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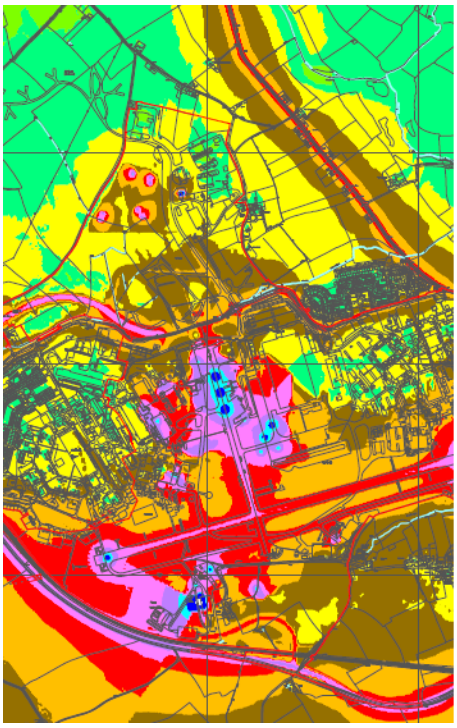
Department of Environment Northern Ireland

Provision of Second Round Noise Maps for Northern Ireland

Summary Report



27 July 2012

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Department of Environment Northern Ireland

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27 July 2012

AMEC Environment & Infrastructure UK Limited

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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

Term	Definition
GIS	Geographic Information System
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 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 to 19:00)
Noise Level - L_e - Evening	L_e (or $L_{evening}$) = $L_{Aeq,4h}$(19:00 to 23:00)
Noise Level - L_n - Night	L_n (or L_{night}) = $L_{Aeq,8h}$(23:00 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)

Term	Definition
QA	Quality Assurance
Round One	Round One noise modelling for the European Noise Directive (Northern Ireland) - 2007
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 therefore let a single contract for the preparation of noise maps on behalf of the Competent Authorities.

AMEC Environment and Infrastructure UK Limited (AMEC) was commissioned to prepare noise maps for the Component Authorities reporting directly to DoE. As part of the commission, AMEC has 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 contract aims to establish estimates of the total number of people 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. Noise exposure statistics required in L_{den} 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 and the estimated total number of people living in each of these areas will be established 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}. The results of the noise mapping will be used to inform and update noise action plans drafted by each competent authority.

Under the contract, noise level exposure statistics were also required for other supplementary noise indicators which are incumbent within national noise policy guidance.

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

- Review of the necessary Competent Authority data to ensure completeness (including a data Quality Assurance);
- Identification of gaps in order to define any further information requirements;
- Modifying and/ or collecting further information through contractor survey (data cleaning and manipulation);
- Collation of the data into relevant datasets; and
- Preparation of Stage 1 report.
- Appraisal of data provided by DoE (and other stakeholders) with gaps identified with Quality Assuring of the data.

The following tasks were undertaken within Stage 1 of the contract:

- 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.

1.2 Purpose of this Report

This report provides a summary of the work undertaken to deliver the Round Two noise maps across Northern Ireland. This includes the process used to develop the 3D model and the emission datasets used within the modelling process; the calculation methods adopted; an overview of the data management and modelling process; post processing steps used to generate the required outputs for the END and a summary of the key population exposure results generated from the study. The aim of this report is to provide the Competent Authorities with an understanding of the processes involved in the assessment of noise for the second round of END mapping. Full details of the processes adopted are provided in the reports produced for each individual noise source assessed.

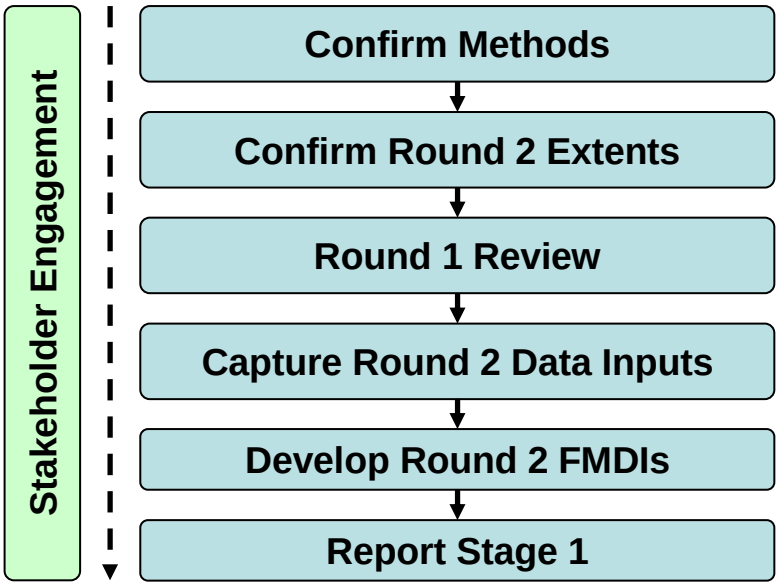
1.3 Overview of the Second Round Approach

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

1.3.1 Stage 1

The aim of Stage 1 was the successful development of Final Modified Data Inputs (FMDIs) designed 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 are 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, 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 3D modelling are discussed in relation to both the approach undertaken in Round One and the methodology adopted for Round Two.

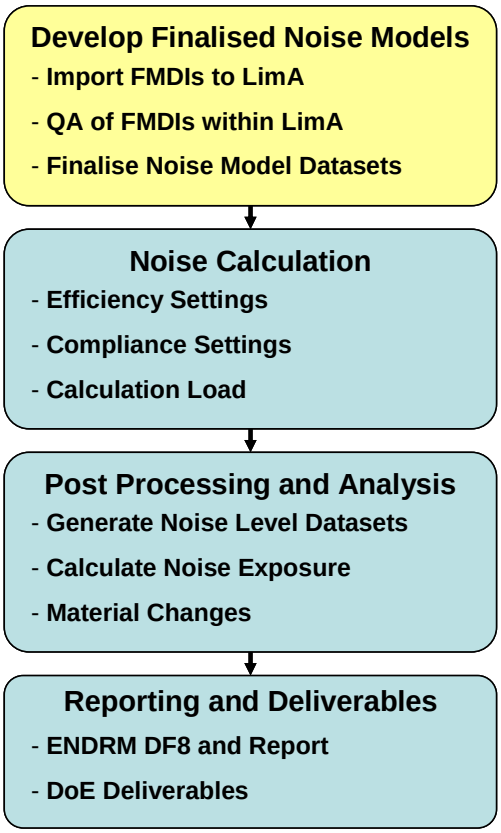
1.3.2 Stage 2

The aim and scope of Stage 2 was:

- 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 Reportnet.

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 must encompass 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 (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 for each of the noise sources. Maps showing the geographical extent of the areas are also provided in Plates 2.1 – 2.4.

2.1 Agglomeration Modelling Extent

The only agglomeration 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 198 km^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 596 km^2 is shown in Plate 2.1. This area is the same geographical area as used for round one mapping exercise.

2.2 Airport Modelling Extent

At the start of the Round Two, contact was established between AMEC and Belfast City and Belfast International Airports. Subsequent discussions with representatives of the airports confirmed that there have not been any significant physical changes or changes to airspace or runway operations at either airport since 2006. The location of the two airports is shown on Plate 2.1.

2.3 Industry Modelling Extent

The 104 industrial (industry, waste and harbour) sites considered in Round One were reviewed at the start of Round Two. This process included assessing the location, extent and (where possible) the operational activities of each of the Round One sites. An additional 14 sites which potentially required mapping under the END requirements were provided to AMEC by DoE.

Each of the target sites were then identified and mapped using available OSNI aerial photography/ mapping and online review of Google Earth and StreetView imagery. Any premises which were not identifiable (i.e. demolished sites) during this process were removed from the list of target sites. After completing this initial assessment, detailed maps of each location were created and provided to DoE Northern Ireland and Belfast Ports and Harbour Authority for review and comment.

This process resulted in removal of some sites and the production of a final dataset of 111 sites used in the final modelling process. The location and extent of these sites within the Belfast agglomeration are shown in Plate 2.2.

2.4 Major Roads Modelling Extent

The major roads to be mapped in this study were identified by linking road flow information supplied by the Northern Ireland Roads Service with road centrelines produced by OSNI. Detailed roads information is provided in the road modelling report.

Using these datasets, all major roads with more than 3 million vehicles were identified using GIS queries. A second GIS process was then used to define a 3 km wide corridor around each of the selected roads. These buffered areas comprise the final major road mapping extent and is shown in Plate 2.3.

The data capture area covered by major roads outside the agglomeration was 4,460 km^2. This compares to the 1,582 km^2 mapped in Round One.

2.5 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. The extent of the data capture area for the major railways is shown in Plate 2.4.

2.6 Round One and Round Two Data Capture Extents

Table 2.1 provides a summary of the extent of the data capture areas used for the Round One and Round Two mapping exercises. This highlights that total data capture area for Round Two is over double the size of the data

capture area used for Round One. This reflects the changes in the requirements of the ENDS directive and the inclusion of additional major roads with more than 3 million vehicle passages per year.

Table 2.1 Round One and Round Two - Extent of Data Capture Area

Noise Source	Round One (km^2)	Round Two (km^2)	Increase in Area (km^2)	Percentage Increase	Round Two Area as a Percentage of Northern Ireland
Agglomeration (including airports, industry and railway sources)	596	596	0	0%	4.3%
Major roads (outside the Belfast agglomeration	1,582	4,460	2,878	182%	32.2%
Total area	2,178	5,056	2,878	132%	36.5%

Plate 2.1 Belfast Agglomeration showing Locations of Belfast City and International Airports and Major Roads

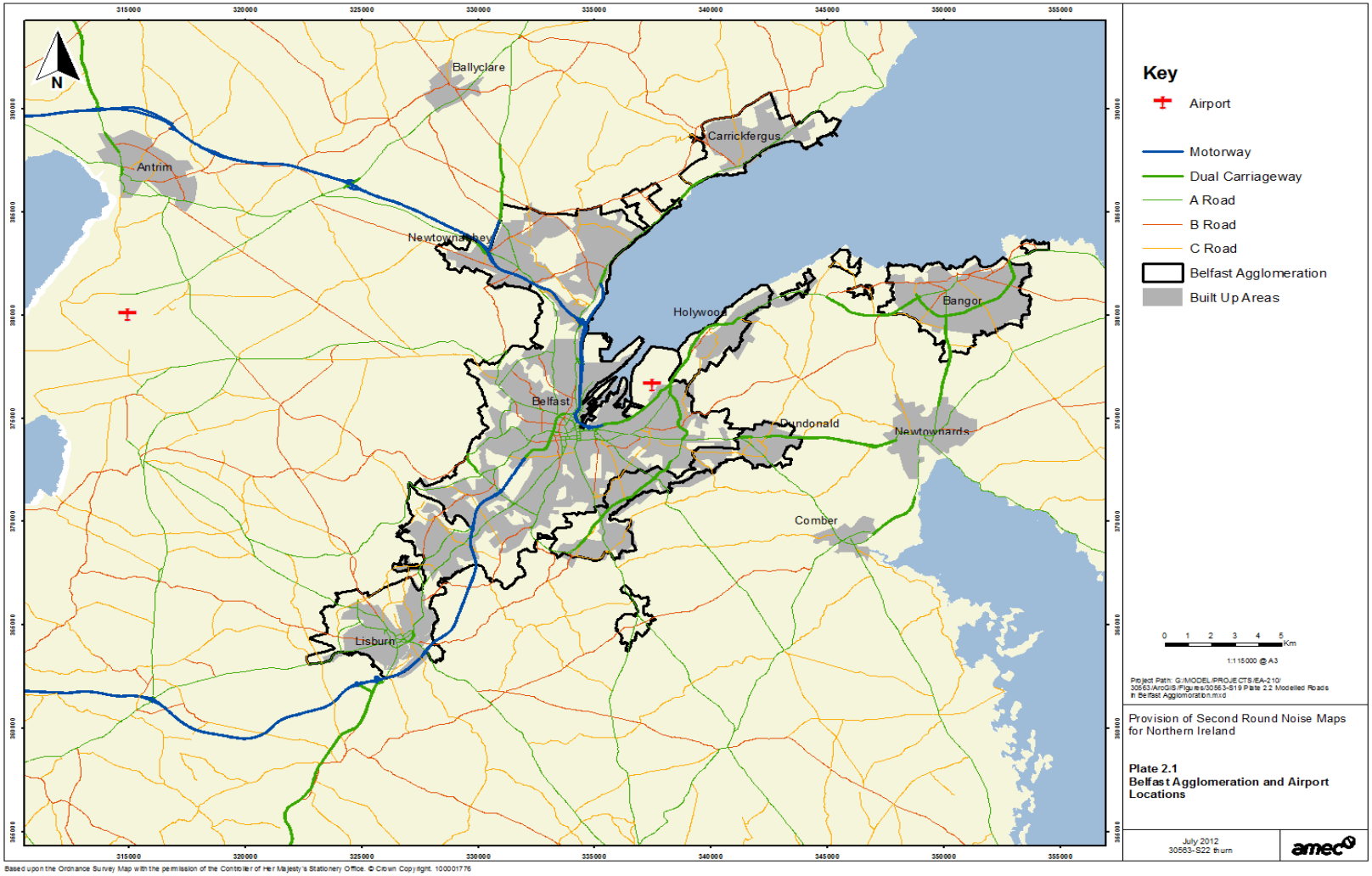


Plate 2.2 Location of Industrial Sites Modelled within the Belfast Agglomeration

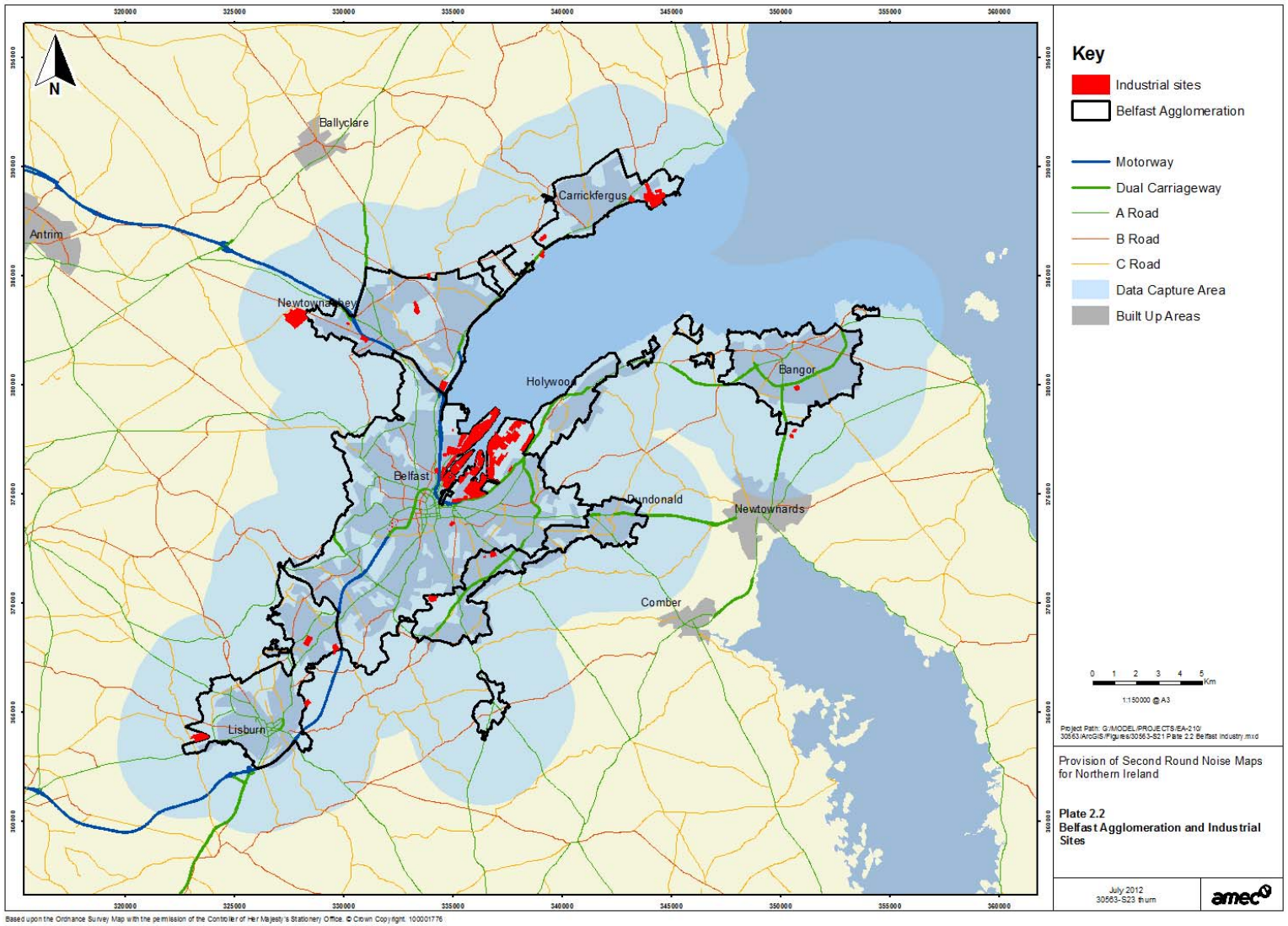


Plate 2.3 Location of Major Roads Modelled outside the Belfast Agglomeration

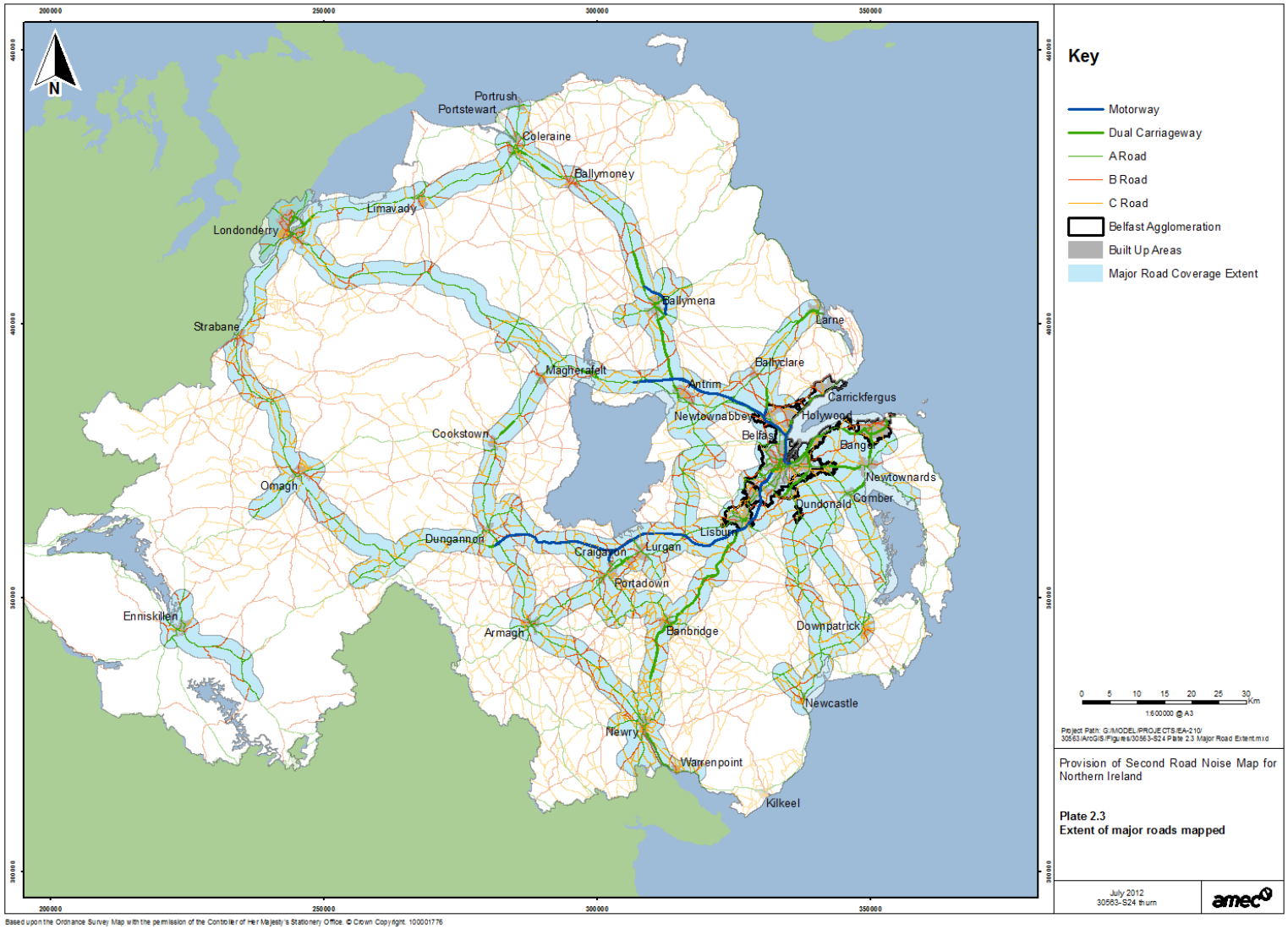
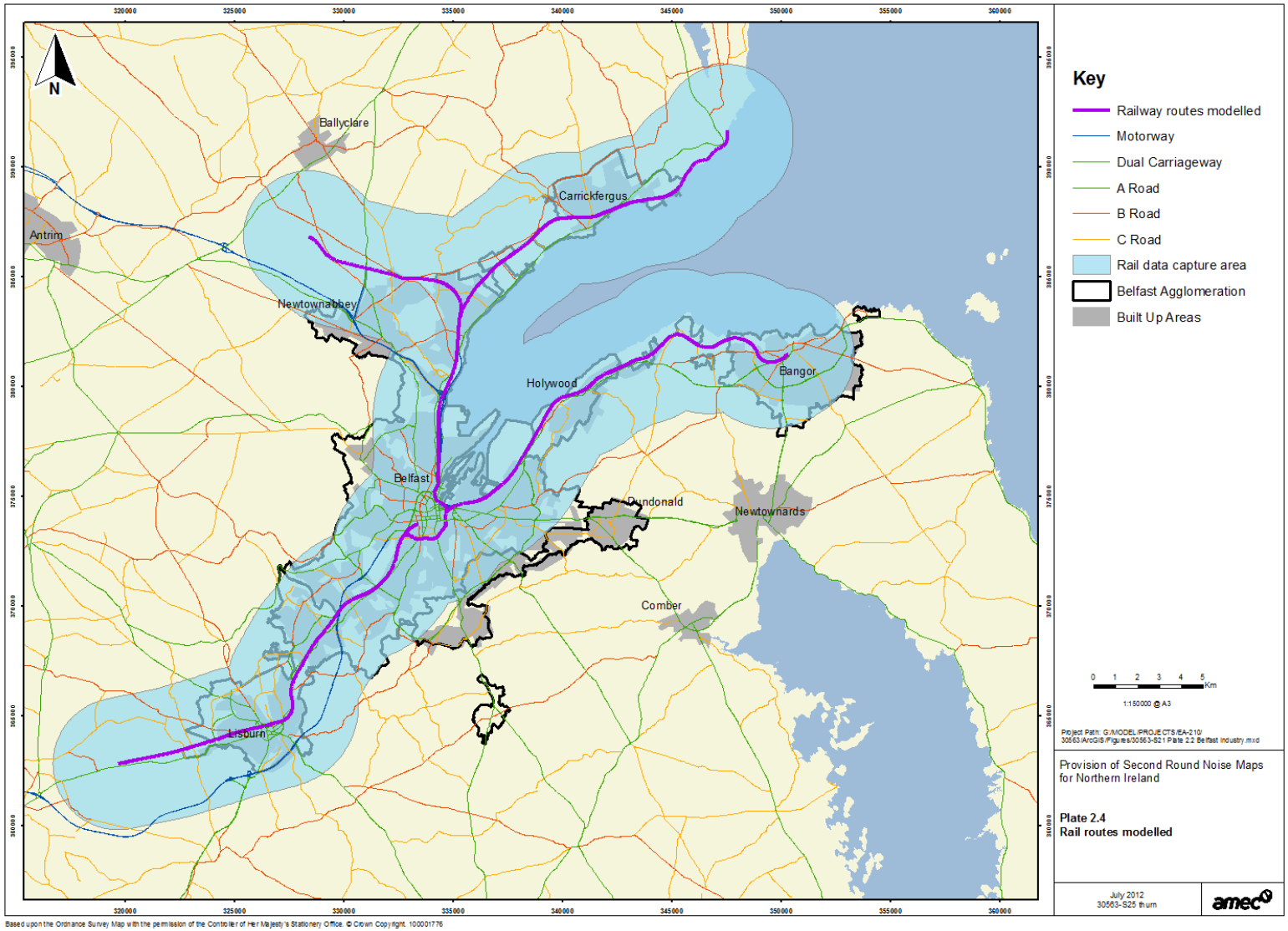


Plate 2.4 Location of Major Railway Routes Modelled inside the Belfast Agglomeration



3. Calculation Methods

3.1 Introduction

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).

The 3D model environment is used to establish the various attenuations during the propagation of noise from source to receiver and as such the 3D model environment is a noise propagation dataset. The preparation of noise emission datasets are reported in separate reports delivered under this contract.

For Round One, dataset specifications were developed for the calculation methods and 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. These are provided in Appendix A.

3.2 Propagation Datasets

Due to the similarities in the information required in the calculation of the propagation of road traffic, railway and industrial noise, it is best practice in noise mapping to produce a single 3D model environment which can facilitate calculations of each noise source. This best practice was implemented during Round One and has been carried forward into Round Two.

Within the noise modelling software, the following datasets comprise the propagation dataset:

- **Buildings Dataset** – this dataset defines the location and the height of buildings;
- **Digital Terrain Model (DTM) Dataset** – this dataset is used to define the height and profile of the terrain upon which other objects are located. The DTM dataset can comprise of the following element:
  - Spot Heights –data representing the height of the terrain at a point;
  - Contour Lines – data presenting areas of terrain with equal height;
  - Break Lines – vector information representing the height of the terrain at specific features.
- **Barriers Dataset –** this dataset defines the location and the height of any noise barriers (i.e. barriers that present an obstacle to noise propagation);
- **Bridges Dataset –** this dataset present the location of bridges;

- **Ground Cover Dataset** – this dataset is used to define the acoustic absorbency of the ground over which noise propagates from source to receiver;

- **Meteorological Dataset** – this dataset defines the average annual meteorological conditions for parameters such as temperature, humidity and wind direction.

Full data specifications and GIS processing steps used to generate each of the individual datasets comprising the 3D model are provided in the Round Two 3D modelling report. The FMDI data specifications are designed to work both within the ArcGIS and LimA software environments. Both software environments are also capable of handling point, polyline and polygon objects and can process heights and elevations in several different formats.

The FMDI dataset specifications have ultimately been driven by the requirements of the LimA noise modelling environment. This means that cartographic, object and object attribution rules required within the LimA environment have been reciprocated within the ArcGIS environment.

To assist this process, the LimAarc ArcGIS extension was utilised. The LimAarc extension streamlines many of the key data interaction stages between the ArcGIS and LimA software environments, reducing the risk of human error. It also enhances key interfaces between the ArcGIS and LimA environments providing additional QA procedures within the noise mapping process.

3.3 Noise Calculation Methods

Under the Regulations the assessment methods prescribed for the mapping of road traffic, railway and industrial noise sources are outlined in Table 3.1. It is confirmed from the 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.

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

- Roads: Calculation of Road Traffic Noise (CRTN) (UK) – adapted version comprising:

  - Department of Transport publication, *'Calculation of Road Traffic Noise'*, HMSO, 1988 ISBN 0115508473; and

  - Defra, Method for Converting the UK Road Traffic Noise Index LA10,18h to the EU Noise Indices for Road Noise Mapping, st/05/91/AGG04442, 24th January 2006.

Table 3.1 Methods of Assessment as Outlined in Schedule 2 of the Regulations (Road, Rail, Airport and Industry)

Assessment method for road traffic noise indicators

6. For road traffic noise indicators the assessment method "Calculation of road traffic noise" (Department of Transport, 7 June 1988, HMSO)(b) shall be used, adapted using the report "Method for converting the UK traffic noise index LA10,18h to EU noise indices for road noise mapping" (DEFRA, 24 January 2006)(c).

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).

Assessment methods for aircraft noise indicators

8. For aircraft noise indicators the assessment method "Report on Standard Method of Computing Noise Contours around Civil Airports" (Second Edition, European Civil Aviation Conference, 2–3 July 1997)(g) shall be used in accordance with paragraph 2.4 of the Annex in the Recommendation.

Assessment methods for industrial noise indicators and port noise indicators

9.—(1) For industrial noise indicators and port noise indicators the propagation assessment method described in "ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of Calculation" (International Standards Organisation, 1996) (a) shall be used in accordance with paragraph 2.5 of the Annex in the Recommendation.

(2) Suitable noise emission data (input data) for "ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation" can be obtained either from measurements carried out in accordance with one of the following methods:

(a) "Acoustics. Determination of sound power levels of multisource industrial plants for evaluation of sound pressure levels in the environment. Engineering method" (BS ISO 8297:1994, British Standards Institute)(b);

(b) "Acoustics. Determination of sound power levels of noise sources using sound pressure. Engineering method in an essentially free field over a reflecting plane" (BS EN ISO 3744:1995, British Standards Institute)(c);

(c) "Acoustics. Determination of sound power levels of noise sources using sound pressure. Survey method using an enveloping measurement surface over a reflecting plane" (BS EN ISO 3746:1996, British Standards Institute)(d);

or by using Toolkit 10 of the "Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure Version 2, Position Paper Final Draft" (European Commission Working Group Assessment of Exposure to Noise, 13 January 2006)(e).

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 airport noise, the assessment for Round One was undertaken with reference to the *"Report on Standard Method of Computing Noise Contours around Civil Airports"* (Second Edition) as implemented in the Federal Aviation Administrations (FAA) Integrated Noise Model (INM) version 6.2. For the Round Two, the method prescribed for airport noise is as described in *"Report on Standard Method of Computing Noise Contours around Civil Airports"* (Third Edition) as implemented in INM version 7 onwards.

The main change between the Second and Third Edition of the method is the inclusion of additional functions and attenuations for bank angles, and the inclusion of new flight procedures and updated thrust reverser components. These changes do not however effect the requirements of the method in relation to 3D modelling and only terrain and geo-positioning information are required from the 3D modelling dataset.

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

- ISO 9613 Interim is described within the following documents:
  - ISO 9613-2: 'Acoustics — Attenuation of sound propagation outdoors, Part 2: General method of calculation';
  - Commission Recommended Adaptations from 2003/613/EC; and
  - The source noise levels used within the calculations should be derived via a methodology in line with the WG-AEN GPGv2 Toolkit 10.

For Round Two, there is no requirement to alter or amend the methods adopted for Round One. It has also been concluded that the adopted versions outlined above remain relevant to the delivery of the strategic noise maps under the Regulations. For Round Two, the noise calculation assessment methods described in this section were used and have informed the preparation of the 3D modelling dataset.

3.4 Software Methods

For Round One noise maps for road, railway and industrial 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. Both software environments were retained for Round Two.

The LimA version adopted for Round Two was version 8.1. This follows confirmation by Stapelfeldt Ingenieurgesellschaft mbH, developers of the LimA noise mapping software, that there have been no modifications to the implementation of the CRTN, CRN or ISO9613 methodologies between versions 8.1 and 5.2.

For Round One, the mapping of airport noise was undertaken using INM version 6.2a implementing ECAC Doc. 29v2. For the mapping of airport noise under Round Two, the project team are contracted to use INM version 7.0a or the latest version of the INM model implementing ECAC Doc29v3. The version of INM used for the mapping of airport noise is INM version 7.0b.

4. Creation of the LimA and INM models

All noise emission datasets and 3D modelling datasets were developed in the GIS environment in accordance with LimA object dataset schemas (see Appendix A) associated with each model layer. This approach was designed to reduce the processing required within either the LimA or INM software environment and was designed to ensure that the datasets are compliant with the two software products.

A key part of this overall process was a five quality assurance process of the Round Two datasets and marked the transition from the GIS environment to the LimA software environment.

The five steps within the QA process were designed to identify whether the various GIS datasets comprising the noise model had been developed to specification. It also aimed to ensure that calculations would run without error and that any issues encountered with any of the noise model layers were identified before calculation and corrected as required.

The QA procedures adopted by the project team broadly reflected those implemented for Round One. However developments within the LimA software have allowed many of these procedures to become automated and further refined. Like the approach adopted in Round One, all QA procedures were undertaken with the assistance of electronic proformas.

These proformas ensured 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.

Further details of the QA work undertaken are set out within the technical reports prepared for each individual noise emission source.

5. Noise Level Calculations

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.

5.1 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 road traffic noise during Round One. The testing studied the effect of the setting upon noise levels above 55 dB L_{den} and 50 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 and INM calculation environments. This review has confirmed that there are no new settings or modifications to the settings testing during Round One. Project policy has therefore been to retain the efficiency settings adopted for Round One for Round Two.

There are several advantages to retaining the efficiency settings from Round One to Round Two, namely consistency within the calculations. Efficiency settings can introduce uncertainties; therefore changes in these settings from Round One to Round Two may mask any actual changes in noise levels between Round One and Round Two. As such, and in order to identify any real changes in noise levels between Round One and Round Two, two sets of calculations would be required using Round One efficiency settings and any new settings adopted

for Round Two. It is the view of the project team that the settings adopted for Round One 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.

5.2 Calculation Process and Creation of Output Files

A majority of the calculations performed for Round Two were undertaken using the LimAserver management software. The management software allows the automation of calculations, with hardware allocated a LimA calculation core per processor. LimAserver management software was used to manage AMEC's two dedicated noise calculation servers comprising a total of 22 available calculation cores.

The noise calculations produced using LimA were subject to a series of processing steps. This processing was designed to ensure the accuracy of the results and to provide outputs in a suitable format for subsequent analysis work. The processing steps performed were:

- Combining the tiled model results to a single model results dataset;
- Calculation of additional noise indicators (including $L_{Aeq\ 16\ hour}$ and/ or L_{den}) from the standard L_{day}, $L_{evening}$ and L_{night} produced by LimA or IMN;
- Use of LimA to interpolate results beneath building footprints to replace default values;
- Refinements to the final calculated results grids. This included that there are 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;
- Export of the noise level results grids to the ESRI ASCII Grid (ASC) format.

The noise assessments for the two airports within the project, namely Belfast International Airport and George Best Belfast City Airport, were undertaken using FAA Integrated Noise Model (INM) v7.0b software. This was used to model the flight movements of aircraft operating in and out of the airports, and generated a grid of receptors noise results at 100 m spacing.

6. Post Processing and Analysis

The preparation of the final Round Two outputs (including final GIS noise datasets, report and exposure analysis) required a number of additional post processing steps to be undertaken. These steps included:

- Import of the raw ASCII noise model calculations to create a series of ESRI grids;
- GIS processing of each of the raw noise model grids to create classified grid results in 5 dB bands. This is required to meet the specific reporting requirements of the END;
- Development of a GIS model to evaluate the area (km^2) exposed within each of the 5 dB noise level bands from each of the noise sources and each END reporting indicator;
- Creation of a residential building dataset using detailed OSNI large scale digital data as an input for the dwelling and population exposure assessment;
- GIS based analysis to assess the number of dwellings exposed within each of the 5 dB noise level bands from each of the noise sources, for each of the assessed indicators;
- GIS based analysis using 2010 census estimates to estimate the number of people within dwellings exposed within each of the 5 dB noise level bands from each of the noise sources, for each of the assessed indicators;
- Production of noise level indicator maps presenting the results of the noise assessment as 5 dB bands within the project extent. Examples of these maps are provided below in Plates 6.1 to 6.7;
- Production of Final Reports covering the project and the work undertaken;
- Population of the EC Electronic Noise Data Reporting Mechanism (ENDRM) for submission of DF4 results to the Commission.

A summary of the key results are provided in the following sections. Further information is provided in the technical reports which have been prepared for each noise source considered in the Round Two study.

Plate 6.1 Round Two – Agglomeration Industry L_{den} Noise Map

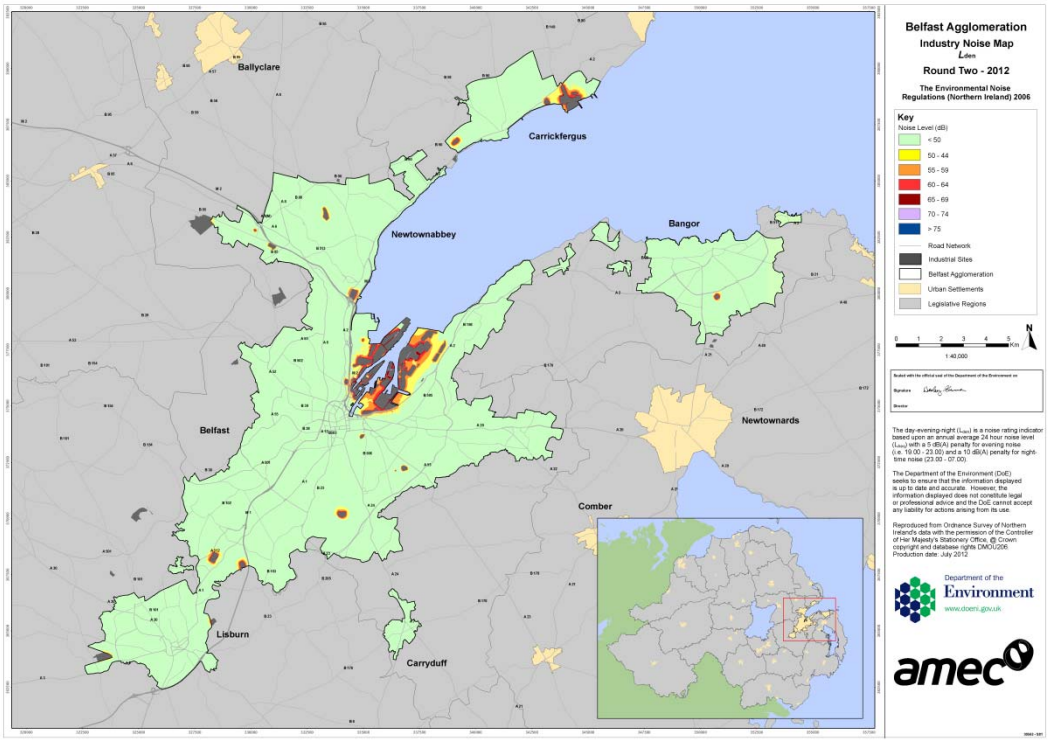


Plate 6.2 Round Two – Agglomeration Railway L_{den} Noise Map

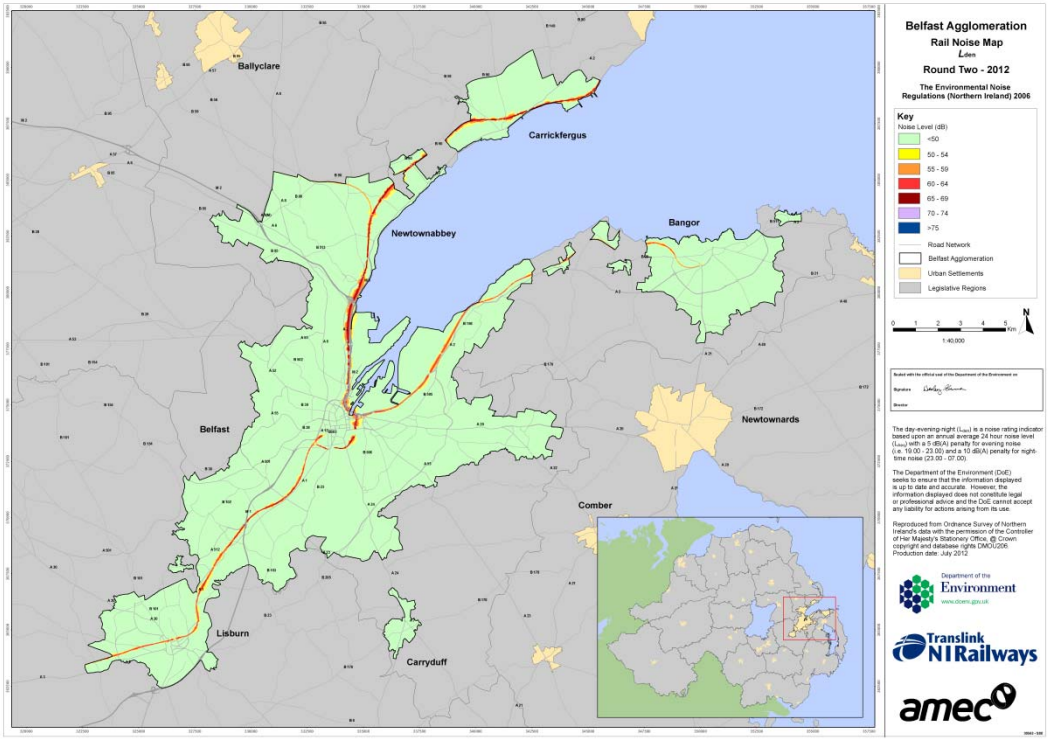


Plate 6.3 Round Two – Agglomeration Roads L_{den} Noise Map

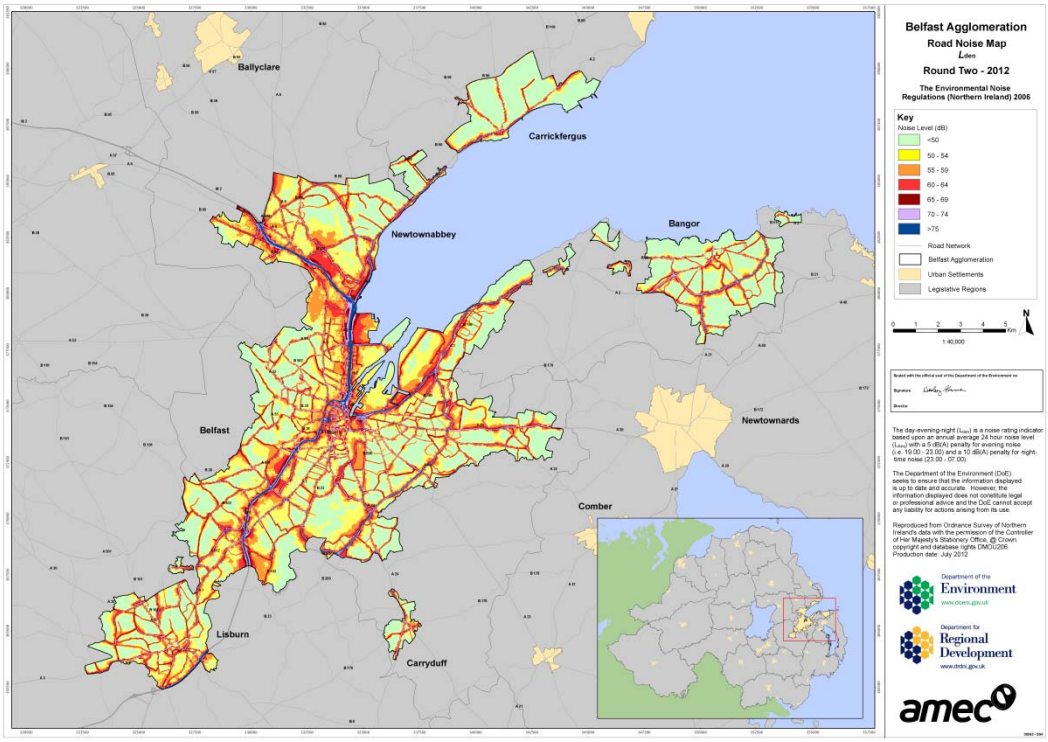


Plate 6.4 Round Two – Agglomeration Belfast City Airport L_{den} Noise Map

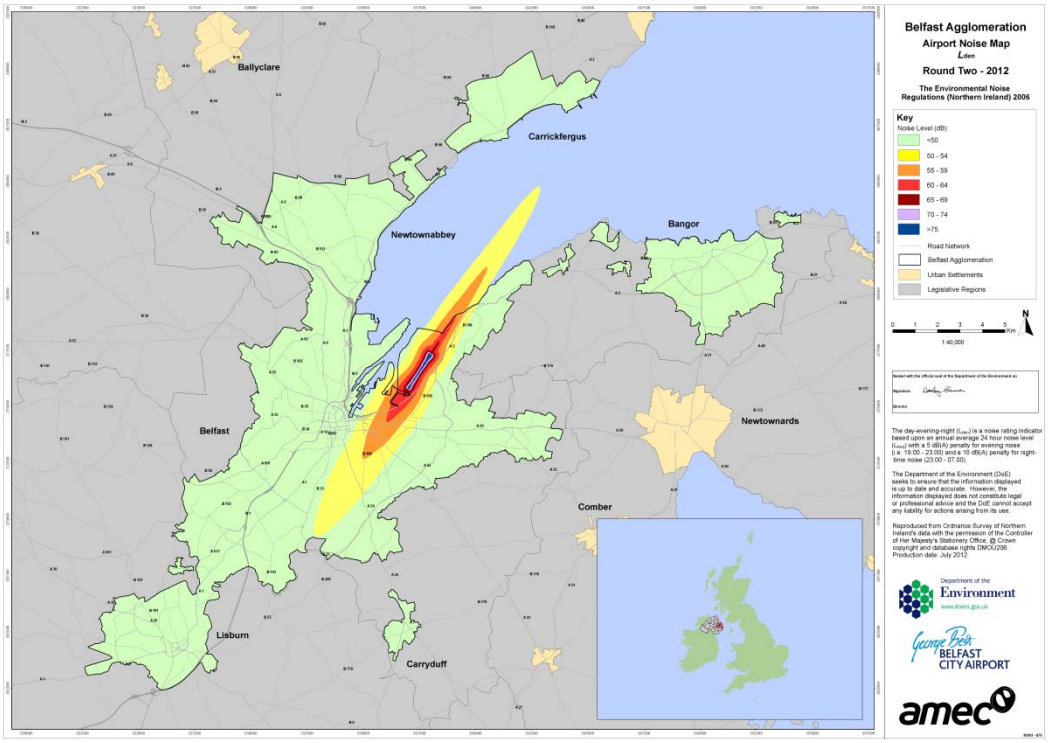


Plate 6.5 Round Two – Agglomeration Consolidated L_{den} Noise Map

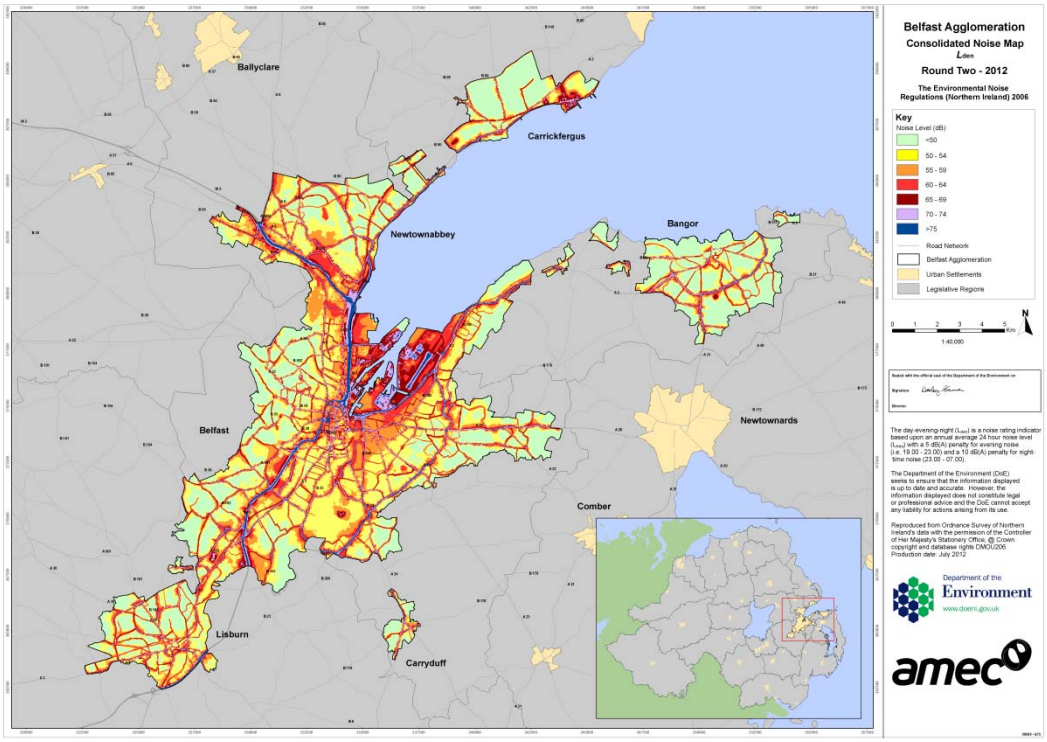


Plate 6.6 Round Two - Major Roads L_{den} Noise Map

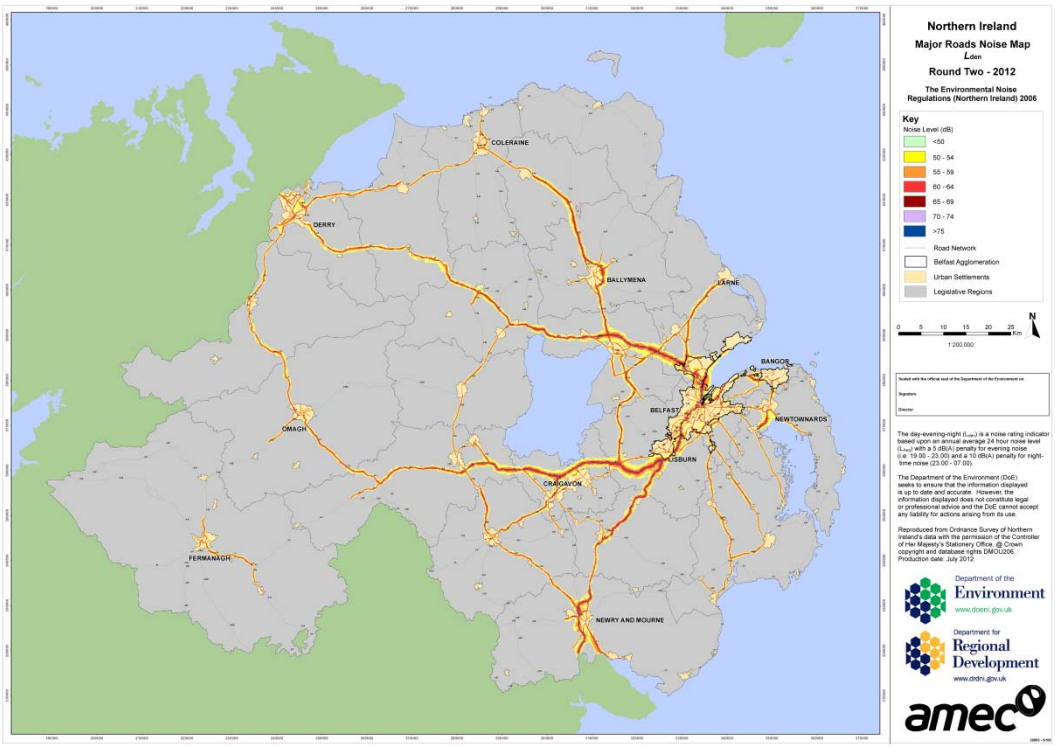
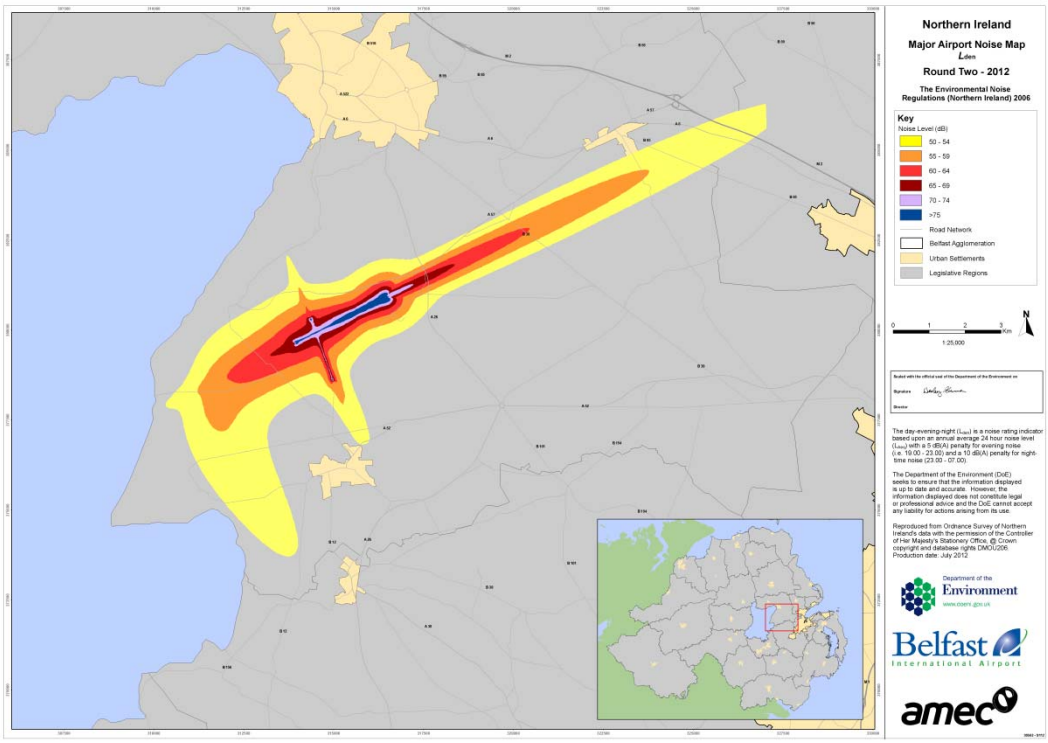


Plate 6.7 Round Two – Belfast International Lden Noise Map



7. Exposure Analysis

The following section summarises the key results of the Round Two dwelling and population exposure analysis. Further details of the analysis methods used to generate these results are presented in the individual technical reports prepared for each noise source.

7.1 Belfast Agglomeration

7.1.1 Agglomeration - Belfast City Airport

Tables 7.1 and 7.2 detail the results of the Round Two END dwelling and population analysis for Belfast City Airport.

Table 7.1 Agglomeration - Belfast City Airport - Dwellings

Noise Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	236,649	234,015	234,112	246,730		**< 45**	254,578
50-54	16,417	17,536	17,468	11,901		**45-49**	6,828
55-59	8,157	9,085	9,054	3,337		**50-54**	569
60-64	752	1,339	1,341	7		**55-59**	
65-69						**60-64**	
70-74						**65-69**	
>=75						**>=70**	
< 50	236,649	234,015	234,112	246,730		**< 45**	254,578
>= 50	25,326	27,960	27,863	15,245		**>= 45**	7,397
Total	261,975	261,975	261,975	261,975		**Total**	261,975

Table 7.2 Agglomeration - Belfast City Airport - Population

Noise Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	521,110	514,803	515,030	543,004		**< 45**	558,808
50-54	34,883	38,151	37,996	23,623		**45-49**	13,159
55-59	15,545	17,391	17,332	6,426		**50-54**	1,098
60-64	1,527	2,720	2,708	12		**55-59**	
65-69						**60-64**	
70-74						**65-69**	
>=75						**>=70**	
< 50	521,110	514,803	515,030	543,004		**< 45**	558,808
>= 50	51,955	58,262	58,036	30,061		**>= 45**	14,257
Total	573,065	573,065	573,065	573,065		**Total**	573,065

7.1.2 Agglomeration - Industry

Tables 7.3 and 7.4 detail the results of the Round Two END dwelling and population analysis for industrial sources in the Belfast Agglomeration.

Table 7.3 Agglomeration - Industry - Dwellings

Noise Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	261,662	260,589	261,661	261,660		**< 45**	261,220
50-54	148	1,057	147	149		**45-49**	520
55-59	71	156	73	72		**50-54**	110
60-64	90	81	90	90		**55-59**	48
65-69	4	75	4	4		**60-64**	74
70-74	0	17	0	0		**65-69**	3
>=75	0		0	0		**>=70**	0
< 50	261,662	260,589	261,661	261,660		**< 45**	261,220
> =50	313	1386	314	315		**> =45**	755
Total	261,975	261,975	261,975	261,975		**Total**	261,975

Table 7.4 Agglomeration - Industry - Population

Noise Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	572,458	570,133	572,456	572,456		**< 45**	571,506
50-54	303	2,289	299	301		**45-49**	1,132
55-59	137	339	143	141		**50-54**	212
60-64	160	145	160	160		**55-59**	83
65-69	7	135	7	7		**60-64**	127
70-74	0	24	0	0		**65-69**	5
>=75	0		0	0		**>=70**	0
< 50	572,458	570,133	572,456	572,456		**< 45**	571,506
>= 50	607	2,932	609	609		**>= 45**	1,559
Total	573,065	573,065	573,065	573,065		**Total**	573,065

7.1.3 Agglomeration - Roads

Tables 7.5 and 7.6 detail the results of the Round Two END dwelling and population analysis for all roads within the Belfast Agglomeration.

Table 7.5 Agglomeration Roads - Dwellings

Noise Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	142,140	109,654	118,931	127,441	194,698		**< 45**	173,875
50-54	54,543	72,214	67,022	62,833	26,292		**45-49**	34,761
55-59	23,372	29,922	28,050	25,794	18,439		**50-54**	22,799
60-64	19,336	21,096	20,889	20,021	17,400		**55-59**	16,970
65-69	15,916	16,226	17,004	16,404	4,820		**60-64**	11,772
70-74	6,301	11,262	9,128	8,748	321		**65-69**	1,668
>=75	367	1,601	951	734	5		**>=70**	130
< 50	142,140	109,654	118,931	127,441	194,698		**< 45**	173,875
> 50	119,835	152,321	143,044	134,534	67,277		**> 45**	88,100
Total	261,975	261,975	261,975	261,975	261,975		**Total**	261,975

Table 7.6 Agglomeration Roads - Population

Noise Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	314,004	243,471	263,912	282,798	428,100		**< 45**	382,747
50-54	118,289	156,835	145,293	135,679	56,762		**45-49**	75,643
55-59	50,971	64,894	60,806	56,092	40,262		**50-54**	49,336
60-64	41,716	45,592	45,231	43,317	37,342		**55-59**	36,702
65-69	34,396	35,035	36,790	35,494	9,962		**60-64**	25,061
70-74	13,007	24,004	19,159	18,237	627		**65-69**	3,328
>=75	682	3,235	1,873	1,447	9		**>=70**	248
< 50	314,004	243,471	263,912	282,798	428,100		**< 45**	382,747
>=50	259,060	329,594	309,152	290,267	144,964		**>= 45**	190,318
Total	573,065	573,065	573,065	573,065	573,065		**Total**	573,065

7.1.4 Agglomeration - Rail

Tables 7.7 and 7.8 detail the results of the Round Two END dwelling and population analysis for all railways within the Belfast Agglomeration.

Table 7.7 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 7.8 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

7.1.5 Agglomeration - Consolidated

An additional requirement of the END is the development of consolidated noise maps and subsequent area, dwelling and population exposure statistics for the Belfast agglomeration boundary.

In the Round Two assessment, consolidated noise levels for L_{day}, $L_{evening}$ and L_{night} were calculated through logarithmic addition of the assessed noise levels for the roads, railways, industry and Belfast City airport with the Belfast agglomeration. L_{den} was then calculated using the following equation where the consolidated L_{day}, $L_{evening}$ and L_{night} noise grids were used as input datasets.

$$L_{den} = 10\lg\frac{1}{24}\left(12*10^{\frac{L_{day}}{10}} + 4*10^{\frac{L_{evening}+5}{10}} + 8*10^{\frac{L_{night}+10}{10}}\right)$$

This assessment process was achieved using series of python coding within ArcGIS.

Using these methods, five final consolidated maps (L_{day}, $L_{evening}$, L_{night} and L_{den}) were created for the Belfast Agglomeration. These maps were then used to develop an estimate of the area, number of dwellings and population exposed to consolidated noise sources in the Belfast agglomeration. These results are provided in Tables 7.9 – 7.11.

Table 7.9 Agglomeration Consolidated - Area (km^2)

Noise Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	77.3	61.4	67.9	118.0		**< 45**	104.4
50-54	46.3	50.7	49.8	29.3		**45-49**	33.4
55-59	27.2	31.1	29.1	19.9		**50-54**	23.9
60-64	21.4	21.5	22.5	18.8		**55-59**	16.3
65-69	15.3	17.7	15.8	9.3		**60-64**	13.7
70-74	8.2	11.7	9.7	2.1		**65-69**	4.9
>=75	2.4	4.1	3.2	0.7		**>=70**	1.5
< 50	77.3	61.4	67.9	118.0		**< 45**	104.4
>= 50	120.8	136.7	130.2	80.1		**>= 45**	93.7
Total	198.1	198.1	198.1	198.1		**Total**	198.1

Table 7.10 Agglomeration Consolidated - Dwellings

Noise Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	119,362	97,601	105,531	175,512		**< 45**	161,529
50-54	63,768	72,541	69,633	38,263		**45-49**	43,814
55-59	33,905	39,900	37,014	24,390		**50-54**	25,121
60-64	21,640	23,571	23,236	18,335		**55-59**	17,804
65-69	16,470	17,976	16,996	5,136		**60-64**	11,898
70-74	6,473	9,419	8,835	351		**65-69**	1,697
>=75	374	984	747	5		**>=70**	129
< 50	119,362	97,601	105,531	175,512		**< 45**	161,529
>= 50	142,630	164,391	156,461	86,480		**>= 45**	100,463
Total	261,992	261,992	261,992	261,992		**Total**	261,992

Table 7.11 Agglomeration Consolidated - Population

Noise Level (dB)	$L_{Aeq, 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
< 50	266,156	217,509	235,892	390,093		**< 45**	358,212
50-54	139,411	159,945	152,345	80,866		**45-49**	93,841
55-59	71,776	85,074	78,869	51,674		**50-54**	53,669
60-64	46,238	50,049	49,474	39,215		**55-59**	38,450
65-69	35,444	38,801	36,630	10,578		**60-64**	25,293
70-74	13,378	19,790	18,416	663		**65-69**	3,387
>=75	695	1,929	1,472	9		**>=70**	246
< 50	266,156	217,509	235,892	390,093		**< 45**	358,212
>= 50	306,942	355,589	337,206	183,005		**>= 45**	214,886
Total	573,098	573,098	573,098	573,098		**Total**	573,098

7.2 Major Airports - Belfast International Airport

Tables 7.12 and 7.13 detail the results of the Round Two END dwelling and population analysis for Belfast International Airport.

Please note that the dwellings/ population reported in these tables are located outside of the Belfast Agglomeration. As a result, no separate tables are presented for the Belfast Agglomeration.

Table 7.12 Belfast International - Dwellings (Northern Ireland)

Noise Level (dB)	$L_{Aeq,\ 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
<50	753,268	752,691	753,343	753,049		**<45**	753,508
50-54	514	937	446	723		**45-49**	304
55-59	85	215	80	97		**50-54**	62
60-64	16	34	14	14		**55-59**	8
65-69		6				**60-64**	1
70-74						**65-69**	
>=75						**>=70**	
< 50	753,268	752,691	753,343	753,049		**< 45**	753,508
>= 50	615	1,192	540	834		**<=45**	375
Total	753,883	753,883	753,883	753,883		**Total**	753,883

Table 7.13 Belfast International – Population (Northern Ireland)

Noise Level (dB)	$L_{Aeq,\ 16\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
<50	1,772,152	1,770,866	1,772,318	1,771,671		**<45**	1,772,714
50-54	1,233	2,143	1,083	1,694		**45-49**	735
55-59	162	501	151	184		**50-54**	104
60-64	24	50	19	22		**55-59**	16
65-69		11				**60-64**	2
70-74						**65-69**	
>=75						**>=70**	
< 50	1,772,152	1,770,866	1,772,318	1,771,671		**< 45**	1,772,714
>= 50	1,419	2,705	1,253	1,900		**<=45**	857
Total	1,773,571	1,773,571	1,773,571	1,773,571		**Total**	1,773,571

7.3 Major Rail

Tables 7.14 – 7.19 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 7.14 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 7.15 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 7.16 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 7.17 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 7.18 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 7.19 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

7.4 Major Roads

Tables 7.20 – 7.25 detail the results of the Round Two END dwelling and population analysis for major roads, within the Belfast Agglomeration, outside the Belfast Agglomeration and across the whole of Northern Ireland.

Table 7.20 Major Roads - Number of Dwellings (Belfast Agglomeration)

Noise Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
<50	186,480	160,589	166,409	175,180	224,058		**<45**	207,255
50-54	39,329	54,596	51,014	46,354	16,086		**45-49**	25,419
55-59	13,837	19,720	18,838	16,104	7,881		**50-54**	11,786
60-64	8,852	10,383	9,940	9,412	9,797		**55-59**	7,952
65-69	8,588	8,036	8,495	8,358	3,834		**60-64**	7,890
70-74	4,550	7,242	6,401	5,894	314		**65-69**	1,547
>=75	339	1,409	878	673	5		**>=70**	126
< 50	186,480	160,589	166,409	175,180	224,058		**< 45**	207,255
>= 50	75,495	101,386	95,566	86,795	37,917		**<=45**	54,720
Total	261,975	261,975	261,975	261,975	261,975		**Total**	261,975

Table 7.21 Major Roads - Population Exposure (Belfast Agglomeration)

Noise Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}		Noise Level (dB)	L_{night}
<50	408,803	352,459	365,266	384,570	491,385		**<45**	454,518
50-54	86,119	119,500	111,582	101,131	34,482		**45-49**	55,415
55-59	29,959	42,739	40,792	34,827	17,253		**50-54**	25,427
60-64	19,316	22,424	21,507	20,478	21,357		**55-59**	17,405
65-69	18,718	17,598	18,621	18,292	7,965		**60-64**	16,989
70-74	9,519	15,493	13,568	12,442	613		**65-69**	3,071
>=75	630	2,851	1,729	1,325	9		**>=70**	240
< 50	408,803	352,459	365,266	384,570	491,385		**< 45**	454,518
>= 50	164,262	220,606	207,799	188,495	81,680		**<=45**	118,547
Total	573,065	573,065	573,065	573,065	573,065		**Total**	573,065

Table 7.22 Major Roads - Number of Dwellings (Outside Agglomeration)

Noise Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	427,866	407,789	412,944	421,422	449,016	**<45**	442,114
50-54	28,131	38,844	35,977	31,480	17,443	**45-49**	20,058
55-59	13,098	17,349	16,365	14,417	9,995	**50-54**	12,271
60-64	10,409	11,287	11,156	10,635	10,199	**55-59**	9,916
65-69	9,501	9,960	9,979	9,801	4,840	**60-64**	6,598
70-74	2,809	6,096	5,036	3,918	414	**65-69**	931
>=75	94	583	451	235	1	**>=70**	20
< 50	427,866	407,789	412,944	421,422	449,016	**< 45**	442,114
>= 50	64,042	84,119	78,964	70,486	42,892	**<=45**	49,794
Total	491,908	491,908	491,908	491,908	491,908	**Total**	491,908

Table 7.23 Major Roads - Population Exposure (Outside Agglomeration)

Noise Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	1,047,659	999,144	1,011,836	1,032,184	1,098,413	**<45**	1,081,874
50-54	67,579	93,368	86,268	75,586	41,934	**45-49**	48,166
55-59	31,482	41,980	39,472	34,697	23,980	**50-54**	29,437
60-64	24,829	26,991	26,713	25,418	24,037	**55-59**	23,485
65-69	22,245	23,625	23,530	23,059	11,182	**60-64**	15,361
70-74	6,496	14,077	11,655	9,035	957	**65-69**	2,133
>=75	214	1,321	1,031	527	3	**>=70**	49
< 50	1,047,659	999,144	1,011,836	1,032,184	1,098,413	**< 45**	1,081,874
>= 50	152,847	201,362	188,670	168,322	102,093	**<=45**	118,632
Total	1,200,506	1,200,506	1,200,506	1,200,506	1,200,506	**Total**	1,200,506

Table 7.24 Major Roads - Number of Dwellings (Northern Ireland)

Noise Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	614,346	568,378	579,353	596,602	673,074	**<45**	649,369
50-54	67,460	93,440	86,991	77,834	33,529	**45-49**	45,477
55-59	26,935	37,069	35,203	30,521	17,876	**50-54**	24,057
60-64	19,261	21,670	21,096	20,047	19,996	**55-59**	17,868
65-69	18,089	17,996	18,474	18,159	8,674	**60-64**	14,488
70-74	7,359	13,338	11,437	9,812	728	**65-69**	2,478
>=75	433	1,992	1,329	908	6	**>=70**	146
< 50	614,346	568,378	579,353	596,602	673,074	**< 45**	649,369
>= 50	139,537	185,505	174,530	157,281	80,809	**<=45**	104,514
Total	753,883	753,883	753,883	753,883	753,883	**Total**	753,883

Table 7.25 Major Roads - Population Exposure (Northern Ireland))

Noise Level (dB)	$L_{Aeq, 16\ hour}$	$L_{A10,18\ hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
<50	1,456,463	1,351,603	1,377,102	1,416,753	1,589,798	**<45**	1,536,392
50-54	153,699	212,868	197,850	176,717	76,416	**45-49**	103,581
55-59	61,441	84,719	80,264	69,524	41,233	**50-54**	54,865
60-64	44,146	49,415	48,220	45,896	45,394	**55-59**	40,891
65-69	40,963	41,224	42,151	41,351	19,147	**60-64**	32,349
70-74	16,016	29,570	25,224	21,476	1,571	**65-69**	5,204
>=75	844	4,172	2,760	1,852	12	**>=70**	289
< 50	1,456,463	1,351,603	1,377,102	1,416,753	1,589,798	**< 45**	1,536,392
>= 50	317,108	421,968	396,469	356,818	183,773	**<=45**	237,179
Total	1,773,571	1,773,571	1,773,571	1,773,571	1,773,571	**Total**	1,773,571

7.5 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). 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.

Appendix A
LimA Dataset Specifications

Table A.1 Overview of Applicable 3D-Modelling Datasets in LimA

Layer Overview	Spatial Reference	Object Dimensions	Elevation Reference	Elevation Reference Position	Elevation Definition	Unit	LimA Object Type
DTM Spot Heights	Vector	2.5D/3D Points	Absolute	AMSL	Constant per object	Metre (m)	**GEL**
DTM Contour Lines	Vector	2.5 D Polylines	Absolute	AMSL	Constant per object	Metre (m)	**GEL**
DTM Breaklines	Vector	3D Polylines	Absolute	AMSL	Height per vertex	Metre (m)	**HIN HA 4**
Ground Cover	Vector	2D Polygons	NA	NA	NA	NA	**TOP**
Buildings	Vector	2.5D Polygons	Relative	Roof height (relative to AMSL)	Constant per object	Metre (m)	**HIN HA 2**
Bridges	Vector	3D Polygons	Absolute	AMSL	Height per vertex	Metre (m)	**HIN HA 7**
Barriers e.g. Noise barriers, retaining walls	Vector	2.5D/3D Polylines	Relative or absolute	Barrier height (AMSL or Relative to AMSL)	Constant per object or height per vertex	Metre (m)	**HIN HA 1**
Meteorology Wind Direction	Vector	NA	NA	NA	NA	NA	**N/A**
Meteorology Wind speed	NA	NA	NA	NA	NA	m/s	
Meteorology Air Temperature	NA	NA	NA	NA	NA	Celsius	
Meteorology Relative humidity	NA	NA	NA	NA	NA	%	

Note: All vector polygon and polyline objects should not have vertices with a separation distances less than 0.05 m. Elevations should not be different at identical horizontal positions.

Table A.2 Spot Height Elevation (GEL Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_GEL	Spot Height in Metres AMSL	Floating Point	Calculated/ Data Input	Default Value	0.00	None
				Min. Value	-9999.99	
				Max. Value	9999.99	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.3 Equal Height Contour Elevation (GEL Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_GEL	Equal Height in Metres AMSL	Floating Point	Calculated/ Data Input	Default Value	0.00	None
				Min. Value	-9999.99	
				Max. Value	9999.99	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.4 Breaklines (HIN HA 4 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_HIN	Object Name	String	Data Input	Default Value	EMB_EDGE	
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		
				Max. Length	20	
L_HA	Object Type	Integer	Data Input	Default Value	4	
				Max. Length	2	
L_BAUL	Screening Effect	Floating Point	Data Input	Default Value	1	
				Precision	1 d.p.	
				Max. Length	6	

Table A.4 (continued) Breaklines (HIN HA 4 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_RV	Reflection Loss	Floating Point	Data Input	Default Value	1	
				Precision	1 d.p.	
				Max. Length	10	
L_MAK	Material	String	Data Input	Default Value	-	
				Max. Length	20	
L_Z	Height of Object in AMSL	String	Calculated	Default Value	A	
				Max. Length	20	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.5 Buildings (HIN HA 2 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_HIN	Object Name	String	Data Input	Default Value	BUILD_2-5D	None
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		None
				Max. Length	20	
L_HA	Object Type	Integer	Data Input	Default Value	2	None
				Max. Length	2	
L_BAUL	Screening Effect	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	6	
L_RV	Reflection Loss	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	10	
L_MAK	Material	String	Data Input	Default Value	-	None
				Max. Length	20	

Table A.5 (continued) Buildings (HIN HA 2 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
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_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.6 Barriers (HIN HA 1 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_HIN	Object Name	String	Data Input	Default Value	BARRIER_2-5D	None
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		None
				Max. Length	16	
L_HA	Object Type	Integer	Data Input	Default Value	1	None
				Max. Length	2	
L_BAUL	Screening Effect	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	6	
L_RV	Reflection Loss	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	10	
L_MAK	Material	String	Data Input	Default Value	-	None
				Max. Length	20	
L_Z	Height of Barrier in meters relative to ground/ object	String	Calculated	Default Value	2 D	None
				Example: 4.5m high barrier at the roadside should be attributed as “4.5 D”		
				Max. Length	10	

Table A.6 (continued) Barriers (HIN HA 1 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.7 Bridges (HIN HA 7 Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_HIN	Object Name	String	Data Input	Default Value	BRIDGE_3D	None
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		None
				Max. Length	16	
L_HA	Object Type	Integer	Data Input	Default Value	7	None
				Max. Length	2	
L_BAUL	Screening Effect	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	6	
L_RV	Reflection Loss	Floating Point	Data Input	Default Value	1	None
				Precision	1 d.p.	
				Max. Length	10	
L_MAK	Material	String	Data Input	Default Value	-	None
				Max. Length	20	
L_Z	Height of Bridge in meters AMSL	String	Calculated	Default Value	A	None
				Max. Length	10	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	

Table A.8 Ground Cover (TOP Object)

Field/ Attribute Name	Full Description	Data Type	Status	Properties		Special Values
L_TOP	Object Name	String	Data Input	Default Value	GROUND_COVER	None
				Max. Length	20	
L_ID	Unique ID Number	Double	Data Input	Unique ID		None
				Max. Length	16	
L_G	Reflection Factor	Floating Point	Data Input	Default Value	0	None
				Precision	1	
				Max. Length	6	
L_VAR	Calculation Variant	String	Software Function	Default Value	+	None
				Max. Length	20	