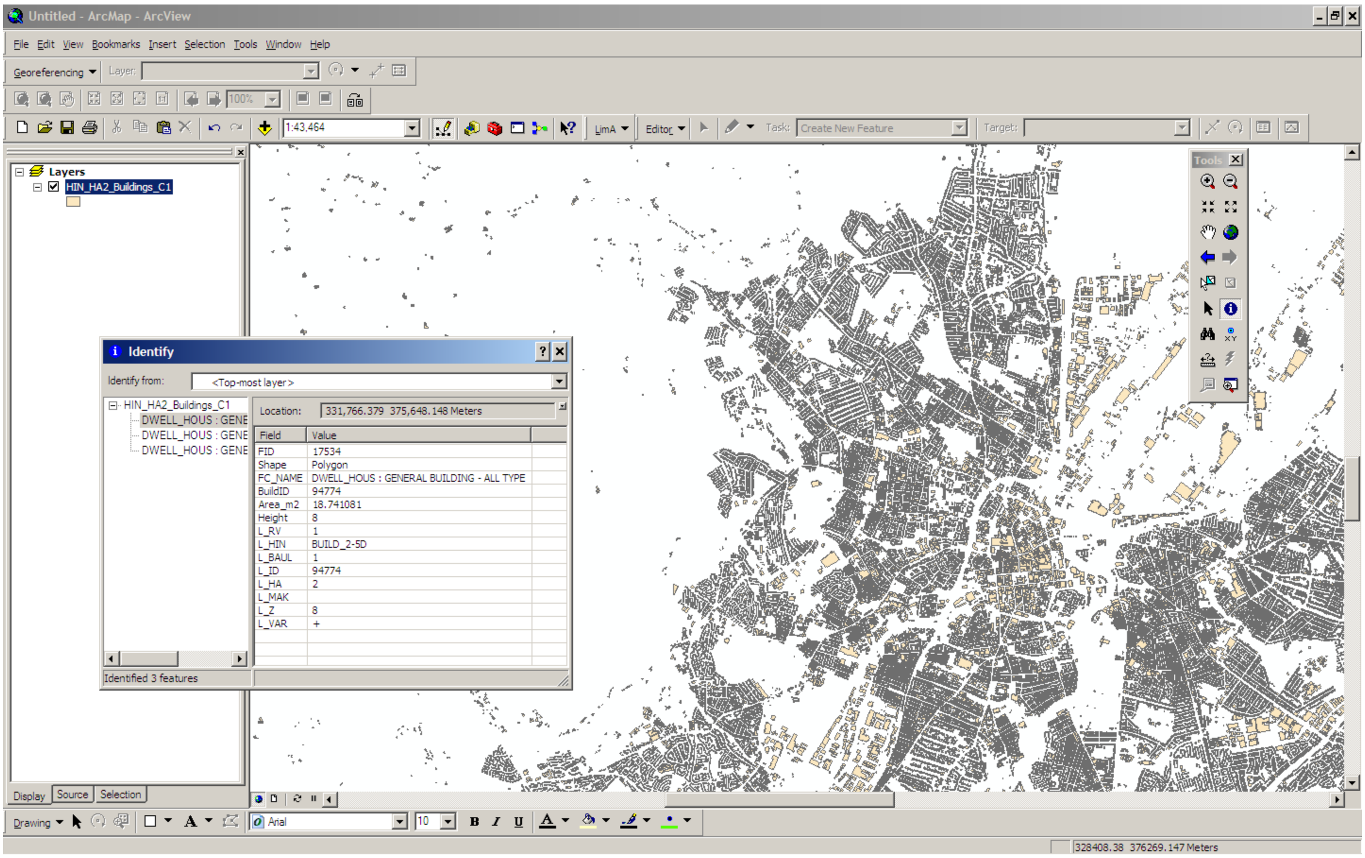
Corrective Actions		Description
Data Layer	File Path	
~~HIN_HA1~~	~~No Data Layer for Project Sub-Area~~	
HIN_HA2	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\SOURCE\HIN_HA2\A2_HIN_HA2_03.S	Doubles identified and elements renumbered, saved as rev03
HIN_HA4	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\SOURCE\HIN_HA4\A2_HIN_HA4_02.S	All clean - saved rev02
HIN_HA7	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\SOURCE\HIN_HA7\A2_HIN_HA7_02.S	All clean - saved rev02
GEL	\\emanlima1\LimAjobs\30563\DATA_TESTINGA2\SOURCE\GEL\A2_GEL_01.SHP	All clean - saved rev02

The QA procedure comprises of a five stage process. The first three stages of the QA procedure are implemented on a layer by layer basis. The fourth stage of the QA procedure requires the interaction of all 3D modelling layers to ensure that the noise model is correctly compiled. The fifth and final stage of the QA process involves undertaking test calculations.

7.2 Stage 1 of the QA Process

Stage 1 of the QA procedure is a check of the datasets in the GIS environment by a member of the noise calculation team prior to import into the LimA environment. The purpose of this stage is to ensure that the data has been correctly prepared in terms of spatial extent, object type and attribution and is generally suitable for importation into the LimA environment. This process is outlined in Plate 7.2.

Plate 7.2 GIS Dataset checking in ArcGIS Prior to Import into LimA

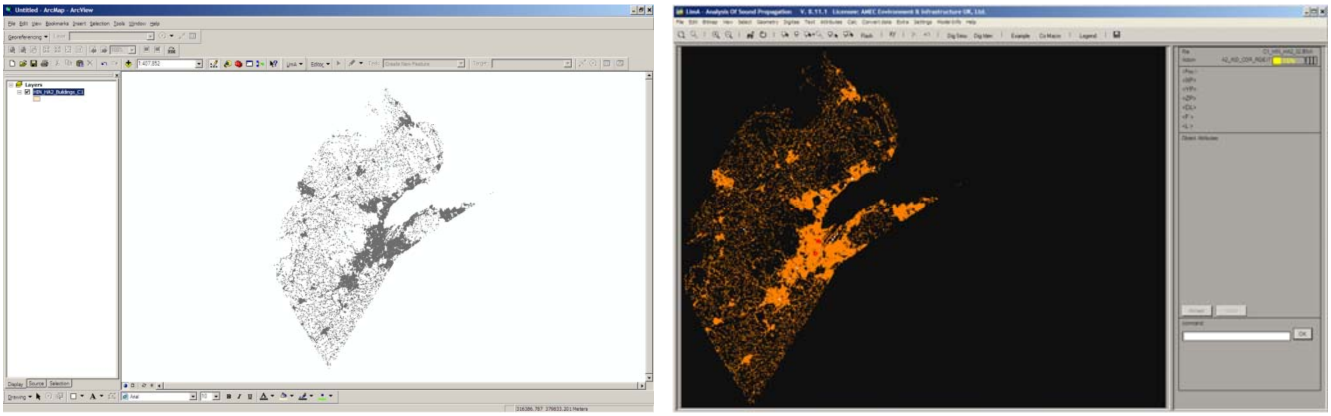


7.3 Stage 2 of the QA Process

Stage 2 of the QA procedure is the importation of the GIS model layers into the LimA environment. All data is exported from the GIS environment in Shapefile format and imported into the LimA environment in the software's proprietary BNA file format. The importation process is a one-to-one conversion as is illustrated in Plate 7.3. This means that all objects in GIS must be stored as single feature and should have unique identification numbers. As part of the importation, LimA warns of any objects which do not meet this requirement or have significant non-compliant topographies.

The QA process in Stage 2 requires the documentation of any errors during importation and feedback to the GIS project team when any errors are encountered with corrective actions.

Plate 7.3 Data in ArcGIS and LimA Environments Respectively



7.4 Stage 3A of the QA Process

Stage 3A incorporates the testing of the imported datasets within the LimA modeling environment. The LimA modeling environment has several built in check procedures which look for topographic and attribution issues and/or errors. Each model layer has a different series of checks that it must undergo. For example, bridge objects have a check designed specifically for their object type.

Once imported the QA procedure requires each LimA modeling object (e.g. bridge, building etc.) to undergo a series of checks. These checks include:

- Object integrity checks (i.e. does the object meet its topographic definitions);
- Attribution checks (i.e. are the attributes populated appropriately);
- Object definitions checks; and
- Duplicable object checks.

Where errors are identified by the check procedures, LimA marks the objects for correction. Depending upon the number of corrections required the QA procedures allows these to be undertaken within LimA or alternatively passed back to the GIS team with a set of corrective actions. All amendments are documented within the proformas.

7.5 Stage 3B of the QA Process

Stage 3B of the QA procedure reflects those undertaken in Stage 3A except these checks are undertaken within the LimA calculation environment. Each layer is subject to LimA's 'Model Check' procedure. When performed on a layer-by-layer basis, this check highlights any object attribution or topographic errors that are not highlighted within the LimA modelling environment. These include:

- Incorrect object attribution (i.e. are the attributes populated appropriately);
- Duplicable object checks; and
- Incorrect or incompatible topographies (e.g. polylines with incomparable vertex spacing).

The checks undertaken as part of LimA's 'Model Check' function are more rigorous that than those undertaken in Stage 3A within the LimA modeling environment. These checks ensure that each model layer is error free prior to Stage 4.

7.6 Stage 4 of the QA Process

Stage 4 is the most involved stage of the QA process. Stage 4 is a QA of the interaction of the various model datasets comprising the noise model. The Stage 4 QA process is broken into several small stages as outlined in Table 7.1. An example of the interface used for this review process is provided in Plate 7.4.

Table 7.1 Tests undertaken in Stage 4 of the QA Process

Test	Model Layers	Description
T1	HIN HA 4, GEL, HIN HA 7	Bridges interact correctly with the DTM
T2	HIN HA 4, GEL, HIN HA 2	Buildings interact correctly with the DTM
T3	HIN HA 4, GEL, HIN HA 1	Barriers interact correctly with the DTM
T4	HIN HA 4, GEL, HIN HA 2, HIN HA 7, HIN HA 1, TOP	Bridge, Barrier and Building interact correctly with the DTM and Ground Cover
T5	As T4 and BRT Objects	Check Complete Ground Model interaction with BRT Railway Noise Emission Objects

Each test culminates in the complete QA of the ground model within the LimA calculation environment using the 'Model Check' feature.

In Test T1, the noise calculation team review the digitisation of each bridge and their 3D positioning as outlined in Section 8. Each bridge is reviewed in 3D and corrected if necessary. Bridges which are incorrectly digitised are automatically flagged by the LimA calculation core however incorrect position is not. A manual check is therefore the only means of ensuring that bridges have been correctly digitised.

In Test T2, the ‘Model Check’ functions evaluates the height of flat topped buildings based on the relative height of the building and the height of the terrain at the start point of the building object. The key output of the check is the identification of buildings which have relative heights which fall below the surrounding terrain. This is possible in locations where buildings are located on sloping terrain.

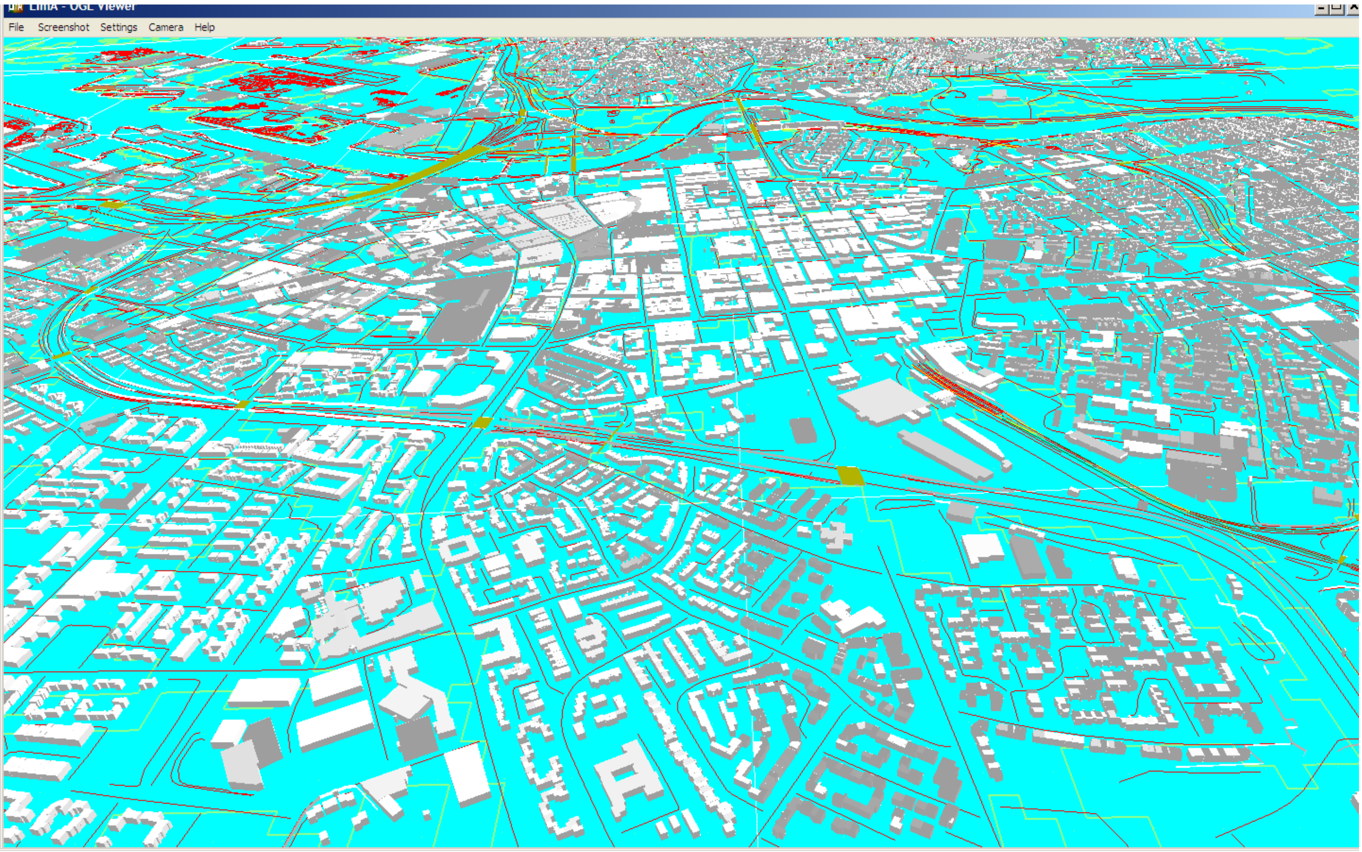
Where this occurs, it is necessary to reposition the start point of the building object to another location which ensures that the top of the building object is above the terrain at all locations. For Round One, these errors had to be correctly manually. Due to the increased extents in Round Two, the project team worked with Stapelfeldt to develop an automated solution which corrects the start position of the building objects where the building falls below the terrain.

For Test T3, each barrier was reviewed in 3D to ensure that it is correctly aligned with respect to the DTM. Where alignments appear incorrect, these are corrected within the software. Where barriers are positioned on bridges, these must also be reviewed to ensure that they sit correctly on the bridge structure and the adjoining terrain. Each barrier is reviewed in 3D and corrected appropriately.

For Test T4, all ground model layers are interacted together. The output from the LimA ‘Model Check’ function is reviewed to ensure that the interaction of objects does not result in any additional errors. Areas are selected from the model and 3D views generated which are reviewed manually. These areas are selected in the location of bridges and barriers.

For Test T5, all ground model layers are interacted with the source datasets. For the road and railway datasets, the model is reviewed in 3D in areas where roads or railways sources interact with bridges to ensure that the sources are correctly positioned above or below the bridge objects. If corrections are required, these are made within the LimA modelling environment.

Plate 7.4 Example of Stage 3D Model Review



3D from Railway Noise Model overlooking Great Victoria Street Station with Belfast Central in the background

7.7 Stage 5 of the QA Process

Stage 5 of the QA process involved undertaking a series of test calculations to ensure that the noise model and calculations would not fail and that no errors identified during the development of the modelling layers has been missed or had not been corrected. The test calculations also ensure that any errors that cannot be identified through the QA process that may lead to fatal errors in the calculation core are identified prior to the actual calculation of the model. To ensure that all models were subject to a full QA, a separate member of the project team was tasked to undertake Stage 5.

Test calculations were undertaken using low resolution grid settings with LimA's tiling function activated to replicate the actual final calculation configuration. This process also ensured that settings pertaining to the extent of calculation and the associated tiles required within the calculation were correct.

Calculation logs produced by LimA for each tile were reviewed for any error messages or warning to ensure that the tiling of the calculation did not result in any additional errors. Following successful completion of the test calculations, the project undertook the following task in preparation for the calculations.

- All model layers are copied into a final calculation folder and renamed as final;

- All calculation environment settings files were copied to the final calculation folder;
- The calculation of the model was scheduled against a resource planner.

8. Noise Level Calculations

This section details the approach to the noise level calculations for the assessment of railway noise in Northern Ireland. The noise calculations are a culmination of the source emission datasets and the 3D modelling datasets which facilitate the propagation of noise from the point of emission into the environment and to the receptor.

The means by which these calculations are undertaken and indeed the accuracy of these calculations can vary significantly depending upon choices made in the settings of the calculations. Some calculation settings simply determine how many calculations should be undertaken and to what resolution these should occur to. Other calculation settings require the user to determine how certain elements of a calculation method are handled whilst other calculations settings are used to derive efficiencies in the calculation process. All these settings combine to determine the computational load of the calculations and the compliance of the calculations with the various assessment methods.

Strategic noise mapping under the Directive and the Regulations is clear in terms of the area and resolution of the calculations. Therefore, in order to ensure that calculations are undertaken in a compliant but efficient manner, consideration must be given to settings and calculation technique which allow calculations to be efficient yet allow calculated noise levels to retain compliance with the assessment method without introducing excessive uncertainties.

8.1 Efficiency Settings

Efficiency settings are designed to reduce the computational load of a noise calculation by either reducing the number of calculations required or by reducing the complexity of each calculation. This is achieved by settings which instruct the calculation core to ignore or discount certain noise sources or aspects of the calculation. As outlined above, although efficiency settings have advantages in reducing the computation load and time of the calculations, they can introduce uncertainties into the calculated noise levels. As a rule of thumb, a slower calculation is likely to introduce less uncertainty than a faster one.

Efficiency settings can be applied separately or in combination with each other. A series of efficiency settings were tested for the calculation of railway noise during R1. The testing studied the effect of the setting upon noise levels above 55 dB L_{den} and 45 dB L_{night} thresholds requiring reporting of population exposure under the Directive. The testing was comprehensive and demonstrated that a combination of settings could result in significant benefits in calculation times whilst introducing low levels of uncertainty into the final results.

The project team have reviewed these settings against the settings currently available within the LimA calculation environment. This review has confirmed that there are no new settings or modifications to the settings testing during R1. Project policy has therefore been to retain the efficiency settings adopted for R1 for R2.

There are several advantages to retaining the efficiency settings from R1 to R2, namely consistency within the calculations. Efficiency settings can introduce uncertainties; therefore changes in these settings from R1 to R2 may mask any actual changes in noise levels between R1 and R2. As such, and in order to identify any real changes in noise levels between R1 and R2, two sets of calculations would be required using R1 efficiency settings and any new settings adopted for R2. It is the view of the project team that the settings adopted for R1 should be retained in perpetuity until the introduction of any new assessment method. Any new assessment method is likely to require a review of all calculation efficiency and compliance settings.

8.2 Calculation Settings

Table 8.1 presents an overview of the calculation settings adopted for the calculation of railway noise in Northern Ireland. These settings were retained from R1.

Table 8.1 Railway Calculation Settings

Setting	Setting Type	Description	Setting in R2
Grid Resolution	Calculation Grid Definition	Defined by the Regulations and Directive as 10m. This setting defined the distance between grid points in the calculation grid.	10m
Calculation Height	Calculation Grid Definition	This setting defines the calculation height of each point within the calculation grid. The Regulations and Directive define calculation height at 4m relative to the ground.	4m
Reflection Order	Compliance	Reflection order is the number of reflections considered in any given source to receiver propagation. CRN gives consideration to 1 reflection with the exception of those produce when a railway line is within a retained cutting.	1
Reflection Distance	Compliance	Reflection distance is the distance at which reflections from reflective objects are considered to effect noise levels at receivers. There is no guidance in CRN as to what distances reflections should be considered. For R1, a value of 50m was adopted as this is the upper rounded value of reflections considered in the example calculations within the appendices of CRN.	50m
Dynamic Error Margin	Efficiency	Dynamic error margin is the maximum uncertainty allowed within any calculation. The setting functions by estimating the influence of a noise source at a receiver through performing a simple noise distance attenuation. Where the influence is considered not to materially affect noise levels at the receiver, the source is discounted. Where the source is considered to affect noise levels, a full propagation calculation is undertaken for the source.	On – 3 dB
Simplify Propagation Analysis	Efficiency	When turned off, each propagation path assessed by LimA is considered in full with all obstacles (i.e. buildings and barriers) assessed in terms of their screening potential. When turned on, obstacles that are located a reasonable distance from the source and receiver are discounted as these are least likely to have any screening potential.	On

Table 8.1 (continued) Railway Calculation Settings

Setting	Setting Type	Description	Setting in R2
Eliminate Inner Walls	Efficiency	When activated, this setting instructions the LimA calculation core to ignore the effect of any walls of buildings that are identical i.e. the walls between buildings in a terrace.	Off
Source Search Radius	Efficiency & Compliance	This setting limits the distance from a receiver point at which noise sources are considered for calculation.	1500m

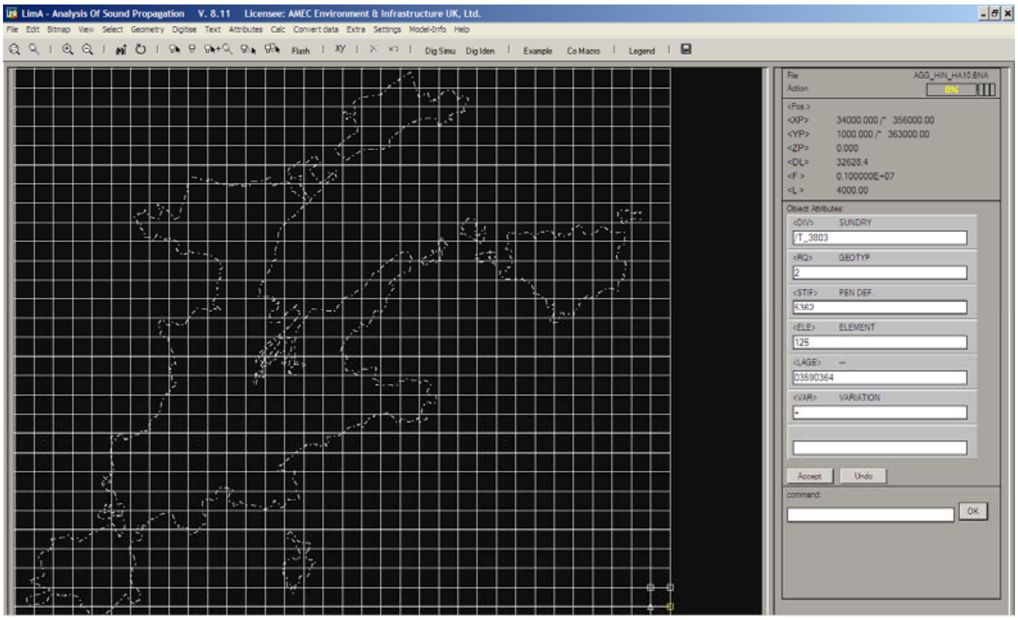
8.3 Distributed Calculation

In addition to efficiency settings, calculations can also be made quicker through distributing calculations across hardware and computer processors. Additional savings in calculation time can also be found through the optimisation of the hardware environment.

8.3.1 Calculation Tiling

The primary method of distributing calculations within the LimA software environment is through the use of its 'Tiling' functionality. The tiling function allows a large model and calculation area to be segmented into a series of smaller areas which can be calculated on a number of processor and across several computers at once. Plate 8.1 shows an example of calculation tiling for calculation within Belfast agglomeration. The plate shows that calculation area is broken up into a grid of calculation tiles which can be distributed for calculation. The size of these tiles can be specified within the tiling function however it has been demonstrated that 1km by 1km calculation tiles result in quicker calculations than larger tiles due to amount of modelling information read and processed by the calculation core.

Plate 8.1 Example of Tiling Function within the Belfast agglomeration



The use of tiling has not been limited to calculation. Many aspects of the project have been undertaken with respect to the grid lines that are formed through the tiling function. For example, queries raised during the modelling of the major road network have been flagged by calculation tile to allow calculations in other locations to be undertaken away from areas which are still waiting to be resolved. To this extent, the project team have developed a tiling grid which covers Northern Ireland to facilitate the management of the modelling and calculations as illustrated in Plate 8.2.

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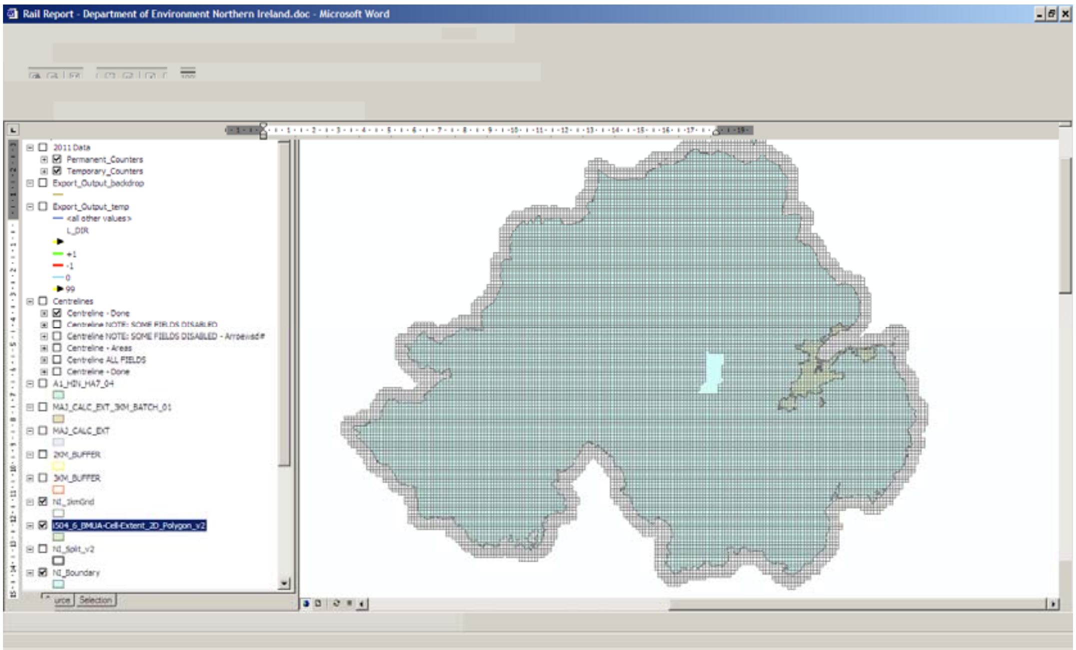
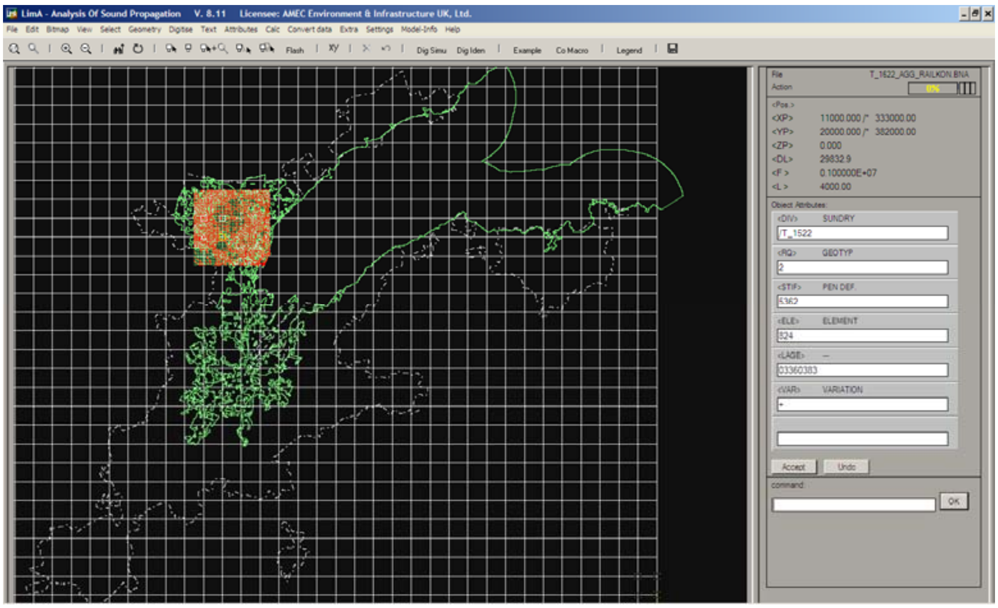
Plate 8.2 National Tiling Grid



Prior to calculation, LimA creates a series of calculation instruction files and results folders for each calculation tile. The instruction files instruct the LimA calculation core to read in only the model data that is relevant to calculations within the tile. This is defined at the calculation extents plus the distance defined by the source search distance calculation setting. This approach ensures that only the modelling data required to calculate noise levels within the calculation tile is read into the LimA calculation core. An example of this process is presented in Plate 8.3. The instruction files also instruct the calculation core to only calculate noise levels within the tile.

Plate 8.3 LimA Tiling Example



The key advantage of the LimA tiling function is:

- **Reduced calculation times** through the distribution of calculations and through efficient use of model data during calculations; and
- **Redundancy** – tiling calculations can be restarted and models revised on a tile by tile basis allowing calculations to be revised or started in the event of model errors or hardware failure.

8.3.2 Calculation Servers

LimA manages calculations using its LimAserver management software. The management software allows the automation of calculations. Hardware is allocated a LimA calculation core per processor. When a tiling calculation is started, calculation run files are copied to a 'Global Spool' folder. The LimAserver management software reads the Global Spool folder for run files and then reviews whether any LimA calculations core are available. When a calculation core is available, the LimAserver software copies the run file to the available core and starts the calculation accordingly. The LimAserver software can manage processors on a single hardware device or on many devices that are distributed across a network.

The LimAserver management software ensures that calculations are continuous. The server system is also designed to identify and report any calculation tiles that exhibit fatal errors.

8.3.3 Hardware

AMEC have two dedicated noise calculation servers comprising a total of 22 available calculation cores. These machines are optimised for calculations using the LimA calculation core and were acquired with processors with high floating point performances. Optimisations of these servers have been undertaken in terms of physical memory allocation to ensure that calculations can occur almost entirely within the Random Access Memory (RAM).

8.4 Post Processing and Output Grids

The LimA tiling function and calculation core produce results grids for each calculation tile and the indicators defined during calculation. In order to simplify the assessment of population exposure, it is necessary to join each tiled results grid together into a single grid representative of the area under assessment. In addition, the calculation core is currently restricted to the computation of a certain number of noise indicators. As such, the process of producing output grids must also be configured to enable the calculation of additional noise indicators. Whilst there are tools within the LimA software package that allow this to occur, the specific requirements of this contract have required the development of a post processing routine.

This post processing routine has been automated through the development of a Python script. Each stage of the post processing script is outlined in the following sections and summarised in Plate 8.4.

8.4.1 Calculation Output Files

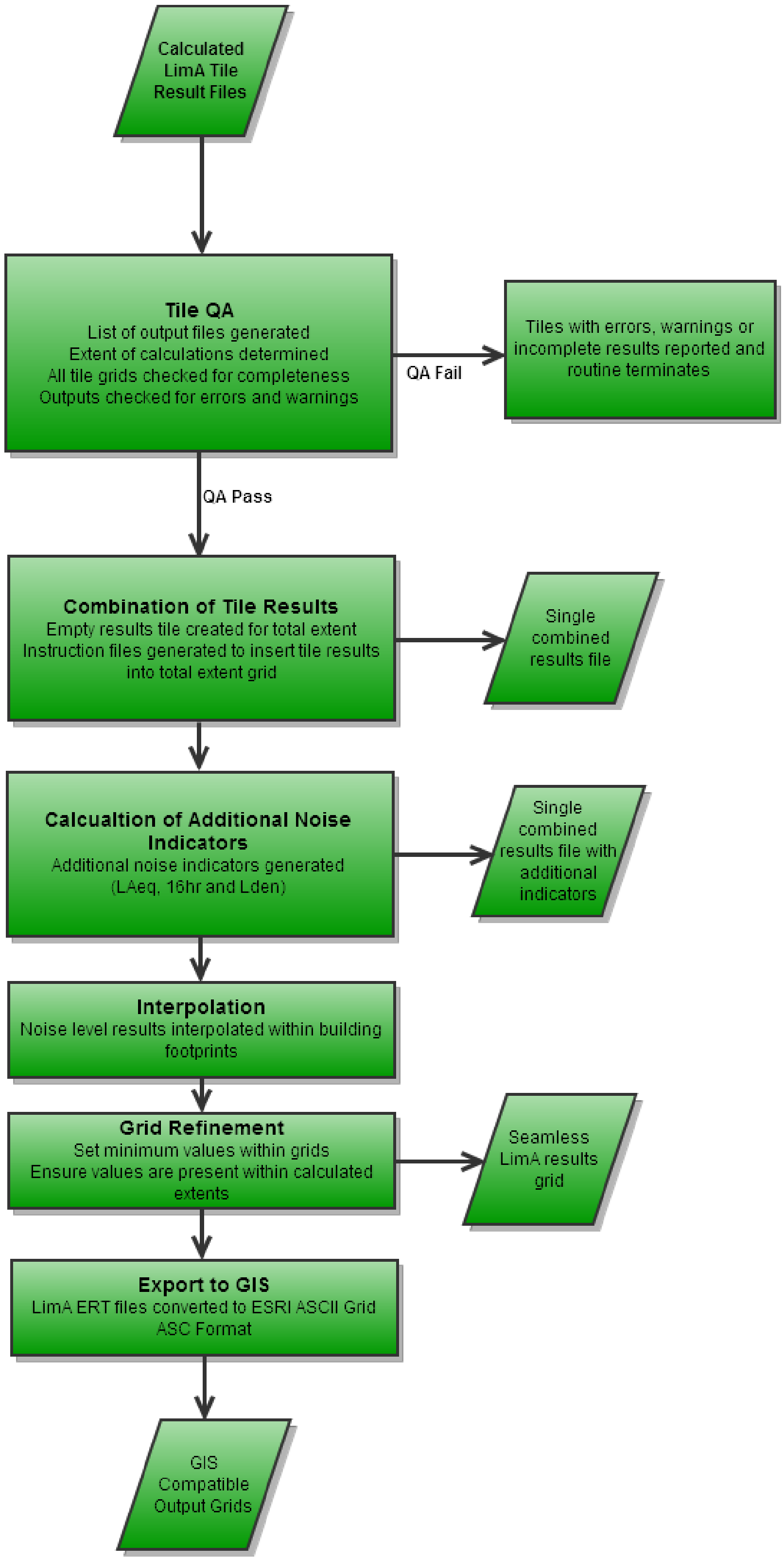
The first stage of the post processing script is to check each of the output files produced by each calculation tile. The purpose of this stage is to ensure that each tile within the calculation area has been calculated and that there are no error messages, failed calculations or warnings. Although errors and warnings are covered by the QA process described in Section 7, errors and warnings can result from the clipping process which is undertaken by the LimA calculation core during tiling.

In the event of any errors, warnings or incomplete calculations, the post processing script halts and produces a message to enable further investigation.

8.4.2 Combining the Tile Results

The next stage of the post processing routine is the combination of the tiles into a single results grid. The first step of this process is the identification of the total calculation extents. This is achieved by reading the calculated extents of each tile and identifying the maximum and minimum gird positions. Once identified, the processing routine sends an instruction to the LimA_9 module to generate blank results grids for these extents. Once produced, a series of additional instruction files are produced for the LimA_9 module for the insertion of each calculated result file into the single result grid. The processing routine monitors the progress of the LimA_9 module through this step ensuring that instruction files are send once a tile has been added.

Plate 8.4 Process Flow of the Post Processing Routine



8.4.3 Calculation of Additional Noise Indicators

As discussed, the LimA calculation does not calculate all of the noise indicators required under this contract. These additional indicators have therefore been calculated as part of the post processing routine and are detailed in Table 8.2.

Table 8.2 Noise Indicators Required under Contract

Indicator	Description	Incumbent Within	Produced During
L_{den}	Annual Average Day-Evening-Night Noise Rating Level (24-hour)	Regulations and END	Post-processing
L_{day}	Annual Average 12-hour daytime noise level (0700-1900hrs)	Regulations and END	Calculation
L_{eve}	Annual Average 4-hour evening noise level (1900-2300hrs)	Regulations and END	Calculation
L_{night}	Annual Average 8-hour night-time noise level (2300-0700hrs)	Regulations, END and NI Planning Policy Guidance	Calculation
$L_{Aeq,\ 16hr}$	Annual Average 16-hour daytime noise level (0700-2300hrs)	NI Planning Policy Guidance	Post-processing
$L_{Aeq,\ 18hr}$	Annual Average 18-hour daytime noise level (0600-0000hrs)	CRN and Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1995	Calculation

As outlined in Table 8.2, the L_{den} and $L_{Aeq,\ 16hr}$ indicators were generated as part of the post-processing routine. This was undertaken within the post processing routine through reading line by line through the single complete grids and calculating the values based on indicators output as part of the calculation.

For L_{den} the post processing routine calculated this indicator as follows:

$$L_{den} = 10\log\left[\left(\frac{1}{24}\right)\times\left(12\times10^{\frac{L_{day}}{10}} + 4\times10^{\frac{L_{eve}+5}{10}} + 8\times10^{\frac{L_{night}+10}{10}}\right)\right]$$

For $L_{Aeq,\ 16hr}$ the post processing routine calculated the indicator as below:

$$L_{Aeq,16hr} = 10\log\left[\left(\frac{12}{16}\times10^{\frac{L_{day}}{10}}\right)+\left(\frac{4}{16}\times10^{\frac{L_{eve}}{10}}\right)\right]$$

Once calculated, the L_{den} and $L_{Aeq,\ 16hr}$ results are appended to the result file.

8.4.4 Interpolation within Buildings

To enable population exposure, a seamless results grid is required. During calculation, LimA reports default values where noise level grid points are located within buildings. The LimA_9 module has a function to interpolate noise levels within buildings using noise levels immediate to their extents.

Following the calculation of the supplementary indicators, the processing script creates instruction files for the LimA_9 module to interpolate within building footprints. As part of the interpolation process, an additional column "INT" is appended to the results file to identify results which are produced as part of calculation and those which are the result of interpolation.

8.4.5 Grid Refinement

Calculations are undertaken within defined calculation areas. In the case of railway noise, major rail is calculated 1500m from major rail sources. For agglomeration rail, railway noise levels are calculated within the agglomeration boundary. Over large distances, attenuations during propagation can be higher than noise levels at source. This results in calculated noise levels that are below a measurable threshold within the environment. Although these levels are not required in terms of reporting population exposure to the commission, it is necessary that areas where these levels are identified have a notational value for the purposes of identifying quiet areas.

The next stage of the processing script is to refine the calculated results grids. This requires two actions:

- Setting all calculated noise levels so that no calculated noise level falls below a minimum value of 15 dB(A); and
- Ensuring that all noise levels within the calculations areas have values.

This is achieved using functions held within the LimA_9 module. Following interpolation, the processing script sends instruction to LimA_9 to undertake the actions outlined above.

8.4.6 Export to GIS

Following grid refinement, the noise level results grids are export to the ESRI ASCII Grid (ASC) format. This was achieved through the processing routine sending instructions to the LimA_39 module which manages translations from LimA to a variety of GIS formats. As part of the exportation process, the files outlined in Table 8.3 were generated.

Table 8.3 GIS ASC Results Files for Railway Noise Mapping

File	Major Rail/ Agglomeration Rail	Noise Indicator	Description
LPED	Agglomeration	L_{day}	Annual Average 12-hour daytime noise level (0700-1900hrs)
LPEE	Agglomeration	L_{eve}	Annual Average 4-hour evening noise level (1900-2300hrs)
LPEN	Agglomeration	L_{night}	Annual Average 8-hour night-time noise level (2300-0700hrs)
L18H	Agglomeration	$L_{Aeq, 18hr}$	Annual Average 18-hour daytime noise level (0600-0000hrs)
L6HN	Agglomeration	$L_{Aeq, 6hr}$	Annual Average 6-hour night-time noise level (0600-0000hrs)
L16H	Agglomeration	$L_{Aeq, 16hr}$	Annual Average 16-hour daytime noise level (0700-2300hrs)
LDEN	Agglomeration	L_{den}	Annual Average Day-Evening-Night Noise Rating Level (24-hour)
M_LPED	Major Rail	L_{day}	Annual Average 12-hour daytime noise level (0700-1900hrs)
M_LPEE	Major Rail	L_{eve}	Annual Average 4-hour evening noise level (1900-2300hrs)
M_LPEN	Major Rail	L_{night}	Annual Average 8-hour night-time noise level (2300-0700hrs)
M_L18H	Major Rail	$L_{Aeq, 18hr}$	Annual Average 18-hour daytime noise level (0600-0000hrs)
M_L6HN	Major Rail	$L_{Aeq, 6hr}$	Annual Average 6-hour night-time noise level (0600-0000hrs)
M_L16H	Major Rail	$L_{Aeq, 16hr}$	Annual Average 16-hour daytime noise level (0700-2300hrs)
M_LDEN	Major Rail	L_{den}	Annual Average Day-Evening-Night Noise Rating Level (24-hour)

9. Area Calculations

The first post processing step that was undertaken on the raw continuous output noise grids was a reclassification of the grids into bands. The reclassification bands used are outlined in Table 9.1.

Table 9.1 Noise Bands used to Reclassify Output Grids

Noise Level Result	Noise Bands						
L_{den}	< 50	50-54	55-59	60-64	65-69	70-74	>=75
L_{day}	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{evening}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{Aeq,18 hour}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{Aeq, 16 hour}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
$L_{Aeq, 6 hour}$	< 50	50-54	55-59	60-64	65-69	70-74	>=75
L_{night}	< 45	45-49	50-54	55-59	60-64	65-69	>=70

The geometric area of the noise bands for each of the bands was calculated based on the outputs. The results are shown in Table 9.2 for the Major Rail and Table 9.3 for the Agglomeration Rail, with examples of the railway map outputs (L_{den}) provided in Plate 9.1.

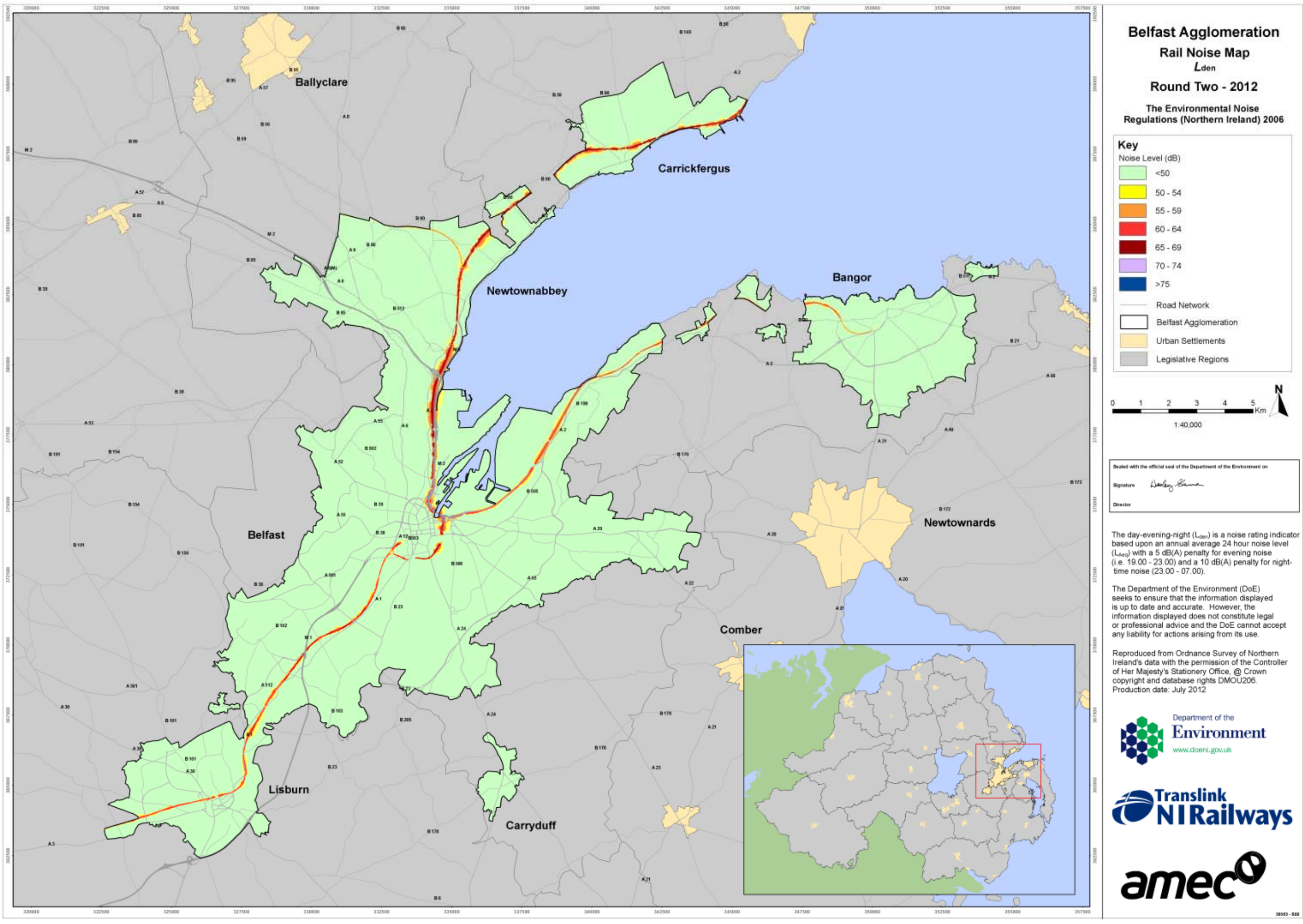
Table 9.2 Major Rail - Area of Noise Bands (dB) in km²

Noise Level	LAeq, 16 hour	$L_{Aeq,18 hour}$	$L_{Aeq, 6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level	L_{night}
< 50	128.42	128.54	134.36	127.87	128.16	129.27	**< 45**	131.31
50-54	2.74	2.70	0.35	2.86	2.82	2.46	**45-49**	1.87
55-59	1.83	1.81	0.11	1.96	1.89	1.72	**50-54**	1.20
60-64	1.45	1.41	0.00	1.55	1.52	1.07	**55-59**	0.39
65-69	0.36	0.34	0.00	0.52	0.42	0.28	**60-64**	0.04
70-74	0.01	0.01	0.00	0.05	0.02	0.01	**65-69**	0.00
>=75	0.00	0.00	0.00	0.00	0.00	0.00	**>=70**	0.00
< 50	128.42	128.54	134.35	127.87	128.16	129.27	**< 45**	131.31
>= 50	6.39	6.27	0.46	6.94	6.67	5.54	**<=45**	3.5
Total	134.81	134.81	134.81	134.81	134.83	134.81	**Total**	134.81

Table 9.3 Agglomeration Rail - Area of Noise Bands in km²

Noise Level	$L_{Aeq, 16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq, 6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level	L_{night}
< 50	190.08	190.21	197.23	189.37	189.79	190.95	**< 45**	193.43
50-54	3.23	3.2	0.75	3.38	3.3	3.01	**45-49**	2.36
55-59	2.32	2.3	0.12	2.5	2.39	2.2	**50-54**	1.57
60-64	1.79	1.74	<0.01	1.89	1.86	1.39	**55-59**	0.7
65-69	0.67	0.64	0.00	0.9	0.74	0.54	**60-64**	0.04
70-74	0.01	0.01	0.00	0.06	0.02	0.01	**65-69**	<0.01
>=75	<0.01	<0.01	0.00	<0.01	<0.01	<0.01	**>=70**	<0.01
< 50	190.08	190.21	197.23	189.37	189.79	190.95	**< 45**	193.43
>= 50	8.02	7.89	0.87	8.73	8.31	7.15	**<=45**	4.67
Total	198.1	198.1	198.1	198.1	198.1	198.1	**Total**	198.1

Plate 9.1 Round Two – Agglomeration Railway L_{den} Noise Map



10. Population Exposure and Analysis

10.1 Population Exposure Methodology

Annex VI of the END states that a population exposure assessment is required as an output of the END noise mapping process and that the results of this assessment need to be reported to the European Commission (EC). Annex VI also states that the estimated number of people (in hundreds) living in dwellings that are exposed to noise are to be calculated for the various scenarios mapped. There is no definition of a 'dwelling' in the END although the term is used within Article 3 (q), Annex I (1), Annex III, Annex IV (1) and Annex VI (1.5, 1.6) and (2.5, 2.6).

A number of key dataset have been used within the population exposure assessment developed in the second round study. These datasets used were:

(a) Detailed building polygons recorded in the OSNI large scale mapping. This data was also used as a key input into the development of the noise maps.

(b) OSNI Pointer dataset which provide details of the function of individual buildings across Northern Ireland. The Pointer data set is described by OSNI as the primary address database for Northern Ireland and is maintained by Land & Property Services (LPS), with input from Local Councils and Royal Mail.

(c) 2008 and 2010 estimates of population are provided by the Northern Ireland Statistics and Research Agency. The 2008 dataset is the latest population estimates available for the 5022 detailed census output areas, while the 2010 population estimates provides information for the coarser 890 super output areas covering Northern Ireland.

The first step in the population exposure assessment involved the development of an effective estimate of the 2010 population in each of the 5022 detailed census output areas. This was achieved by analysing the changes in population between 2008 and 2010 using the coarser datasets to derive an increase factor which could be applied to the detailed 2008 population data. This results in the production of the final dataset used in the remainder of the R2 population analysis.

The second stage of the process was focused on developing an estimate of the number of people per house needed to undertake the population exposure assessment. This was generated by calculating the number of residential properties in each census area and dividing this value by the estimates of 2010 population in the census area. One limitation of this method is that the pointer data might not identify all of the residential properties, for instance if a residential property is located above commercial premises. As a consequence, the methodology is reliant on the accuracy and currency of the Pointer dataset and the classification of the class of building.

As per the assumptions used in the Round 1 study, Annex I (1) of the END indicates that noise exposure assessments should be at the most exposed façade. The most exposed façade is defined as the external wall facing onto and nearest to the specific noise source. For the purposes of this assessment the highest overall value assigned to a dwelling is to be considered the most exposed façade as per recommendations set out within the WG-AEN

Good Practice Guide v2. To calculate the level of exposure the residential dwelling building extents were intersected with the reclassified noise grids. From this process, the number of dwellings and the number of people exposed was calculated. The results of this analysis are presented in Section 10.2.

In reviewing the final exposure results, it is important to consider the various factors which influence the final exposure analysis. These factors include: differences in the age of the population datasets used in the analysis; changes and improvements in the OS Pointer address dataset since Round 1; and the remaining limitations of the OSNI Pointer address dataset. These limitations include the absence of an attribute code to distinguish communal residences (i.e. student residence, army living accommodation) from standard residential accommodation.

An additional example of data currency issues and an explanation of why some areas of the agglomeration have lower than expected exposure values is demonstrated on the Queens road area of the docks development. The top left plate shows the buildings from the OSNI Largescale data, the dwellings are identified in colour and other buildings are shown in grey. The top right and bottom left plate show images from Google maps that show the development, in construction and more recently constructed. As the date of the census data is 2008, it is possible that the census data doesn't include these apartment complexes and/or that the building data does not reflect the correct building classification.

Plate 10.1 Example of Data Currency in the Population Exposure Analysis

10.2 Railway - Population Exposure Analysis

Tables 10.1 and 10.2 detail the results of the Round Two END dwelling and population analysis for all railways within the Belfast Agglomeration. These results have been produced using the methodology described in Section 10.1.

10.2.1 Agglomeration - Railway

Table 10.1 Agglomeration Railway - Dwellings

Noise Level (dB)	$L_{Aeq, 16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq, 6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
< 50	257,192	257,264	261,593	256,683	256,961	257,813	**< 45**	259,401
50-54	2,100	2,092	360	2,321	2,188	1,868	**45-49**	1,374
55-59	1,395	1,373	22	1,396	1,411	1,378	**50-54**	878
60-64	997	971	0	1,178	1,092	717	**55-59**	316
65-69	291	275	0	383	321	199	**60-64**	6
70-74	0	0	0	14	2	0	**65-69**	0
>=75	0	0	0	0	0	0	**>=70**	0
< 50	257,192	257,264	261,593	256,683	256,961	257,813	**< 45**	259,401
>= 50	4,783	4,711	382	5,292	5,014	4,162	**>= 45**	2,574
Total	261,975	261,975	261,975	261,975	261,975	261,975	**Total**	261,975

Table 10.2 Agglomeration Railway - Population

Noise Level (dB)	$L_{Aeq, 16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq, 6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
< 50	564,125	564,256	572,419	563,124	563,684	565,357	**< 45**	568,483
50-54	4,131	4,124	612	4,518	4,311	3,645	**45-49**	2,473
55-59	2,580	2,523	32	2,672	2,617	2,462	**50-54**	1,540
60-64	1,739	1,694	0	2,060	1,912	1,266	**55-59**	555
65-69	490	466	0	669	537	333	**60-64**	13
70-74	0	0	0	21	3	0	**65-69**	0
>=75	0	0	0	0	0	0	**>=70**	0
< 50	564,125	564,256	572,419	563,124	563,684	565,357	**< 45**	568,483
>= 50	8,940	8,807	644	9,940	9,380	7,706	**>= 45**	4,581
Total	573,065	573,065	573,065	573,065	573,065	573,065	**Total**	573,065

10.2.2 Major Rail

Tables 10.3 – 10.4 detail the results of the Round Two END dwelling and population analysis for major railways, within the Belfast Agglomeration, outside the Belfast Agglomeration and across the whole of Northern Ireland.

Table 10.3 Major Railway - Dwellings (Belfast Agglomeration)

Noise Level (dB)	$L_{Aeq,16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq,6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	258,738	258,799	261,810	258,404	258,565	259,218	**<45**	260,263
50-54	1,442	1,420	143	1,579	1,514	1,231	**45-49**	968
55-59	957	950	22	944	959	988	**50-54**	610
60-64	734	710		876	814	467	**55-59**	128
65-69	104	96		160	121	71	**60-64**	6
70-74				12	2		**65-69**	
>=75							**>=70**	
< 50	258,738	258,799	261,810	258,404	258,565	259,218	**< 45**	260,263
>= 50	3,237	3,176	165	3,571	3,410	2,757	**<=45**	1,712
Total	261,975	261,975	261,975	261,975	261,975	261,975	**Total**	261,975

Table 10.4 Major Railway - Population (Belfast Agglomeration)

Noise Level (dB)	$L_{Aeq,16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq,6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	567,009	567,121	572,822	566,325	566,676	567,972	**<45**	570,058
50-54	2,881	2,845	211	3,129	3,038	2,431	**45-49**	1,719
55-59	1,753	1,732	32	1,810	1,756	1,739	**50-54**	1,056
60-64	1,265	1,223		1,512	1,411	816	**55-59**	220
65-69	157	144		271	182	106	**60-64**	12
70-74				18	3		**65-69**	
>=75							**>=70**	
< 50	567,009	567,121	572,822	566,325	566,676	567,972	**< 45**	570,058
>= 50	6,056	5,944	243	6,740	6,389	5,093	**<=45**	3,007
Total	573,065	573,065	573,065	573,065	573,065	573,065	**Total**	573,065

Table 10.5 Major Railway - Dwellings (Outside Agglomeration)

Noise Level (dB)	$L_{Aeq, 16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq, 6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	491,887	491,888	491,908	491,885	491,885	491,892	**<45**	491,896
50-54	8	8	0	10	10	4	**45-49**	5
55-59	4	3	0	3	3	7	**50-54**	7
60-64	9	9	0	10	10	5	**55-59**	0
65-69	0	0	0	0	0	0	**60-64**	0
70-74	0	0	0	0	0	0	**65-69**	0
>=75	0	0	0	0	0	0	**>=70**	0
< 50	491,887	491,888	491,908	491,885	491,885	491,892	**< 45**	491,896
>= 50	21	20	0	23	23	16	**<=45**	12
Total	491,908	491,908	491,908	491,908	491,908	491,908	**Total**	491,908

Table 10.6 Major Railway - Population (Outside Agglomeration)

Noise Level (dB)	$L_{Aeq, 16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq, 6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	1,200,474	1,200,476	1,200,506	1,200,471	1,200,471	1,200,481	**<45**	1,200,488
50-54	13	12	0	16	16	7	**45-49**	8
55-59	7	5	0	5	5	11	**50-54**	10
60-64	13	13	0	15	15	7	**55-59**	0
65-69	0	0	0	0	0	0	**60-64**	0
70-74	0	0	0	0	0	0	**65-69**	0
>=75	0	0	0	0	0	0	**>=70**	0
< 50	1,200,474	1,200,476	1,200,506	1,200,471	1,200,471	1,200,481	**< 45**	1,200,488
>= 50	32	30	0	35	35	25	**<=45**	18
Total	1,200,506	1,200,506	1,200,506	1,200,506	1,200,506	1,200,506	**Total**	1,200,506

Table 10.7 Major Railway - Dwellings (Northern Ireland)

Noise Level (dB)	$L_{Aeq, 16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq, 6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	750,625	750,687	753,718	750,289	750,450	751,110	**<45**	752,159
50-54	1,450	1,428	143	1,589	1,524	1,235	**45-49**	973
55-59	961	953	22	947	962	995	**50-54**	617
60-64	743	719	0	886	824	472	**55-59**	128
65-69	104	96	0	160	121	71	**60-64**	6
70-74	0	0	0	12	2	0	**65-69**	0
>=75	0	0	0	0	0	0	**>=70**	0
< 50	750,625	750,687	753,718	750,289	750,450	751,110	**< 45**	752,159
>= 50	3,258	3,196	165	3,594	3,433	2,773	**<=45**	1,724
Total	753,883	753,883	753,883	753,883	753,883	753,883	**Total**	753,883

Table 10.8 Major Railway - Population (Northern Ireland)

Noise Level (dB)	$L_{Aeq, 16 hour}$	$L_{Aeq,18 hour}$	$L_{Aeq, 6 hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	1,767,483	1,767,597	1,773,328	1,766,796	1,767,147	1,768,454	**<45**	1,770,546
50-54	2,894	2,858	211	3,144	3,053	2,438	**45-49**	1,727
55-59	1,760	1,737	32	1,815	1,761	1,750	**50-54**	1,066
60-64	1,278	1,236	0	1,527	1,425	823	**55-59**	220
65-69	157	144	0	271	182	106	**60-64**	12
70-74			0	18	3	0	**65-69**	0
>=75	0	0	0	0	0	0	**>=70**	0
< 50	1,767,483	1,767,597	1,773,328	1,766,796	1,767,147	1,768,454	**< 45**	1,770,546
>= 50	6,088	5,974	243	6,775	6,424	5,117	**<=45**	3,025
Total	1,773,571	1,773,571	1,773,571	1,773,571	1,773,571	1,773,571	**Total**	1,773,571

10.3 Railway - ENDRM Reporting

There is a requirement to report exposure assessments to the EC in order to comply with END. The ENDRM consists of 10 core Data Flows which cover the first two implementation rounds of the END. The results of the noise mapping including the population and the dwelling are reported via Data Flow 4 and 8.

The results from this round were entered into the relevant Data Flow 4 and 8 data tables that are available from the EC (http://dd.eionet.europa.eu/datasets/2906). For the Railway report, the relevant table reference is DF4_8_MRail (Major rail noise exposure outside agglomerations) and DF4_8_Agg_Rail (Major rail noise exposure inside agglomerations). Additional spatial datasets will be projected into ETRS89 Lambert Azimuthal Equal Area 52N 10E grid in line with EEA guidance (www.eionet.europa.eu/gis/).

It is important to note that only certain elements (mandatory fields) in Data Flow 4 and 8 are required to be reported and these fields are detailed below in Tables 10.9 and 10.10.

Table 10.9 ENDRM Mandatory Fields for Tables DF4_8_Agg_Rail

Required Reporting Element	Description
*ReportingEntityUniqueCode	A single character Unique code assigned by the Member State to each Reporting Entity.
* Lden5559	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
* Lden6064	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
* Lden6569	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
* Lden7074	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 70-74 dB(A), 4 m above the ground and on the most exposed façade.
* Lden75	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
* Lden5559FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 55-59 dB(A), 4 m above the ground and on the most exposed façade
* Lden6064FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 60-64 dB(A), 4 m above the ground and on the most exposed façade

Table 10.9 (continued) ENDRM Mandatory Fields for Table DF4_8_Agg_Rail

Required Reporting Element	Description
* Lden6569FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 65-59 dB(A), 4 m above the ground and on the most exposed façade
* Lden7074FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source between 70-74 dB(A), 4 m above the ground and on the most exposed façade
* Lden75FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight5054	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 50-54 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight5559	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight6064	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight6569	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight70	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight >70 dB(A), 4 m above the ground and on the most exposed façade
* Lnight5054FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 50-54 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight5559FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 55-59 dB(A), 4 m above the ground and on the most exposed façade
* Lnight6064FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 60-64 dB(A), 4 m above the ground and on the most exposed façade
* Lnight6569FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 65-69 dB(A), 4 m above the ground and on the most exposed façade
* Lnight70FromMajorSource	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight from a Major Source >70 dB(A), 4 m above the ground and on the most exposed façade.
* ComputationAndMeasurementMethodsReportDetails	The full name of the report, the author/publisher and date of production.

Table 10.10 ENDRM Mandatory Fields for Tables DF4_8_MRail

Required Reporting Element	Description
*ReportingEntityUniqueCode	
* Lden5559	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
* Lden6064	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
* Lden6569	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
* Lden7074	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden between 70-74 dB(A), 4 m above the ground and on the most exposed façade.
* Lden75	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
* Lnight5054	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 50-54 dB(A), 4 m above the ground and on the most exposed façade
* Lnight5559	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 55-59 dB(A), 4 m above the ground and on the most exposed façade
* Lnight6064	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 60-64 dB(A), 4 m above the ground and on the most exposed façade
* Lnight6569	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source between 65-69 dB(A), 4 m above the ground and on the most exposed façade
* Lnight70	The estimated total number of people (rounded to the nearest hundred) living outside agglomerations in dwellings that are exposed to values of Lnight from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
* AreaExposedToLden55IncludingAgglomerations	The estimated total area (in km2) exposed to values of Lden higher than 55 dB. The area must include agglomerations.
* AreaExposedToLden65IncludingAgglomerations	The estimated total area (in km2) exposed to values of Lden higher than 65 dB. The area must include agglomerations.
* AreaExposedToLden75IncludingAgglomerations	The estimated total area (in km2) exposed to values of Lden higher than 75 dB. The area must include agglomerations.
* Lden55IncludingAgglomerations	The estimated total number of people (rounded to the nearest hundred) exposed to values of Lden higher than 55 dB. The number of people must include agglomerations.
* Lden65IncludingAgglomerations	The estimated total number of people (rounded to the nearest hundred) exposed to values of Lden higher than 65 dB. The number of people must include agglomerations.
* Lden75IncludingAgglomerations	The estimated total number of people (rounded to the nearest hundred) exposed to values of Lden higher than 75 dB. The number of people must include agglomerations.

Table 10.10 (continued) ENDRM Mandatory Fields for Tables DF4_8_MRail

Required Reporting Element	Description
* DwellingsExposedToLden55IncludingAgglomerations	The estimated total number of dwellings (rounded to the nearest hundred) exposed to values of Lden higher than 55 dB. The number of dwellings must include agglomerations.
* DwellingsExposedToLden65IncludingAgglomerations	The estimated total number of dwellings (rounded to the nearest hundred) exposed to values of Lden higher than 65 dB. The number of dwellings must include agglomerations.
* DwellingsExposedToLden75IncludingAgglomerations	The estimated total number of dwellings (rounded to the nearest hundred) exposed to values of Lden higher than 75 dB. The number of dwellings must include agglomerations.
* ComputationAndMeasurementMethodsReportDetails	Computation and measurement methods report details

The final Data Flow 4 and 8 Tables have been provided as a separate deliverable under this contract and will enable DoE to fulfil Northern Ireland’s requirements for the END.

11. Comparison between R1 and R2

For the railways in Northern Ireland, the main change in the data inputs between Round One and Round Two, in terms of noise emissions is the change in rolling stock and a change in the number of movements. In addition to changes in emissions, changes in the 3D modelling of the Belfast Agglomeration, notably changes in topography and changes to the modelling of ground cover will also contribute to changes in the population exposed to railway noise. These issues are reported in the remainder of this section.

11.1 Rail Emissions

As outlined above, the key differences in rail emissions from Round One to Round Two are changes in rolling stock and the number of movements between Round One and Round Two, in particularly:

- Class 450 were operating a reduced number in 2011 in comparison to 2006 as these units were being replaced by Class 4000 units; and
- There appears to be a slight increase in the number of trains on the network.

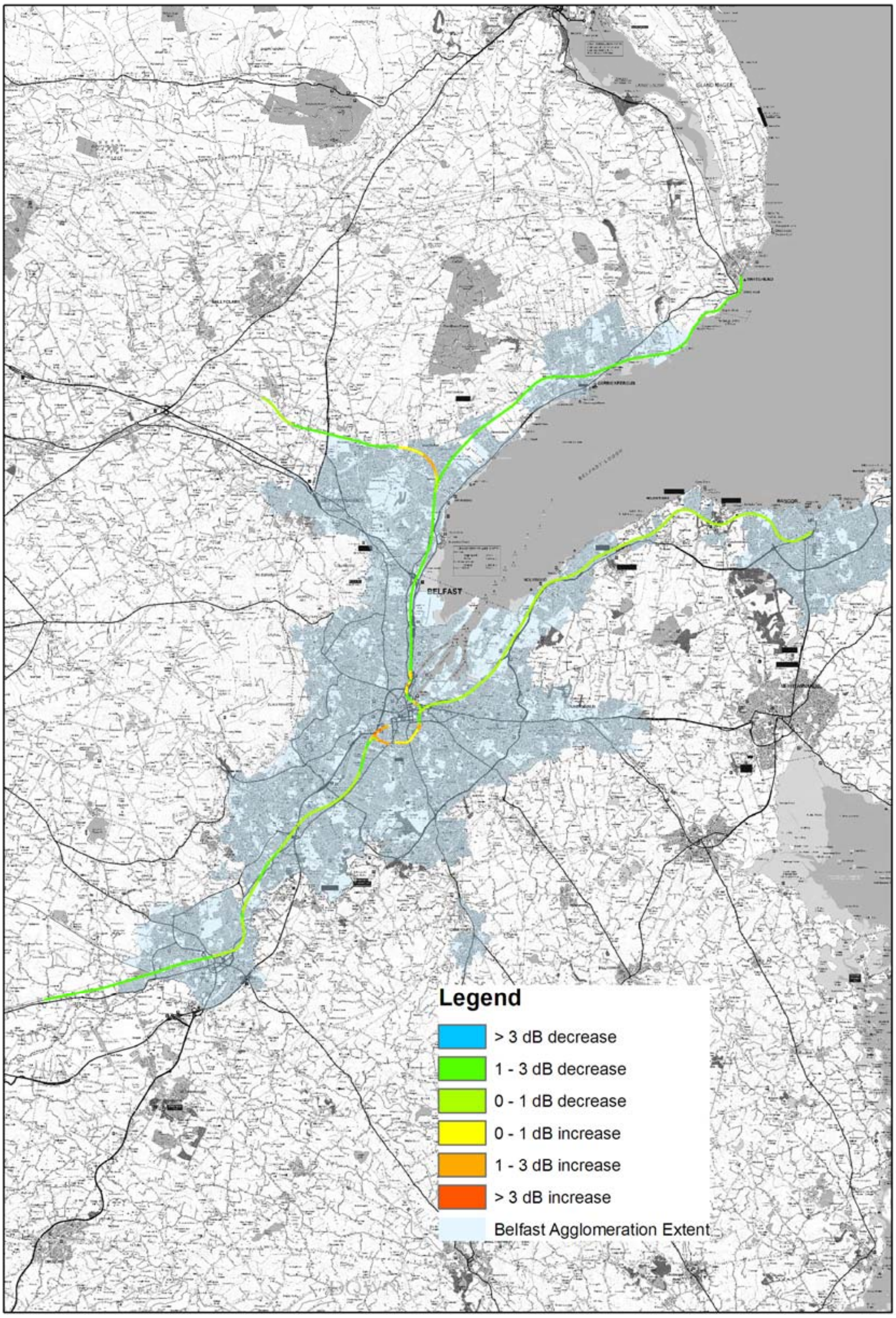
As discussed earlier in this report, improvements and additions in the modeling of railway noise emissions has also resulted in changes. These are:

- The Fortwilliam depot is now considered in Round Two;
- For Round Two, platform selection has been modeled in strict accordance with the rules outlined in the Round 1 report. This did not appear to have occurred in full for GVS or Belfast Central. Appendix B gives further details of this;
- Terminating trains at Carrickfergus and Lisburn are now considered in full;
- A potential error in the modeling in the Round 1 dataset just north of Bleach Green Junction on the Antrim line has been identified and corrected. This error relates to a section of rail line (around 1.2km in length) which did not appear to have been allocated a full set of movements.

Plate 11.1 presents a comparison of noise emissions between Round One and Round Two in terms of L_{den}.

Plate 11.1 shows that for most of the rail network considered by the mapping, there have been decreases in noise emissions between Round One and Round Two. For the majority of lines, the decreases are limited to 1 dB(A) and reflect changes in rolling stock. Where increases have occurred such as in and around Belfast Central Station, Great Victoria Street Station and Bleach Green Junction, this is due to a change in the modeling of movements on these sections of rail between Round One and Round Two. In general, these decreases in emissions should translate into decreases in population exposure.

Plate 11.1 Comparison of R1 and R2 Emission Levels



11.2 Change in 3D Modelling

11.2.1 Topography

Changes in the topography and terrain model within the 3D model are likely to result in localised changes in noise exposure. For example, the demolition and construction of buildings between Round One and Round Two will significantly affect noise propagation and population exposure. In addition, any fundamental changes or recapturing of terrain by OSNI can also result in change in propagation and resultant population exposure.

11.2.2 Ground Cover

A key improvement of the Round Two model is the treatment of ground cover types. As discussed in the 3D modelling report, the Belfast Agglomeration was previously modelled as being 100% acoustically reflective in Round One. Using data from the NISRA Land Cover Map 2007 dataset, it has been possible to model urban green areas and different types of ground cover. This has resulted in areas of acoustically absorbent ground, such as parks and urban green areas, being modelled. This will in general result in increased ground cover corrections and lower noise levels.

Appendix A
CRN BRT Noise Dataset Specification

Table A.1 BRT Object Overview

Layer Overview	Spatial Reference	Object Dimensions	Elevation Reference	Elevation Reference Position	Elevation Definition	Unit	LimA Object Type
BRT CRN Railway Noise Emission Polyline	Vector	2.5D Polyline	Relative	Relative	Varies per object	Metre (m)	**BRL**

Note: BRT polyline objects should not have vertices with a separation distances less than 0.05m.

Table A.2 BRT Object Specification

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_BRT	Railway Name	String	Data Input	Default Value	RAIL_2D	None
				Max. Length	20	
L_ID	Unique ID Number	String	Data Input	Unique ID		None
				Max. Length	20	
L_RQ	Geometry Type	Integer	Data Input	Default Value	1	None
				Max. Length	4	
L_PD	18-hour Rolling Noise Emission Level (CRN $L_{Aeq, 0600\text{-}0000hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PN	6-hour Rolling Noise Emission Level (CRN $L_{Aeq, 0000\text{-}0600hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PED	12-hour Daytime Rolling Noise Emission Level (CRN $L_{Aeq, 0700\text{-}1900hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	

Table A.2 (continued) BRT Object Specification

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_PEE	4-hour Evening Rolling Noise Emission Level (CRN $L_{Aeq, 1900\text{-}2300hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEN	8-hour Evening Rolling Noise Emission Level (CRN $L_{Aeq, 2300\text{-}0700hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PDD	18-hour Diesel Full Power Noise Emission Level (CRN $L_{Aeq, 0600\text{-}0000hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PDN	6-hour Diesel Full Power Noise Emission Level (CRN $L_{Aeq, 0000\text{-}0600hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEDD	12-hour Daytime Diesel Full Power Noise Emission Level (CRN $L_{Aeq, 0700\text{-}1900hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEDE	4-hour Evening Diesel Full Power Noise Emission Level (CRN $L_{Aeq, 1900\text{-}2300hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEDN	8-hour Evening Diesel Full Power Noise Emission Level (CRN $L_{Aeq, 2300\text{-}0700hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PFD	18-hour Rolling Noise Emission Level (CRN $L_{Aeq, 0600\text{-}0000hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PFN	6-hour Fan Noise Emission Level (CRN $L_{Aeq, 0000\text{-}0600hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEFD	12-hour Daytime Fan Noise Emission Level (CRN $L_{Aeq, 0700\text{-}1900hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	

Table A.2 (continued) BRT Object Specification

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_PEFE	4-hour Evening Fan Noise Emission Level (CRN $L_{Aeq, 1900\text{-}2300hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_PEFN	8-hour Evening Fan Noise Emission Level (CRN $L_{Aeq, 2300\text{-}0700hrs}$)	String	Calculated	Default Value	0 V	None
				Precision	1 d.p.	
				Max. Length	6	
L_Z	Height of Object in AMSL	String	Calculated	Default Value	8.00	None
				Min Value.	0.00	
				Max Value	9999.99	
				Precision	2 dp	
				Max. Length	10	
L_TT	Track Type	Integer	Data Input	Default Value	8.00	1: CWR + Concrete Slp 2: CWR + Timber Slip 3: Jointed Track 4: Switch or Crossing 5: Slab Track
				Max. Length	10	
L_TS	Support Structure	Integer	Data Input	Default Value	8.00	0: No Support 1: Concrete Bridge 2: Stone Bridge 3: Brick Bridge 4: Steel Bridge 5: Steel Box Girder Bridge
				Max. Length	10	
L_ATQ	Acoustic Track Quality of Railheads	Floating Point	Data Input	Default Value	4 dB	None
				Max. Length	10	
L_VEL	Measured speed profile	Floating Point	Data Input	Default Value	0	None
				Max. Length	6	
L_VAD	Maximum Line Speed	Floating Point	Data Input	Default Value	0	None
				Precision	1 d.p.	
				Max. Length	5	

Table A.2 (continued) BRT Object Specification

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_MAJ	Major or Non-Major Rail Section	Integer	Data Input	Max. Length	3	0: Non-Major 1: Major
L_VAR	Calculation variant	String	Data Input	Default Value	+	-
				Max. Length	20	
J_ID01 - 99	Movements Allocation Factor	Floating Point	Data Input	Default Value	1	None
				Max. Length	1	
				Range	0 - 1	

Appendix B
Round 2 Railway Movements

Table B.1 2011 Round Two Modelling Passenger Movements

J_ID	Train	Movements Provided By	Line	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	6-Hour (0000-0600hrs)	18-Hour (0600-0000hrs)
JID_01	Class 3000	Train	Bangor-Portadown	Bangor - Belfast Central		11960	9048	2340	572	0	11960
JID_02	Class 3000	Train	Bangor-Portadown	Bangor - Belfast Central		3640	3120	260	260	0	3640
JID_03	Class 3000	Train	Bangor-Portadown	Belfast Central - GVS		15080	11648	2340	1092	0	15080
JID_04	Class 3000	Train	Bangor-Portadown	GVS - Lisburn		8944	6500	1768	676	0	10348
JID_05	Class 3000	Train	Bangor-Portadown	GVS - Lisburn		2860	2600	0	260	0	2805
JID_06	Class 3000	Train	Bangor-Portadown	GVS - Lisburn		1040	1040	0	0	0	1040
JID_07	Class 3000	Train	Bangor-Poradown	GVS - Lisburn		780	780	0	0	0	780
JID_08	Class 3000	Train	Bangor-Portadown	Belfast Central - Bangor		11648	8996	2340	312	0	11648
JID_09	Class 3000	Train	Bangor-Portadown	Belfast Central - Bangor		3120	3120	0	0	0	3120
JID_10	Class 3000	Train	Bangor-Portadown	GVS - Central		13572	10712	2288	572	0	13572
JID_11	Class 3000	Train	Bangor-Portadown	Lisburn - GVS	80% of these movements occur before Lisburn based on terminating service data showing around 20% originate at Lisburn.	11648	9256	1768	624	0	11648

Table B.1 (continued) 2011 Round Two Modelling Passenger Movements

J_ID	Train	Movements Provided By	Line	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	6-Hour (0000-0600hrs)	18-Hour (0600-0000hrs)
JID_12	Class 3000	Train	Bangor-Portadown	Lisburn - GVS	70% of these movements occur before Lisburn based on terminating service data showing around 30% originate at Lisburn	3380	3120	260	0	0	3380
JID_13	Class 450	Train	Belfast – Carrickfergus	Central - Carrickfergus	Terminating movements show around 75% continue past Carrick	9960	7602	1924	434	261	9699
JID_14	Class 4000	Train	Belfast - Carrickfergus	Central - Carrickfergus	Terminating movements show around 22% terminate at Carrickfergus	840	770	70	0	0	840
JID_15	Class 450	Train	Belfast - Carrickfergus	Central - Carrickfergus		520	520	0	0	0	520
JID_16	Class 450	Train	Belfast - Carrickferg	GVS - Central	Around 40% of movements terminate at Central with 60% continuing past Central to Carrickfergus	2756	2496	260	0	0	2756
JID_17	Class 450	Train	Belfast – Carrickfergus	Carrickfergus - Central	Around 75% of the movements originate before Carrickfergus due to 25% shown to terminate at Carrickfergus when heading north	10844	8070	2202	572	0	10844
JID_18	Class 450	Train	Belfast - Carrickfergus	Carrickfergus - Central	Around 78% of the movements originate before Carrickfergus due to 22% shown to terminate at Carrickfergus when heading north	520	520	0	0	0	520
JID_19	Class 4000	Train	Belfast – Carrickfergus	Carrickfergus - Central		770	70	0	0	0	840
JID_20	Class 450	Train	Belfast - Carrickfergus	Central - GVS		3172	2288	624	260	0	3172

Table B.1 (continued) 2011 Round Two Modelling Passenger Movements

J_ID	Train	Movements Provided By	Line	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	6-Hour (0000-0600hrs)	18-Hour (0600-0000hrs)
JID_21	Class 3000	Train	Belfast - Londonderry	Central - Antrim		4420	3432	728	260	0	4420
JID_22	Class 3000	Train	Belfast - Londonderry	GVS - Central (LY)		3588	2912	676	0	0	3588
JID_23	Class 3000	Train	Belfast - Londonderry	Antrim - Central (LY)		4368	3432	936	0	312	4368
JID_24	Class 3000	Train	Belfast - Londonderry	Central - GVS (LY)		3848	2912	936	0	0	3848
JID_25	Enterprise	Train	Belfast - Dublin	Central - Dublin		2756	2132	312	312	0	2756
JID_26	Enterprise	Train	Belfast - Dublin	Dublin - Central		2756	2028	728	0	0	2756

Class 3000 trains are 3-vehicle units
Class 450 trains are 3-vehicle units
Class 4000 trains are 3-vehicle units
Enterprise Train Comprises a Class 201 Locomotive and 8 No. Mark IIf/IIb Coaches

Table B.2 2011 Round Two Modelling Out-of-Service Movements

J_ID	Train	Movements Provided By	Line	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	6-Hour (0000-0600hrs)	18-Hour (0600-0000hrs)
JID_31	Class 110 Locomotive	VEHICLE		To York Road Depot		365	365	0	0	0	365
JID_32	Class 201 Locomotive	VEHICLE		To York Road Depot		365	0	365	0	0	365
JID_33	Enterprise Loco Hauled Carriage	VEHICLE		To York Road Depot		5840	0	5840	0	0	5840
JID_34	Class 450	TRAIN		To York Road Depot		1925	825	550	550	0	1925
JID_35	Class 4000	TRAIN		To York Road		630	270	180	180	0	630
JID_36	Class 3000	TRAIN		To York Road Depot		2190	1460	730	0	0	2190
JID_37	Class 80	VEHICLE		To York Road Depot		90	0	0	90	0	90
JID_38	Class 110 Locomotive	VEHICLE		Leaving York Road Depot		365	365	0	0	0	365
JID_39	Class 201 Locomotive	VEHICLE		Leaving York Road Depot		365	365	0	0	0	365
JID_40	Enterprise Loco Hauled Carriage	VEHICLE		Leaving York Road Depot		5840	2920	0	2920	0	5840
JID_41	Class 450	TRAIN		Leaving York Road Depot		1925	825	550	550	0	1925
JID_42	Class 4000	TRAIN		Leaving		830	270	180	180	0	830

Table B.2 (continued) 2011 Round Two Modelling Out-of-Service Movements

J_ID	Train	Movements Provided By	Line	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	6-Hour (0000-0600hrs)	18-Hour (0600-0000hrs)
JID_43	Class 3000	TRAIN		Leaving York Road Depot		2190	1095	365	730	0	2190
JID_44	Class 80	VEHICLE		Leaving York Road Depot		90	0	0	90	0	90

Table B.3 2011 Round Two Modelling Engineering Movements

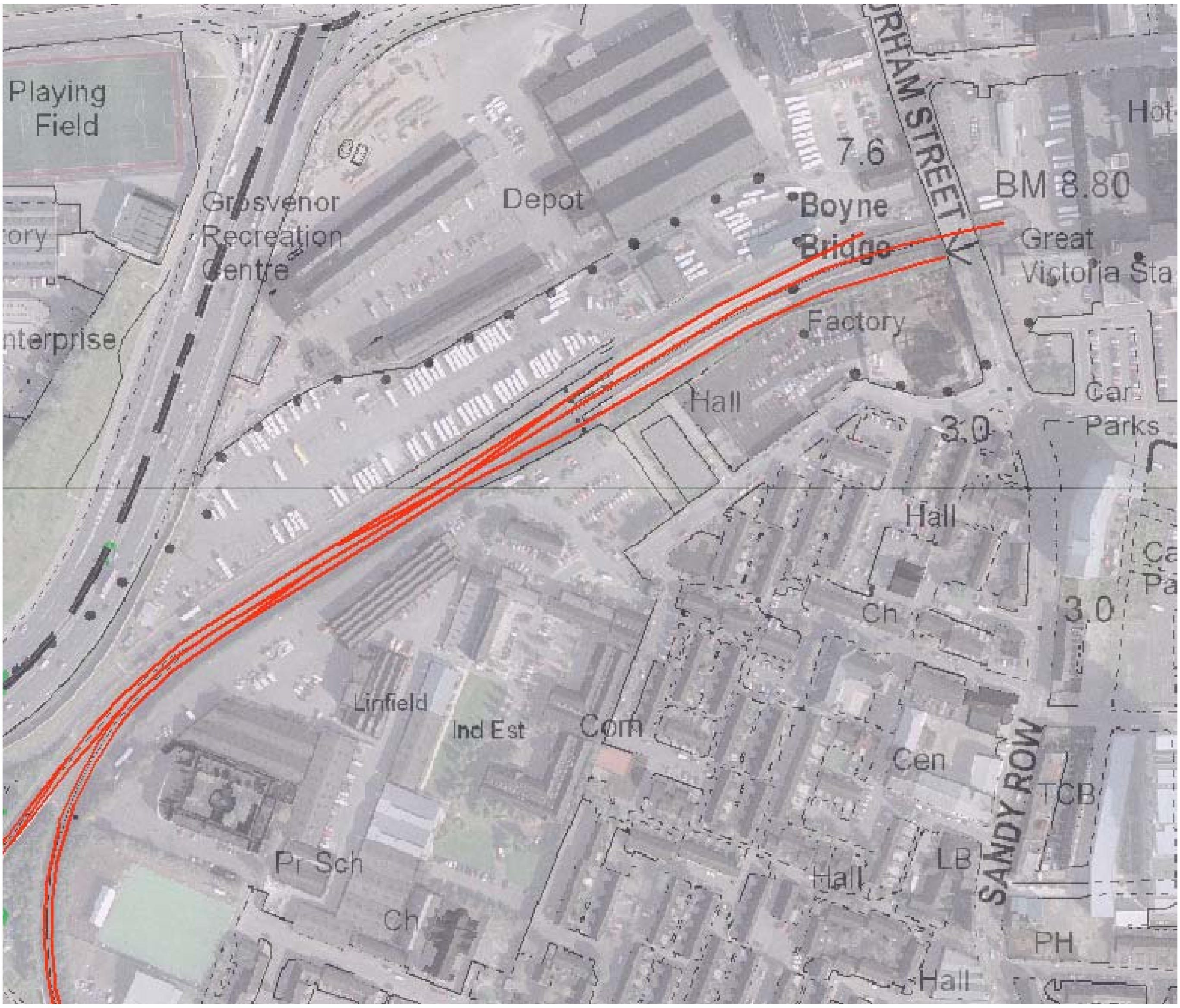
J_ID	Train	Movements Provided By	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	6-Hour (0000-0600hrs)	18-Hour (0600-0000hrs)
JID_45	Tampers (Plasser 07-16 / 08 / 08	Vehicle	York Road Depot to Carrickfergus		15	0	0	15	5	10
JID_46	Tampers (Plasser 07-16 / 08 / 08	Vehicle	Carrickfergus to York Road Depot		15	0	0	15	5	10
JID_47	Tampers (Plasser 07-16 / 08 / 08	Vehicle	York Road Depot to Lisburn		40	0	0	40	10	30
JID_48	Tampers (Plasser 07-16 / 08 / 08	Vehicle	Lisburn to York Road Depot		40	0	0	40	10	30
JID_49	Tampers (Plasser 07-16 / 08 / 08	Vehicle	York Road Depot to Antrim		40	0	0	40	10	30
JID_50	Tampers (Plasser 07-16 / 08 / 08	Vehicle	Antrim to York Road Depot		40	0	0	40	10	30
JID_51	Tampers (Plasser 07-16 / 08 / 08	Vehicle	York Road Depot to Bangor		15	0	0	15	5	10
JID_52	Tampers (Plasser 07-16 / 08 / 08	Vehicle	Bangor toYork Road Depot		15	0	0	15	5	10
JID_53	GM loco	Vehicle	York Road Depot to Antrim		40	20	0	20	7	33
JID_54	GM loco	Vehicle	Antrim to York Road Depot		40	20	0	20	7	33
JID_55	GM loco and hoppers	Vehicle	Antrim to Belfast to Portadown		40	20	0	20	7	33
JID_56	GM loco and hoppers	Vehicle	Portadown to Belfast to Antrim		40	20	0	20	7	33
JID_57	GM loco	Vehicle	York Road Depot to Adelaide		40	20	0	20	7	33
JID_58	GM loco	Vehicle	Adelaide to York Road Depot		40	20	0	20	7	33

Table B.3 (continued) 2011 Round Two Modelling Engineering Movements

J_ID	Train	Movements Provided By	Route	Notes	24-Hour	Day (0700-1900hrs)	Evening (1900-2300hrs)	Night (2300-0700hrs)	6-Hour (0000-0600hrs)	18-Hour (0600-0000hrs)
JID_59	GM loco and hoppers	Vehicle	Adelaide to Portadown		40	20	0	20	7	33
JID_60	GM loco and hoppers	Vehicle	Portadown to Adelaide		40	20	0	20	7	33
JID_61	GM loco - training	Vehicle	York Road to Templepatrick		70	0	0	70	15	55
JID_62	GM loco - training	Vehicle	Templepatrick to York Road		70	0	0	70	15	55
JID_63	GM loco + Flat Bed Wagons	Vehicle	York Road Depot to Carrickfergus		6	1	0	5	1	5
JID_64	GM loco + Flat Bed Wagons	Vehicle	Carrickfergus to York Road Depot		6	1	0	5	1	5
JID_65	GM loco + Flat Bed Wagons	Vehicle	York Road Depot to Lisburn		15	5	0	10	3	12
JID_66	GM loco + Flat Bed Wagons	Vehicle	Lisburn to York Road Depot		15	5	0	10	3	12
JID_67	GM loco + Flat Bed Wagons	Vehicle	York Road Depot to Antrim		20	5	0	15	5	15
JID_68	GM loco + Flat Bed Wagons	Vehicle	Antrim - York Road Depot		20	5	0	15	5	15
JID_69	GM loco + Flat Bed Wagons	Vehicle	York Road Depot - Bangor		6	1	0	5	1	5
JID_70	GM loco + Flat Bed Wagons	Vehicle	Bangor - York Road Depot		6	1	0	5	1	5
JID_71	VMT and Sandite Train	Vehicle	York Road - Portadown - Bangor - Carrick - York Roa		200	100	0	100	25	175

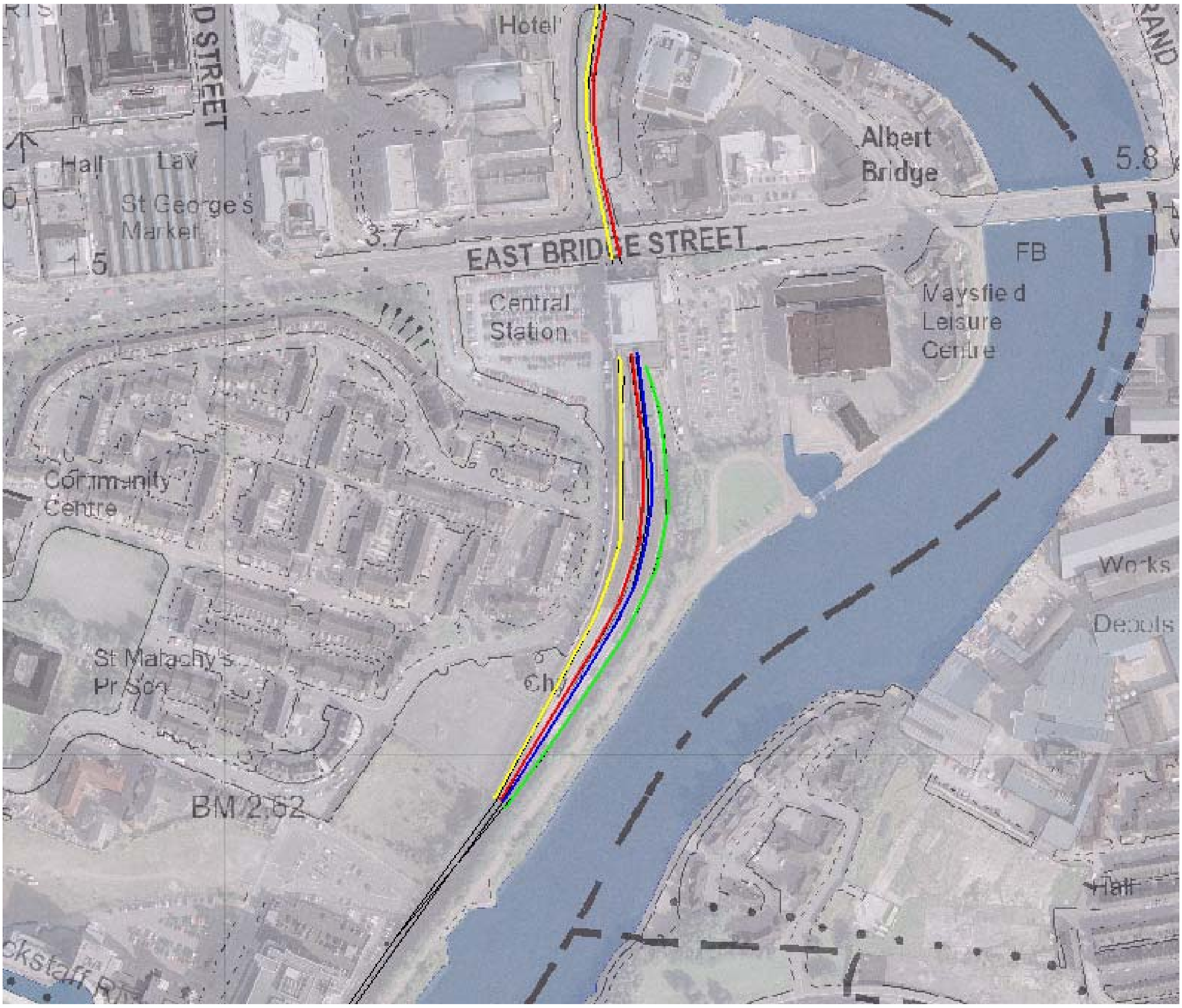
Appendix C
Stations and Depots

Great Victoria Street



Movements into and out of GVS are modelled onto three platforms. It has been assumed that all platforms are used equally and that a third of all train movement and services into and out of the stations are allocated over each of the modelled platforms.

Belfast Central



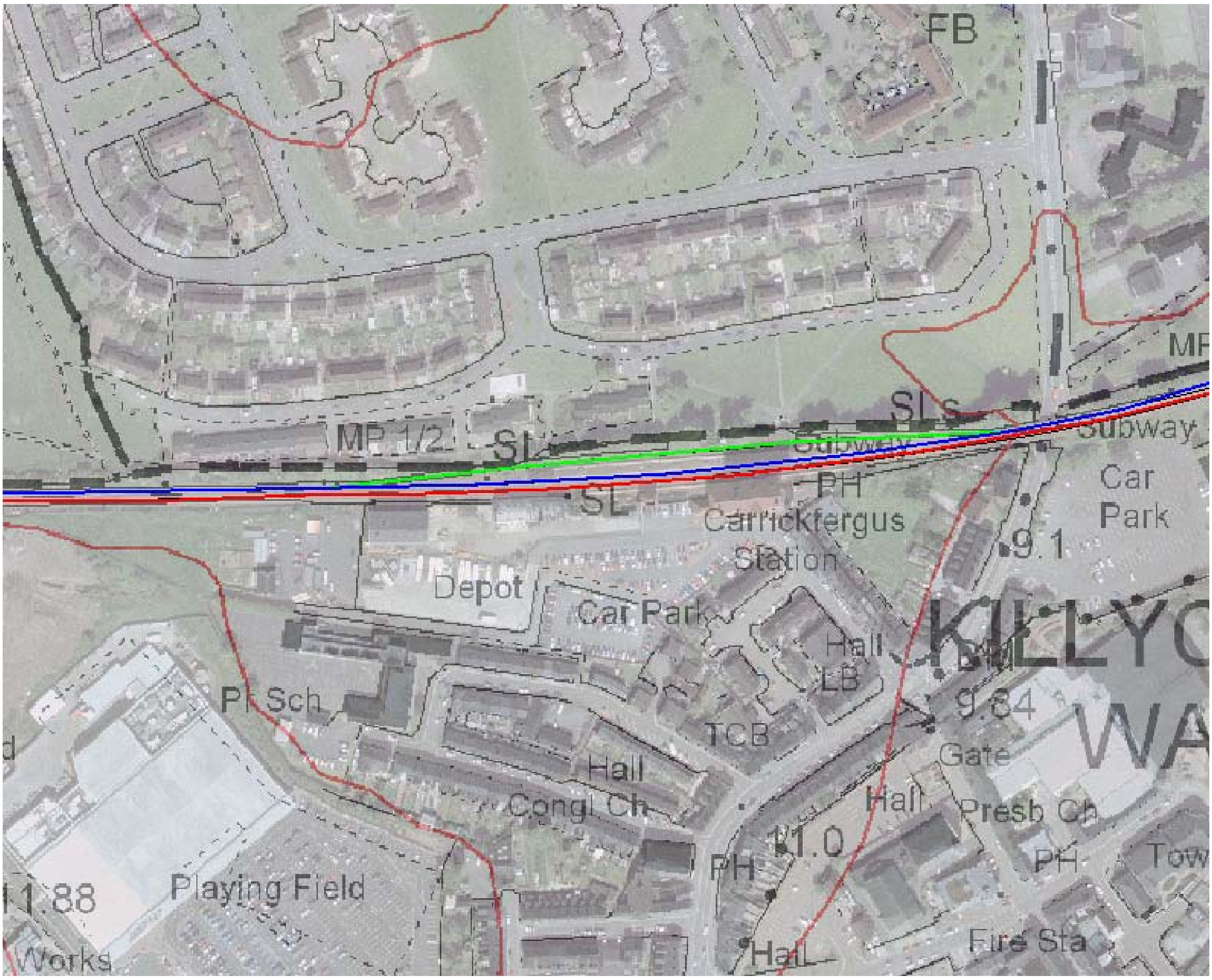
Yellow line models all heading from and to Bangor, Larne and Londonderry.

Red line models all services to and from Londonderry and Bangor.

Blue and Green line models equally model all terminating services terminating at GVS and heading back to Belfast Central

Blue line models Dublin Enterprise Services terminating and departing at and from Belfast Central

Carrickfergus



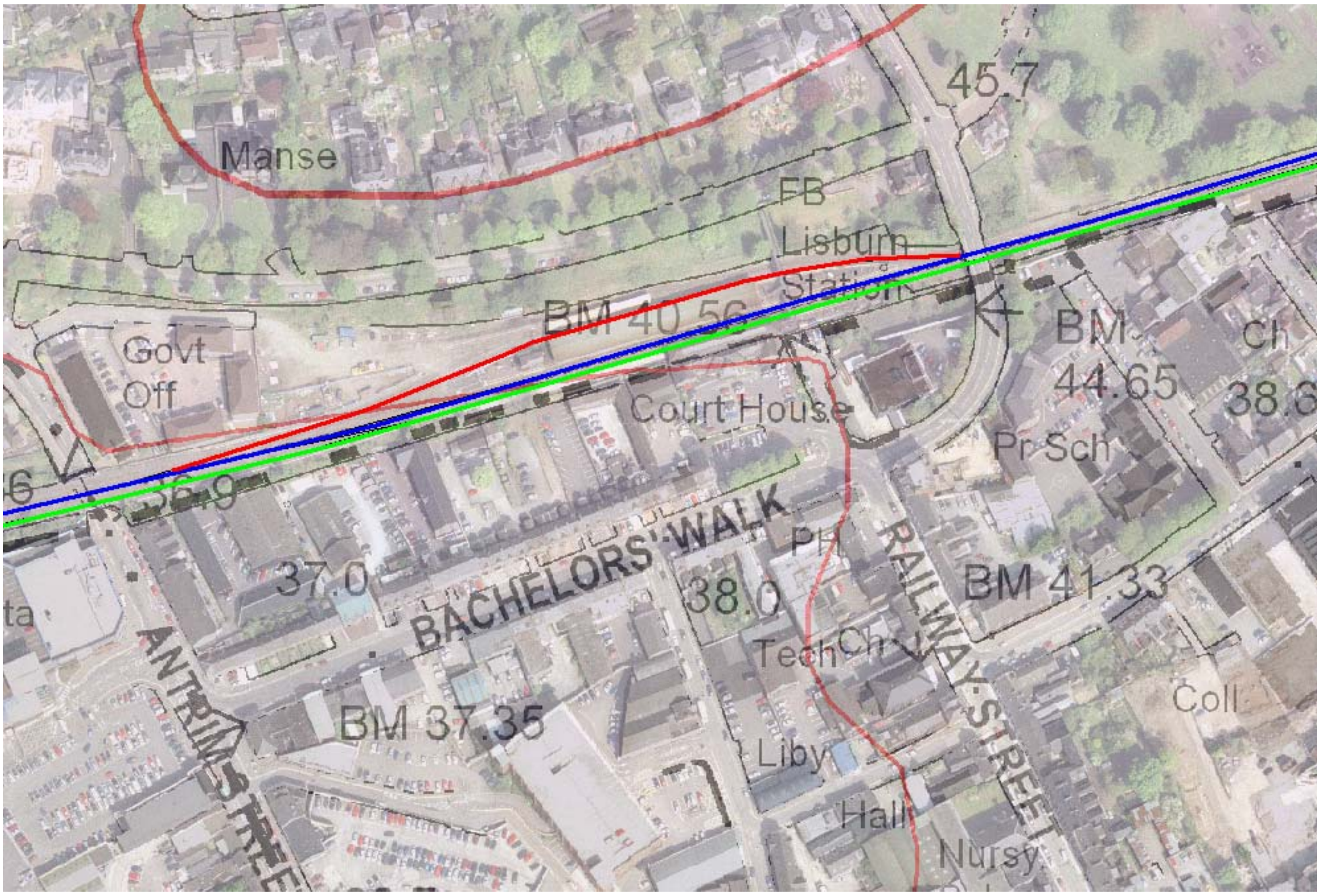
Red line is used to model services stopping at and passing through Carrickfergus towards Belfast

Blue line is used to model services stopping at and passing through Carrickfergus from Belfast

Green line models services terminating at or originating from Carrickfergus.

Note: Data provided by Translink during Round Two indicates that around 20-25% of services terminate at Carrickfergus. The data shows that a corresponding 75-80% of services continue through Carrickfergus or originate before Carrickfergus.

Lisburn

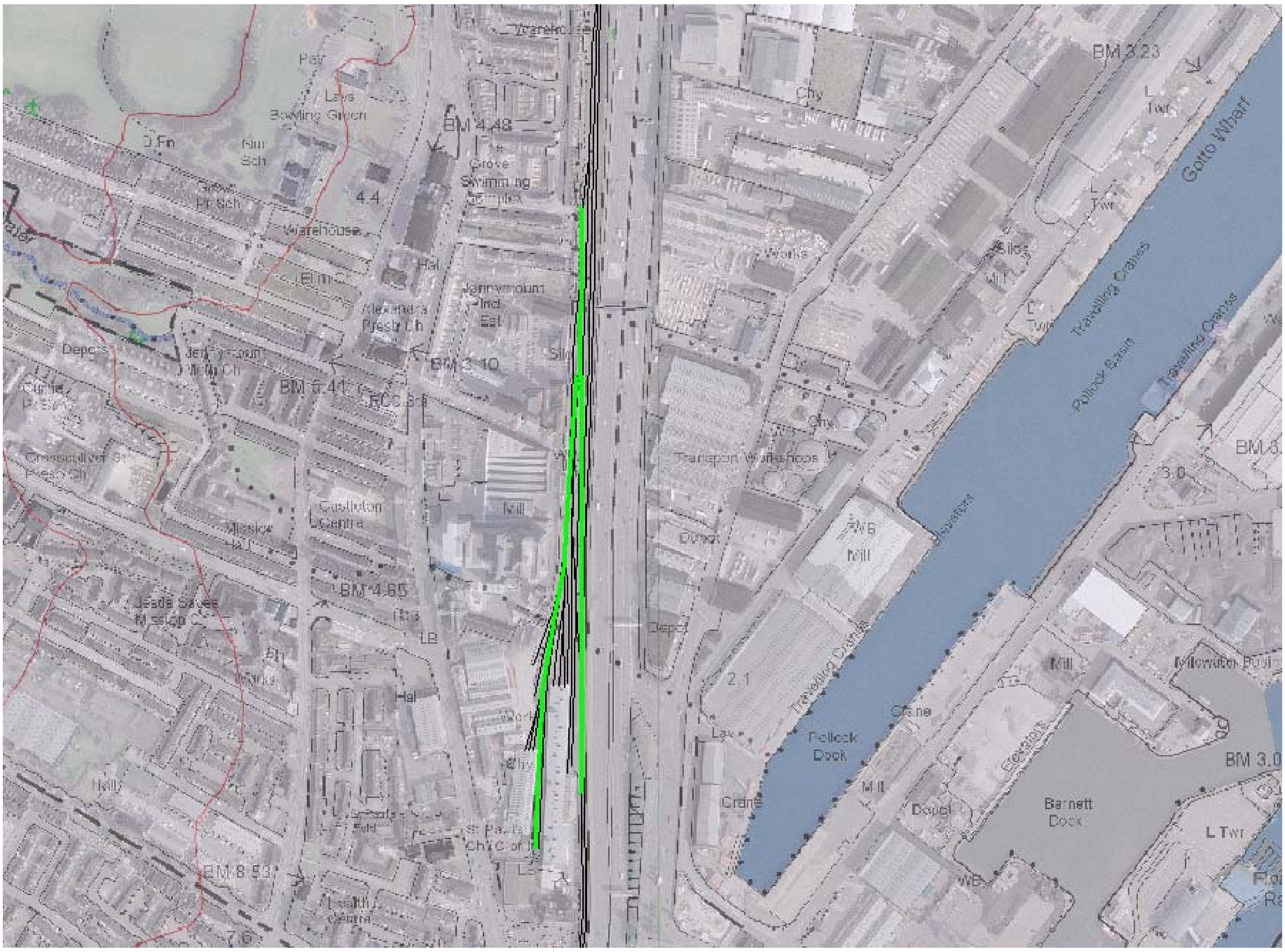


Green and Red lines model services passing through and stopping at Lisburn.

Red line models services that terminate at or originate from Lisburn.

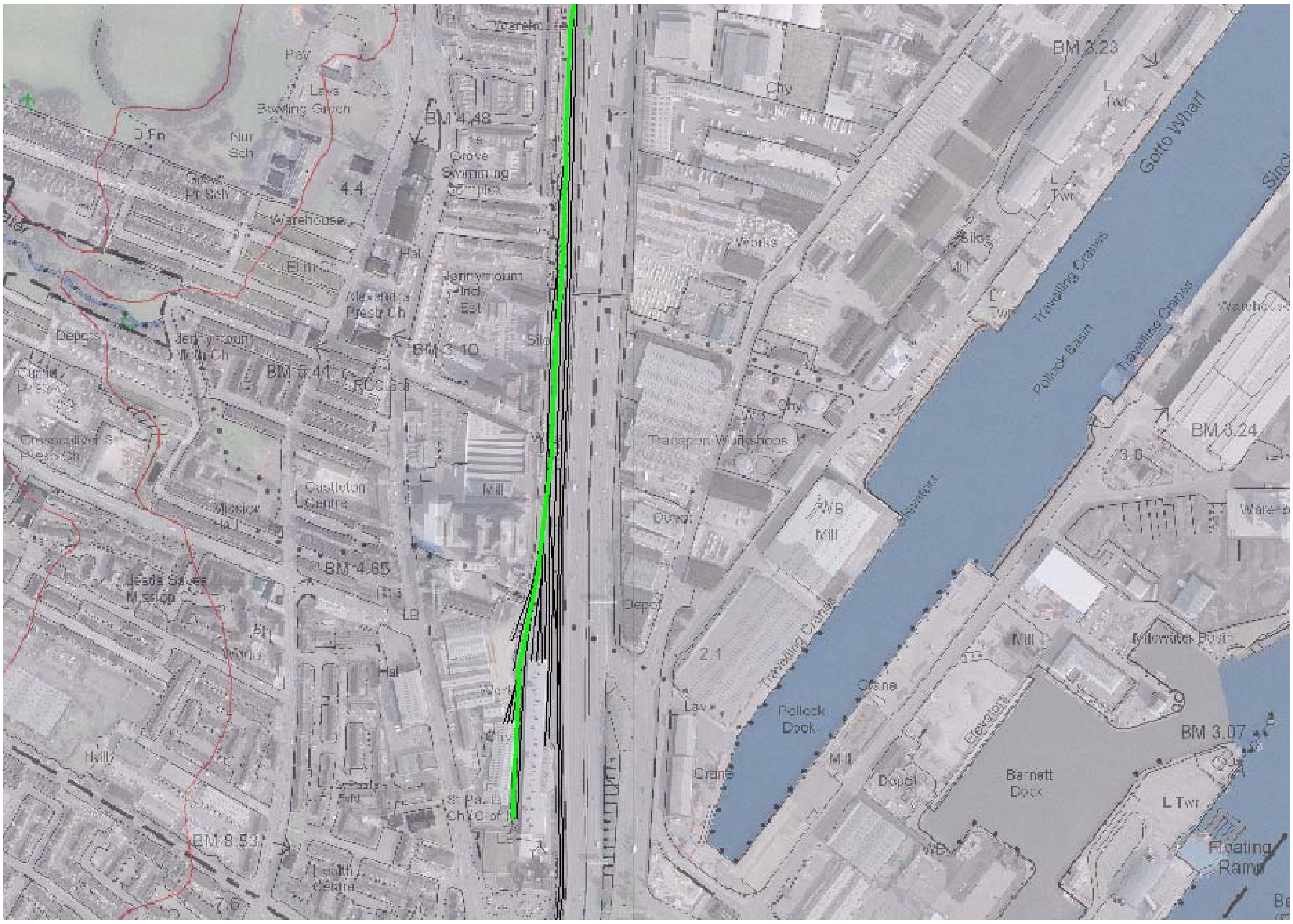
Note: Data provided by Translink for Round Two indicates that 70-80% of movements originate before or travel beyond Lisburn station. The remaining 20-30% terminates or originates at Lisburn.

York Road Depot – Trains Entering Depot from Belfast End



Green line represents trains entering depot from the Belfast end.

York Road Depot – Trains Entering Depot from North



Green line represents train movements entering York Road Depot from the north