Report

Round 4 Noise Mapping for Northern Ireland

Railway Modelling Report

For Department of Agriculture, Environment and Rural Affairs (DAERA)

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1 Glossary

Term	Definition
3D	3-dimensional
AEDT 3e	Calculation software used to calculate aircraft noise
Agglomeration	An area of a territory that has a population exceeding 100,000 people with a population density that allows it to be considered as an urbanised area
CNOSSOS-EU	Common Noise Assessment Methods for Europe - the noise modelling method used in the Round 4 noise mapping
CNOSSOS-EU:2020	CNOSSOS-EU as amended by the Delegated Directive
CORINE	Ground cover dataset available from Copernicus
CRN, 1995	Method for Calculation of Railway Noise
CRTN, 1988	Method for Calculation of Road Traffic Noise
DAERA	Department of Agriculture, Environment and Rural Affairs
dB	Decibel, a logarithmic unit of sound
Delegated Directive (EU) 2021/1226	Commission Delegated Directive (EU) 2021/1226 of 21 December 2020 amending, for the purposes of adapting to scientific and technical progress, Annex II to Directive 2002/49/EC of the European Parliament and of the Council as regards common noise assessment methods
Directive 2002/49/EC	Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. Commonly referred to as the 'Environmental Noise Directive' (END)
Directive 2015/996	COMMISSION DIRECTIVE (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council
EC	European Commission
ECAC	European Civil Aviation Conference
ECAC Doc.29 4th Edition	Report on Standard Method of Computing Noise Contours around Civil Airports
END	Environmental Noise Directive
ENR	Environmental Noise Regulations
EU	European Union
GeoTiff	A geospatial file format for raster data
GIS	Geographic Information System
ICAO	International Civil Aviation Authority
ISO 9613-2:1996	For assessing noise from industrial sources. Acoustics - Attenuation of sound propagation outdoors, Part 2: General method of calculation
$L_{Aeq,6hr}$	The night level, the A-weighted, L_{eq} (equivalent sound level) determined over all the 6-hour night periods (00:00-06:00) of a year
$L_{Aeq,16h}$	The equivalent continuous sound level in dB(A) that, over the period 07:00-23:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period
$L_{Aeq,18hr}$	The equivalent continuous sound level in dB(A) that, over the period 06:00-24:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period
L_{day}	The day level, the A-weighted, L_{eq} (equivalent sound level), determined over all the 12-hour day periods (07:00-19:00) of a year
L_{den}	The day-evening-night level indicator for overall annoyance, based upon annual average A-weighted long-term sound over 24 hours. It includes a 5 dB(A) penalty for evening noise (19:00-23:00) and a 10 dB(A) penalty for night-time noise (23:00-07:00)
L_{eve}	The evening level, the A-weighted, L_{eq} (equivalent sound level) determined over all the 4-hour evening periods (19:00-23:00) of a year

LimA	Noise calculation software developed by Stapelfeldt Ingenieurgesellschaft mbH
L_{night}	The night level indicator for sleep disturbance, based upon the A-weighted, L_{eq} (equivalent sound level) determined over all the 8-hour night periods (23:00-07:00) of a year
Member State	A country that is a part of the European Union
NCL	Noise Consultants Limited
NISRA	Northern Ireland Statistics and Research Agency
NMPB 2008	French national calculation methodology "Road noise prediction - Noise propagation computation method including meteorological effects"
OSNI	Ordnance Survey Northern Ireland
QA	Quality Assurance
Raster	Raster data consists of a matrix of cells that are organised into a grid, with each cell containing a value which represents information such as terrain elevation or calculated noise level
RIVM	The Netherlands National Institute for Public Health and the Environment
RIVM Letter report 2019-0023	Amendments for CNOSSOS-EU, Descriptions of issues and proposed solutions.
Round 3	The previous round of strategic noise mapping
Round 4	The current round of strategic noise mapping
Technical working group	A number of representatives that were nominated by EU member states, whose task was to address the issues identified in CNOSSOS-EU through proposing some refinements to the method
The Regulations	A series of environmental noise regulations including: Environmental Noise Regulations (Northern Ireland) 2006, Environmental Noise (Amendment) (NI) Regulations 2018, The Environmental (Miscellaneous Amendments) (Northern Ireland) (EU Exit) Regulations 2019, and The Environment (Legislative Functions from Directives) (EU Exit) Regulations 2019

2 Introduction

Noise Consultants Limited (NCL) was appointed by the Department of Agriculture, Environment and Rural Affairs (DAERA) to prepare the noise maps and associated noise exposure statistics in Northern Ireland.

NCL collaborated with its partners, Stapelfeldt Ingenieurgesellschaft mbH and Acustica Limited (the "Project Team"), to develop the model and deliver the required outputs. This report is part of a series documenting the data decisions, processing, and outputs associated with the project.

2.1 Background

The requirement to deliver strategic noise maps and noise action plans is mandated by the Environmental Noise Regulations (Northern Ireland) 2006 (ENR[1]), as amended by the Environmental Noise (Amendment) (NI) Regulations 2018[2]. These regulations transposed European Commission Directive 2002/49/EC[3], known as the Environmental Noise Directive (END), into Northern Irish law.

The aim of the END is to define a common approach intended to avoid, present or reduce on a prioritised basis the harmful effects, including annoyance, due to the exposure to environmental noise. The END seeks to manage the impact of environmental noise through strategic noise mapping, and requires the preparation and publication of strategic noise maps and noise management actions plans every five years.

The Regulations serve as the principal framework for the assessment and management of environmental noise in Northern Ireland, aiming to mitigate the adverse effects, including annoyance, caused by environmental noise through a standardised approach.

The Regulations require the competent authorities identified within Regulations to create and update noise maps and action plans every five years, aligning with the requirements of the END. Therefore, each competent authority for the different noise sources, as mentioned below, serves as the main contact point for data collection.

- **Major roads** - the Department for Infrastructure (formerly The Department for Regional Development);
- **Major railways** - Translink (a subsidiary company of Northern Ireland Transport Holding Company);
- **Major airports** – the airport operators; and
- **Industry** - the Department of Agriculture, Environment and Rural Affairs (DAERA).

Under the Regulations, the noise sources that shall be identified and mapped are:

- Agglomerations, as defined in the Regulations as an area identified by the Department of the Environment as:
  "(a) having a population in excess of 100,000 persons and a population density equal to or greater than 500 people per km^2; and
  (b) which it considers to be urbanised."
- Major roads, which are roads that
  "(a)are—
  (i)trunk roads;
  (ii)motorways; or
  (iii)classified roads; and
  (b)have more than three million vehicle passages a year."

[1] https://www.legislation.gov.uk/nisr/2006/387/contents/made (Accessed September 2024)
[2] https://www.legislation.gov.uk/nisr/2018/190/made (Accessed September 2024)
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0049 (Accessed September 2024)

- Major railways, which are *"which have more than 30,000 train passages per year."*
- Major airports, which are *"civil airports which have more than 50,000 movements per year (a movement being a take-off or a landing), excluding those purely for training purposes on light aircraft."*
- Industrial noise sources, which are defined as:
  "(a)Part A activities, as defined in Schedule 1 of the Pollution Prevention and Control Regulations (Northern Ireland) 2003[4]*, within an agglomeration or first round agglomeration; and*
  (b)Ports within an agglomeration or first round agglomeration".

The first round of noise mapping in Northern Ireland under the Regulations was completed in 2007. The second round was undertaken five years later in 2012 with the third round carried out in 2017. Under the Regulations, the fourth round of the noise maps should describe the noise situation in 2021.

In accordance with Article 6.2 of the END, the European Commission developed the Common Noise Assessment methods in Europe (CNOSSOS-EU[5]). This assessment method must be adopted for the fourth round of noise maps, it was finalised and given legal effect through Commission Directive 996/2015[6], Which was transposed into Northern Irish law in 2018[7].

The requirement for CNOSSOS-EU to be used as the method of producing noise maps under the Regulations introduces a major change from previous rounds. In the case of road and railway noise, the CNOSSOS-EU method is more sophisticated than the methods previously used in Northern Ireland and the rest of the United Kingdom in delivering the noise maps to date. It introduces a significant number of new data requirements to facilitate the noise maps, includes relatively untested approaches to computing noise emissions, but also provides opportunities in recapturing data so to improve the quality of the maps, which are produced by setting quality standards and providing a more accurate method.

2.2 Purpose of this Report

This report describes the noise modelling platform used to deliver the strategic noise maps, setting out the regional calculation extents, model calculation run scenarios, and post processing of the model calculation results. It also presents the exposure statistics as required by the Regulations and includes figures of the L_{den} and L_{night} noise maps for railway sources.

This report should be read in conjunction with the Stage 1 Data Input Report (Ref: 14668A-20-R03-05-F01), hereafter referred to as the 'Stage 1 Report', which sets out the details of the data collection and review, data processing and quality assurance (QA).

This report is specifically intended to provide details on the sources and processes used to develop the railway source dataset and Round 4 railway noise models, and details on other source types included in the wider Round 4 Noise Mapping can be found in the Stage 2 Final Report (Ref: 14668A-20-R04-05-F01, 'Stage 2 Report'), as well as the relevant "Modelling Reports" for Road, Industry, Belfast City Airport and Belfast International Airport, respectively.

[4] https://www.legislation.gov.uk/nisr/2003/46/contents/made (Accessed November 2024)
[5] https://publications.jrc.ec.europa.eu/repository/handle/JRC72550#:~:text=CNOSSOS%2DEU%20aims%20at%20improving,PAVIOTTI%20Marco%3B%20ANFOSSO%2DL%C3%89D%C3%89E%20Fabienne (Accessed November 2024)
[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0996
[7] Environmental Noise (Amendment) (NI) Regulations 2018

3 Data Capture Extents

The aim of the Round 4 strategic noise maps is to have optimal coverage for major road, major rail and major airport sources (as defined by the Regulations) as well as agglomeration coverage for road, railway, airport and industrial sources.

This section summarises the Round 4 data capture extents. Full details are in the Stage 1 Report.

3.1.1 Agglomeration Extents

The Regulations[8] state that DAERA are to prepare maps that identify all agglomerations:

- Having a population in excess of 100,000 persons; and
- a population density equal to or greater than 500 people per km^2; and
- Which it considers to be urbanised.

The Belfast urban area remains the only agglomeration area in Northern Ireland for the Round 4 noise mapping.

In Round 4, the Belfast Agglomeration area from Round 3 was re-evaluated and redefined using Census 2021 data at the data zone level, as well as 1 km and 100 m grid areas. The updated Round 4 Belfast Agglomeration area continues to accurately represent the densely populated regions surrounding the Belfast urban area, complies with the Regulations, aligns with the population distribution throughout Belfast, and has been adopted for Round 4.

The Round 4 Belfast Agglomeration has a total area of 208.5 km^2, representing a 0.9 km^2 decrease on the Round 3 Belfast Agglomeration boundary. The Belfast Agglomeration boundary for Round 4 was developed through merging and dissolving the Northern Ireland Statistics and Research Agency (NISRA) 2005 and 2015 settlement boundaries, then clipping the dissolved boundaries to the OSNI Largescale NI boundary.

The Round 4 Belfast Agglomeration data capture extent was developed though buffering the agglomeration boundary by 3km and clipping to the OSNI Largescale NI boundary.

3.1.2 Railway Modelling Extents

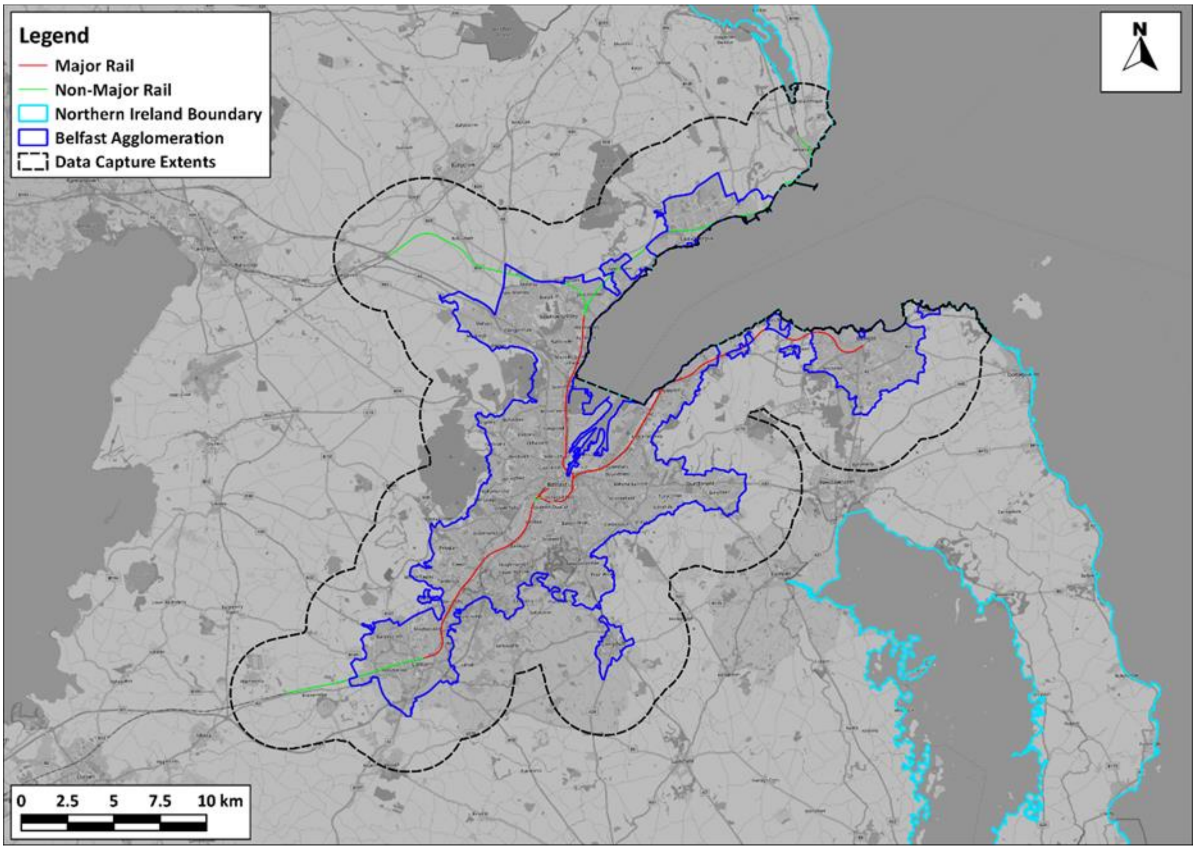
For the Round 4 2021 assessment year, it was confirmed with the competent authority, Translink, that there have been no changes to the network that would alter the extents of the major railways since Round 3.

All of Northern Ireland's major railway network lies within the Belfast Agglomeration, or extends to Bangor. Therefore, only rail sections within 3 km of the agglomeration were considered in the Round 4 data capture. Translink's data subsequently confirmed that Northern Ireland's major railways are situated in and around the Belfast Agglomeration.

Figure 1 presents the Round 4 rail model and data capture extents.

[8] https://www.legislation.gov.uk/nisr/2006/387/contents/made (Accessed November 2024)

Figure 1: Rail Model Data Capture Extents



4 Calculation Method for Round 4

4.1 Calculation Methods for Previous Rounds

For all previous rounds of mapping, Calculation of Railway Noise (CRN, 1995), as adapted, was used for the calculation of railway noise.

As discussed in **Section 0**, for Round 4 there is a requirement to use the Common Noise Assessment Methods in Europe (CNOSSOS-EU) methodology, which is a somewhat different methodology to that used in previous rounds.

4.2 CNOSSOS-EU

4.2.1 Background

The European Commission published Directive 2015/996[9] in July 2015, which established common noise assessment methods according to Directive 2002/49/EC (the END). It replaced Annex II of the END, removing the Interim Methods and now requiring that Member States apply CNOSSOS-EU for the noise modelling of road, rail, aircraft and industrial sources.

Shortly after the publication of Directive 2015/996, some formatting and typographical errors were identified which were addressed in the Corrigendum[10] which was published in January 2018.

The Netherlands National Institute for Public Health and the Environment (RIVM) had identified a number of issues with the CNOSSOS-EU method after undertaking research into the method as set out in Directive 2015/996. Following this, in 2018 the EC approved the formation of a technical working group. The technical working group consisted of a number of representatives that were nominated by EU member states, whose task was to address the issues identified in CNOSSOS-EU through propose some refinements to the method.

In April 2019, the working group published a report (Amendments for CNOSSOS-EU, Descriptions of issues and proposed solutions, RIVM Letter report 2019-0023[11]), which led to the EC drafting Delegated Directive (EU) 2021/1226[12] that set out a number of refinements to be applied to Annex II of the END. Following public consultation, and consultation with The Noise Expert Group[13], it was published in December 2020 with publication in the Official Journal in July 2021.

4.2.2 Calculation of Railway Noise

For railway sources the CNOSSOS-EU:2020 method has three separate modelling parts:

- **Source part:** There are separate noise source emission models for road, rail, industrial and aircraft sources. The noise source emission describes the sound power level emitted by the source as a function of a variety of input factors. For example, in the case of railway traffic, this would include vehicle flow volume and speed, track type, traffic support and location of switches, joints and tight curves.
- **Propagation part:** The propagation part of CNOSSOS-EU:2020 defines how noise levels will attenuate due to aspects such as the distance along a propagation path (source to receiver), air absorption, terrain elevations, screening effects from buildings and barriers, meteorological effects and the influence of ground cover. The CNOSSOS-EU:2020 propagation model is derived

[9] https://eur-lex.europa.eu/eli/dir/2015/996/oj (Accessed November 2024)
[10] https://www.ecac-ceac.org/documents/ecac-documents-and-international-agreements (Accessed November 2024)
[11] https://www.rivm.nl/bibliotheek/rapporten/2019-0023.pdf (Accessed November 2024)
[12] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021L1226 (Accessed November 2024)
[13] https://ec.europa.eu/transparency/expert-groups-register/screen/expert-groups/consult?lang=en&do=groupDetail.groupDetail&groupID=2809&Lang=EN (Accessed November 2024)

from the French NMPB 2008[14] model, and is the same irrespective of the source type being modelled (road/railway/industry).

- **Receiver part:** The receiver part specifies how receiver points should be positioned on dwelling façades, how the number of people and number of dwellings should be attributed to the calculated noise exposure levels at the façade, and how the area exposed to noise should be determined from the calculated noise grids.

4.2.3 Quality Criteria

Section 2.1.2 of CNOSSOS-EU sets out a quality framework. It states the following on the accuracy of input values:

"All input values affecting the emission level of a source shall be determined with at least the accuracy corresponding to an uncertainty of ± 2 dB(A) in the emission level of the source (leaving all other parameters unchanged)."

The approach to assembling the noise model for Northern Ireland had the objective of ensuring that the source emission levels are calculated in a manner which conforms to the CNOSSOS-EU ± 2.0 dB(A) quality criteria.

[14] Sétra, *Road noise prediction - Noise propagation computation method including meteorological effects (NMPB 2008)*, Sétra, June 2009.

5 Dataset Specification and Requirements

The calculation method and the need to create a comprehensive 3D model of buildings, terrain, and bridges for noise propagation dictate the dataset specifications and requirements. The dataset specification and requirements are summarised briefly in this section of the report, with full details provided in the Stage 1 Report.

5.1 CNOSSOS-EU:2020 Model Requirements

5.1.1 Propagation Model

The propagation model consists of features representing terrain elevations (breaklines, spot heights, equal height contours), bridges, buildings, ground cover and meteorological data. Therefore, geospatial objects which can be processed in Geographic Information System (GIS) software are required to represent these features.

5.1.2 Railway Source Emission Model Requirements

The CNOSSOS-EU:2020 railway source emission model requires information on aspects such as 3D railway centreline geometry, rail vehicle flows and speeds for each rail vehicle type, and parameters describing each railway vehicle, railway track and support structures present within the rail network.

6 Noise Modelling Platform

6.1.1 Road, Rail and Industry Modelling Platform and Calculation Extents

The noise models for road, rail and industry were calculated using the LimA (version 2024) calculation software, developed by Stapeldfeldt Ingenieurgesellschaft mbH. It allows the user to calculate noise levels using the CNOSSOS-EU:2020 method. LimA (version 2024) is certified to conform to ISO/TR 17534-4:2020 'Acoustics — Software for the calculation of sound outdoors — Part 4: Recommendations for a quality assured implementation of the COMMISSION DIRECTIVE (EU) 2015/996 in software according to ISO 17534-1', which facilitates a standardised interpretation of the CNOSSOS-EU calculation method.

Details of the dataset selection, processing for the LimA 3D model development, and QA procedures are set out in the Stage 1 Report.

Calculation Efficiency Settings

The CNOSSOS-EU:2020 method for calculating road, rail and industry noise introduces a significantly higher level of complexity in the source emission and propagation calculations compared to the CRTN (1988), CRN (1995) and ISO 9613-2 (1996) methods used in previous noise mapping rounds. Consequently, while the model efficiency settings for the previous rounds were well established and understood, the change in calculation method for Round 4 necessitated updating these settings.

NCL has also been involved in preparing the noise maps for England under a framework for Defra. As part of the framework, the Project Team undertook research into the sensitivity of the CNOSSOS-EU:2020 method to a variety of factors, including calculation benchmark testing to investigate the sensitivity of the CNOSSOS-EU:2020 calculation method to various model efficiency settings. The research aimed to determine appropriate calculation settings which would deliver the calculations within reasonable timescales whilst also having regard for the CNOSSOS-EU:2020 quality framework requirements.

The outcome of this research has informed the model efficiency settings applied to the Round 4 model for Northern Ireland.

Calculation Region Extents

The Northern Ireland road, rail and industry model was split into regions based upon the Belfast Agglomeration and the Northern Ireland county boundaries, given the required meteorological model inputs had been derived on a county and agglomeration basis (see the Stage 1 Report for full details).

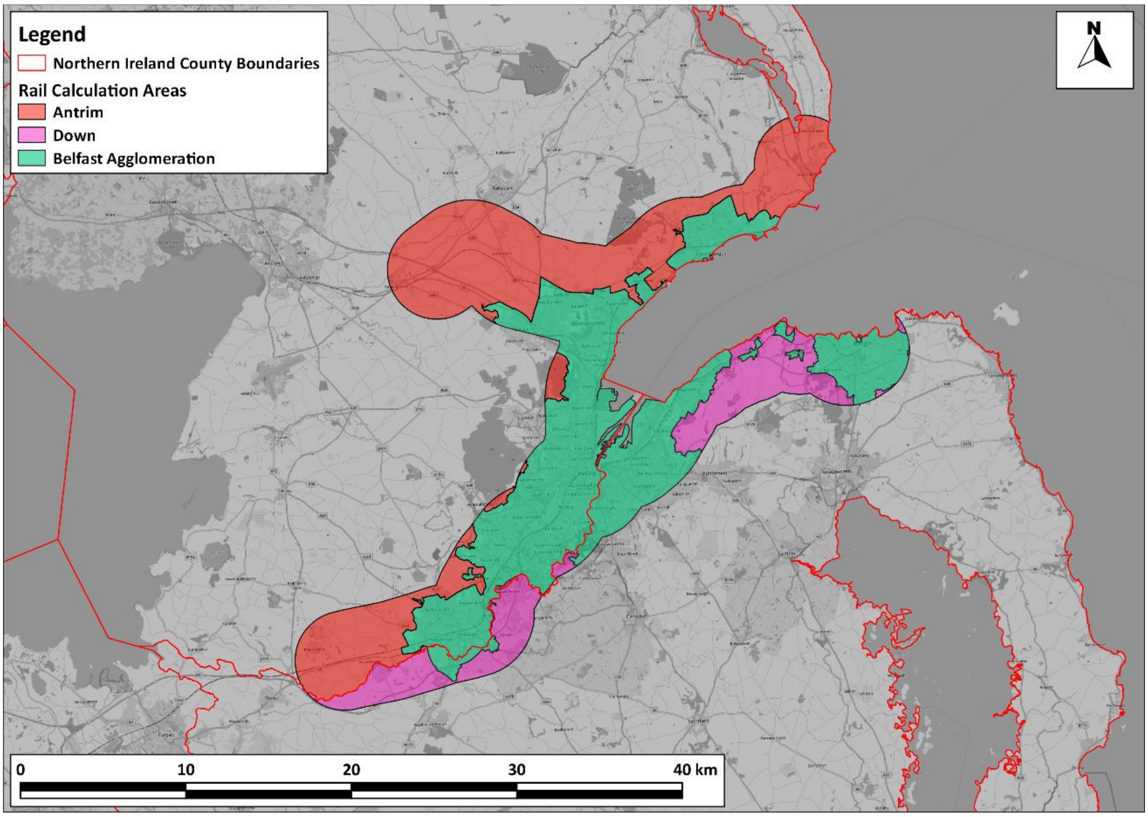
The LimA calculation software allows a user to define calculation extents which dictates the areas that the model will produce calculations within. This improves the calculation efficiency by ensuring that calculations will not be performed in areas where they are not required. It also ensures that calculated results will not overlap where county or agglomeration boundaries meet. The calculation regions were therefore defined as follows:

- **Agglomeration – railways:** Model extents were defined by the Belfast Agglomeration boundary extents and a buffer distance from the railway centrelines of 3,000m. This buffer was sufficient in order to output results calculated down the required levels (55 dB L_{den} and 50 dB L_{night})
- **Major source – railways:** Model extents were defined by the Northern Ireland county boundaries with the agglomeration boundary clipped out, and a buffer distance from the railway centrelines of 3,000m to ensure that results are output down to the required levels (55 dB L_{den} and 50 dB L_{night})

It should be noted that the calculation regions only define where calculated levels will be output. The model will still consider sources located outside of the calculation regions but would contribute to the levels calculated within. This is dictated by the source search radius setting, where contributions from any source included in the model that is outside the calculation region extents but within the defined source search radius of a calculation point will be considered.

Figure 2 presents the calculation extents for railway sources in Round 4.

Figure 2: Belfast Agglomeration and Major Railway Calculation Extents



Calculation Tiling

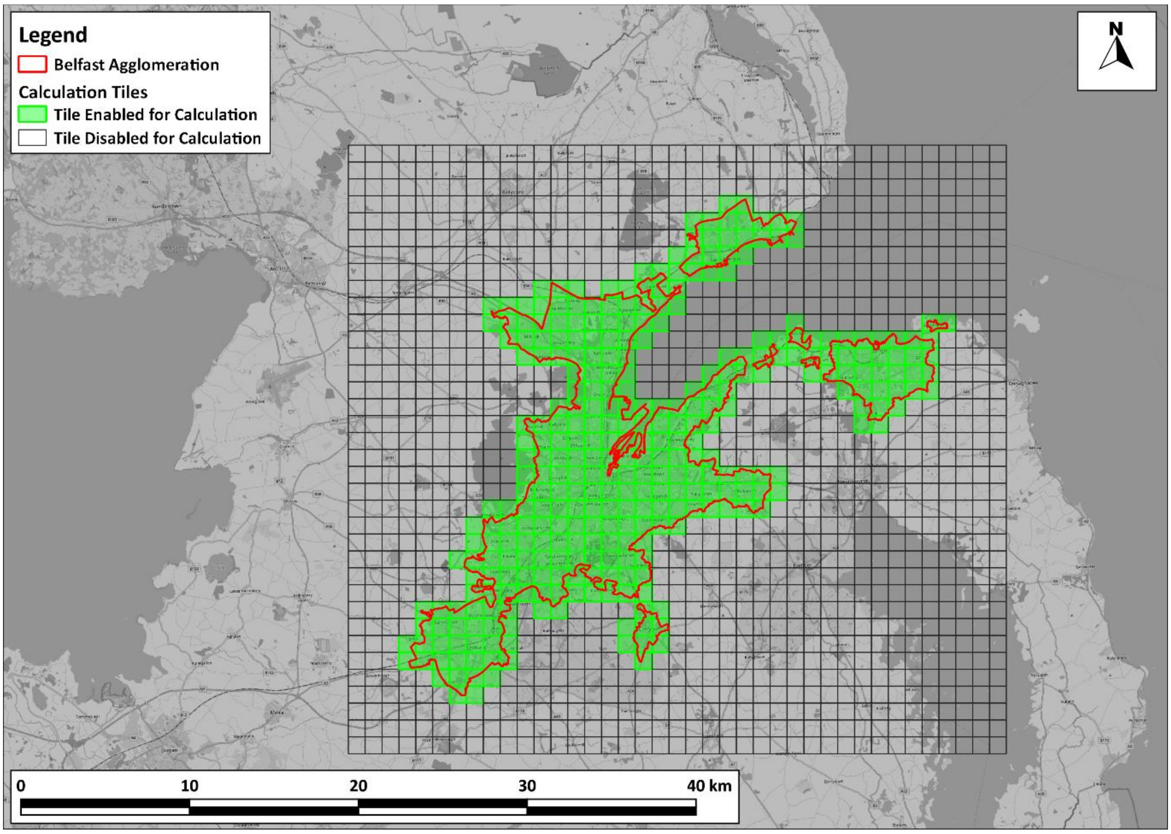
To allow calculations to be distributed across multiple calculation hardware operating in parallel, a process of calculation tiling was applied. This process relied on splitting the noise model around a uniform series of 1km x 1km tiles. Calculations were made in each of the tiles with a computer central processing unit (CPU) allocated to the calculation in each tile. The tiling occurred across a network and the results were deposited as tiles to a centralise location. With the hardware and number of CPUs allocated to the project, 110 km^2 of concurrent calculations were possible.

In the LimA calculation software environment, the tiles can be enabled or disabled to restrict where the model will output the calculated noise results along with the calculation extents described above. The model will only output calculated results within tiles that have been enabled, and within the areas defined by the calculation extents. It should be noted that contributions from all relevant sources located outside an enabled tile (by a distance defined by the Source Search Radius – in this case 3,000m) will still be considered in the calculated results output by the model, irrespective of whether the source is located within an enabled or disabled tile.

Calculations were required for separate sources, meaning that for each tile a calculation was required for roads, railways and industry. Additionally separate calculations were required for façade receiver (for the exposure analysis) and for grids (for maps).

Figure 3 provides an example of the 1km x 1km calculation tiles for the Belfast Agglomeration which was used for the agglomeration railway models.

Figure 3: Belfast Agglomeration Calculation Tiles



Model Calculation Run Scenarios

The Regulations requires L_{den} and L_{night} results to be produced for road traffic, railway and industry sources. For road traffic and railway sources, the Regulations requires that results are calculated across the agglomeration for all modelled sources as well as for those sources identified as 'major' as defined by the Regulations. Separate calculations were not required for major road and rail sources as these could be differentiated as part of a single calculation, with LimA outputting reports for all sources included in the model and for major sources separately.

Two calculated results formats are required for L_{den} and L_{night}:

- 10m grid format: Where the model outputs results every 10m in a uniform grid. These results are used to produce the graphical noise contour maps
- Façade receiver format: Where the model outputs results at receiver points digitised at the façades of residential, school and hospital buildings. These results are used to calculate the exposure statistics (see **Section 8**).

Table 1 summarises the model calculation run scenarios.

Table 1: Model Calculation Run Scenarios

Scenario	Noise Source	Output Noise Metrics*	Results Format
3	Railways (agglomeration) and railways (major sources)	L_{day}, L_{eve}, L_{night}, $L_{Aeq,18hr}$, $L_{Aeq,6hr}$ and L_{den}	10m grid
4	Railways (agglomeration) and railways (major sources)	L_{day}, L_{eve}, L_{night}, $L_{Aeq,18hr}$, $L_{Aeq,6hr}$ and L_{den}	Façade receiver

*__Note:__ Whilst the Regulations does not require results for L_{day} or L_{eve}, they are required along with L_{night} to calculate the L_{den} noise metric – see the description in the glossary table for a more detailed description of the L_{den} noise metric

The model was configured to output results down to a minimum of 40 dB L_{den} and 35 L_{night}, which goes beyond the reporting requirements of the Regulations (55 dB L_{den} and 50 dB L_{night}) and would allow for the calculation of harmful effects as well as enabling the graphical noise maps to present contours down to the lower levels if desired.

Post Processing of Model Outputs

Grid Results

LimA grid calculations are output as an ERT results file (a LimA proprietary file format). It includes the coordinates of each grid calculation point and associated calculated levels across all noise metrics (L_{day}, L_{eve}, L_{night} and L_{den}), including (where relevant) columns for calculated levels from all sources and for 'major' sources.

Whilst the $L_{Aeq,16h}$ noise metric was not output by the model, it was possible to calculate it from the L_{day} and L_{eve} results using the following equation:

$$L_{Aeq,16h} = 10 \times \log_{10}\left(\left(\frac{12}{16}\right) \times 10^{\frac{L_{day}}{10}} + \left(\frac{4}{16}\right) \times 10^{\frac{L_{eve}}{10}}\right)$$

A results file was output for each calculation tile enabled in the model; therefore a process was developed to merge the results and convert them into graphical noise exposure contour maps in a GeoTiff file format which can then be mapped in GIS software as standard.

Receiver Results

Similar to the grid results, LimA also outputs its façade receiver results as an ERT results file format, with a similar structure to that of the grid calculations (coordinates of receiver points and columns of associated calculated levels). The post processing of the levels calculated at the façade receiver points to assign an exposure level to the associated buildings is set out in detail in **Section 0** of this report.

7 Quality Assurance

7.1 Introduction

The Quality Assurance (QA) processes undertaken to ensure that noise modelling can be undertaken effectively within the LimA environment are set out in this section of the report. The model was developed using a combination of processing using Feature Manipulation Software (FME) and GIS to prepare the model input datasets so that processing in the LimA calculation software environment was minimised and model layers are configured in a format suitable for converting into the BNA file formats required by the LimA software.

Specific QA procedures relating to the processing steps undertaken for each model input file is set out in more detail in the Stage 1 report.

7.1.1 QA Process – Stage 1

Stage 1 of the QA process involved checking that the input datasets prepared for LimA ingestion had been suitably prepared in terms of their spatial extent, type of object and ensuring that the dataset attribution was aligned appropriately to the corresponding LimA model layer attribute requirements.

LimA's model layer import tool requires that the input datasets are in a Shapefile format, therefore all of the prepared model input layers were output in a Shapefile format at the last stage of processing prior to the LimA import process.

Figure 4 shows an example of a model layer (buildings) geometry and attribute checks being undertaken in the QGIS GIS environment, with Figure 5 showing the datasets attribution schema checks confirming the suitability of the dataset for importing into the LimA environment.

Figure 4: Model Layer Checking in QGIS Before LimA Import

BUIL_01 — Features Total: 390726, Filtered: 390726, Selected: 0

	NCL_ID	WGB	ID	BAUL	MAK	Z	ZREL	EW	VAR
1	NONRES_2	NONRES_2	714500	1	ABSCO10	5 R	0	-	+
2	NONRES_7	NONRES_7	714503	1	ABSCO10	5 R	0	-	+
3	NONRES_15	NONRES_15	714510	1	ABSCO10	5 R	0	-	+
4	NONRES_17	NONRES_17	714512	1	ABSCO10	5 R	0	-	+
5	NONRES_19	NONRES_19	714514	1	ABSCO10	5 R	0	-	+
6	NONRES_21	NONRES_21	714515	1	ABSCO10	5 R	0	-	+
7	NONRES_25	NONRES_25	714518	1	ABSCO10	5 R	0	-	+
8	NONRES_26	NONRES_26	714519	1	ABSCO10	5 R	0	-	+
9	NONRES_27	NONRES_27	714520	1	ABSCO10	5 R	0	-	+

Figure 5: Model Layer Attribute Schema Checking in QGIS Before LimA Import

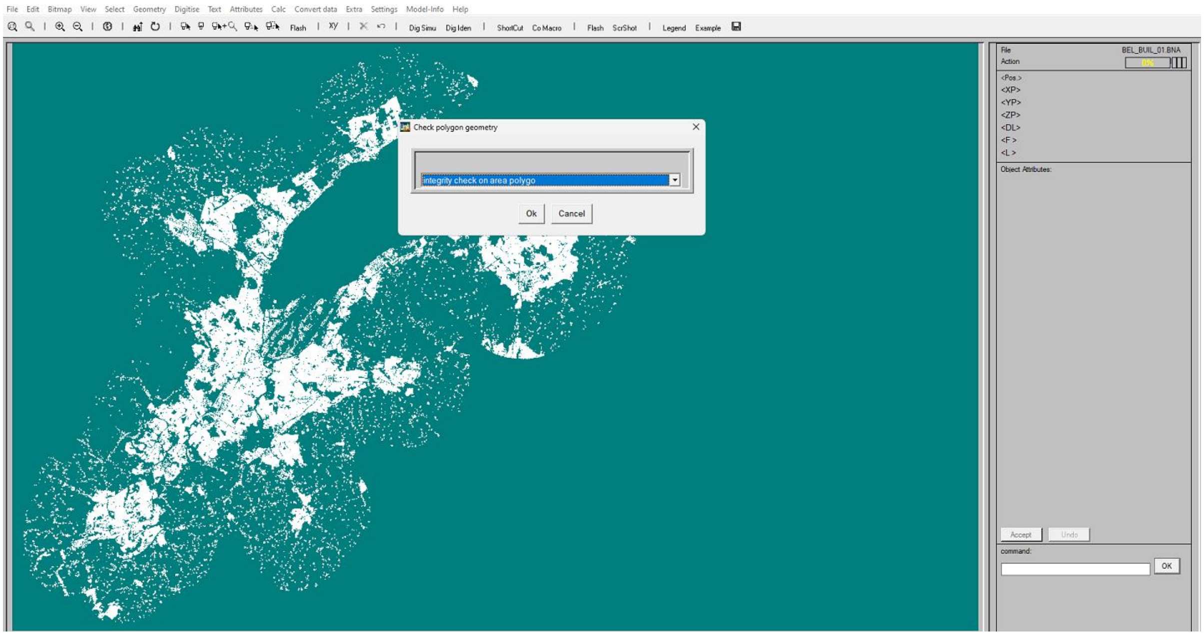
Id	Name	Alias	Type	Type name	Length	Precision
abc 0	NCL_ID		QString	String	50	0
abc 1	WGB		QString	String	50	0
1.2 2	ID		double	Real	20	0
abc 3	BAUL		QString	String	20	0
abc 4	MAK		QString	String	20	0
abc 5	Z		QString	String	20	0
abc 6	ZREL		QString	String	20	0
abc 7	EW		QString	String	20	0
abc 8	VAR		QString	String	20	0

7.1.2 QA Process – Stage 2

Stage 2 of the QA process involved importing the datasets into the LimA proprietary BNA model format and reviewing the converted model data within the LimA environment. Once loaded into LimA, a series of checks using LimA's model object checking tools were performed. These checks included:

- **Integrity checking** – confirming that the object meets the required topographic definitions
- **Attribution checking** – ensuring that the attributed had been mapped over from the Shapefile to the LimA BNA model object
- **Object definition checking**
- **Duplicate object checking**

Figure 6: Example of Integrity Check on Buildings in LimA



Where issues were identified by the LimA model object checking tools, corrective actions were undertaken either in the GIS environment or the LimA modelling environment (depending on the specific issue identified). Where possible, each model object feature had been assigned a unique identification value so that it would be possible to identify the corresponding feature in the GIS environment where necessary.

7.1.3 QA Process – Stage 3

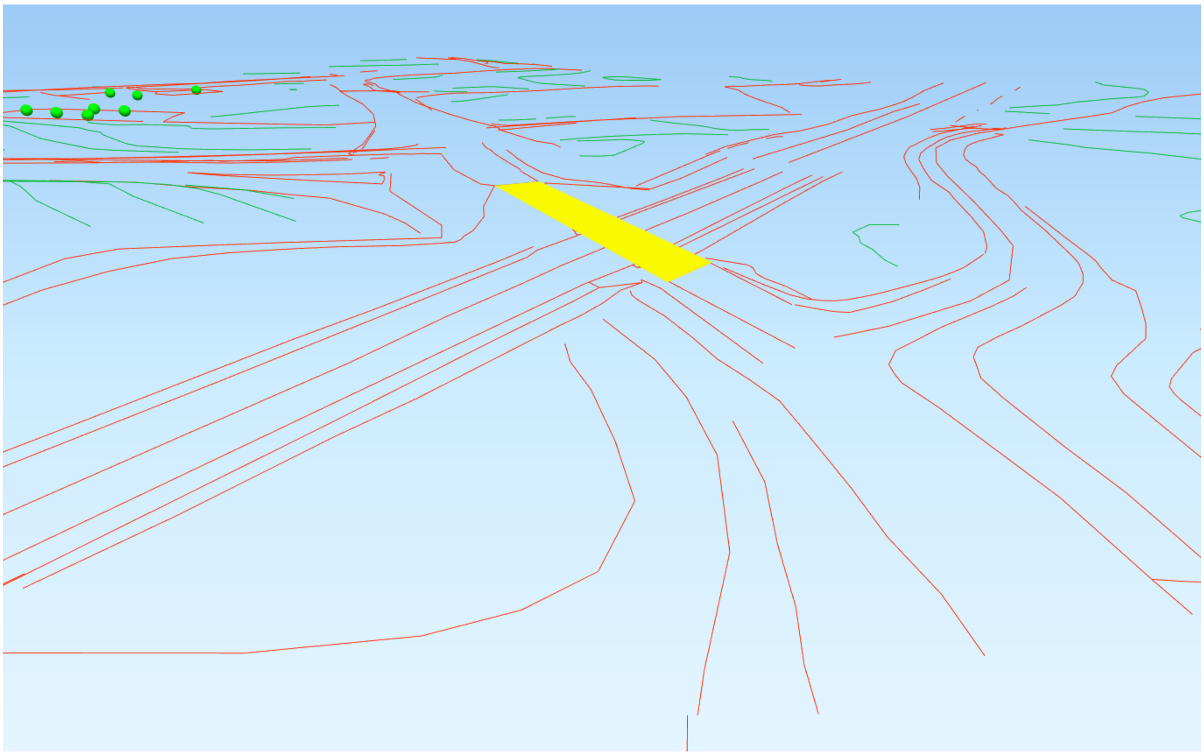
Where Stage 2 of the QA process involved checking each model object individually, Stage 4 required a QA of the interaction between all model objects, ensuring that the topology rules summarised below are adhered to, with a final check to ensure that the noise sources are geometrically aligned to the propagation model:

- **Rule 1:** Confirm that bridge elevations and extents are appropriately aligned with the model spot heights, equal height contours, breaklines and buildings
- **Rule 2:** Confirm that the building geometries are appropriately defined with respect to the model spot heights, equal height contours and breaklines
- **Rule 3:** Confirm that the barrier geometries are appropriately aligned with respect to the model spot heights, equal height contours, breaklines, bridges and buildings
- **Final Check:** Confirm that the noise sources are appropriately aligned with the propagation model

Rule 1

As part of the QA processes implemented during the preparation of the bridges for modelling, checks to ensure that the bridges were appropriately aligned with the local terrain features (spot heights, breaklines and equal height contours) has already been undertaken using the QGIS 3D viewer (as shown in Figure 7), therefore it was not necessary to check each individual bridge feature within the LimA environment (further details provided in the Stage 1 report). However, a review of the bridge object geometries against the other propagation model datasets was undertaken in the LimA environment during the final check of the QA Stage 3 process.

Figure 7: Example of Bridge Checking in the QGIS 3D Viewer



Rule 2

Checks had already been undertaken in GIS to confirm that spot heights were only included within 0.5m of the building footprints, and that buildings did not intersect equal height contours and breaklines (further details provided in the Stage 1 report) prior to importing the building dataset to the LimA model environment. A review of the building object geometries against the propagation model in the LimA environment was undertaken during the final check of the QA Stage 3 process.

Figure 8: Example of Building Interaction Against Equal Height Contours, Breaklines and Spot Heights in GIS

Rule 3

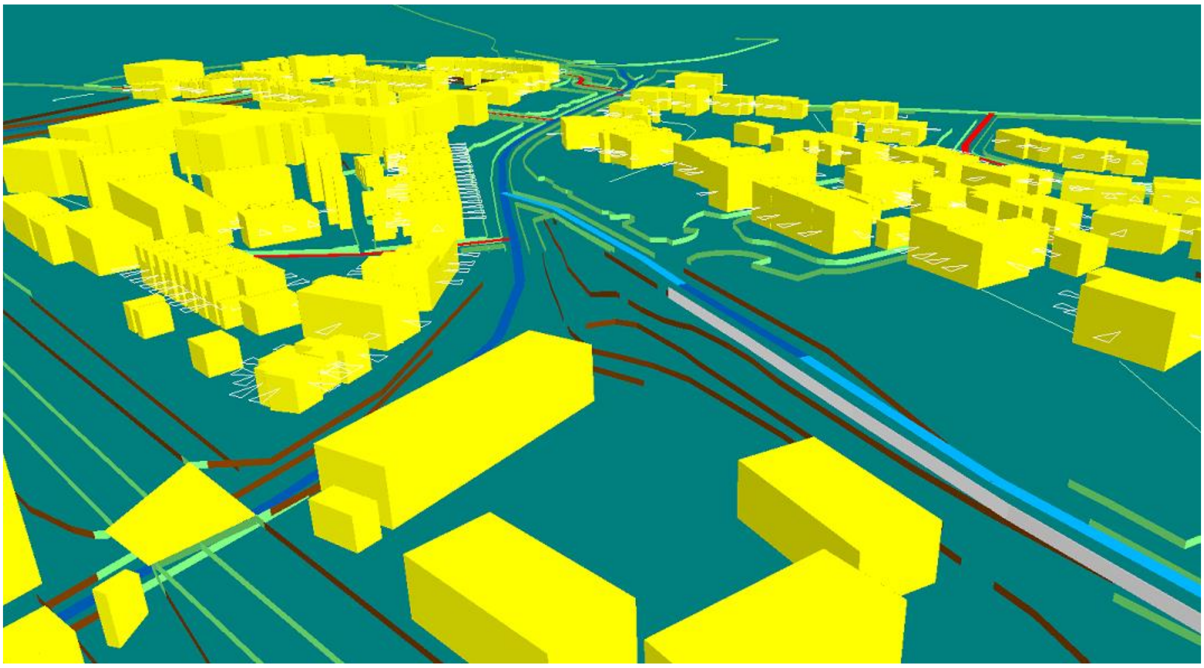
Ensuring that the barriers do not intersect buildings, and that height definitions are applied so that the barrier height is defined with respect to the local terrain (comprising equal height contours, breaklines and spot heights) or bridges, is embedded in the processing steps undertaken to prepare the barriers for importing into the LimA environment. A review of the barrier geometries against the propagation model in the LimA environment was undertaken during the final check of the QA Stage 3 process.

Final Checks

For the final checks, the propagation model layers and model source layers were checked using LimA's Model Check function. The Model Check function involves LimA combining all model layers and running through the calculation core without performing any noise propagation calculations. When completed, LimA then outputs a "KON" BNA file which, when opened, allows the user to view the model in 3D and review the relative interactions between all model datasets.

The areas selected for checking were confirmed to include a mixture of all propagation model layer objects (bridges, breaklines, spot heights, equal height contours, ground cover and barriers) and building façade receivers. Where barriers were to be positioned on top of a bridge deck, these were checked to ensure that the elevations were defined appropriately with reference to the corresponding bridge deck elevation. Building façade receivers were checked to ensure that they aligned appropriately with the corresponding building, and that the attribution of the receivers had been defined appropriately to include the corresponding building unique identifier which would enable the calculated results to be linked back to the associated building to facilitate the generation of exposure statistics.

Figure 9: Example of 3D Model View Checks in LimA



7.2 LimA Version QA

The Round 3 strategic noise mapping was undertaken using LimA v11.2. For Round 4, LimA v2024 has been used. This version of LimA as has been specifically configured for performing strategic noise map calculations using the CNOSSOS-EU method.

For Round 3, a comparison of calculated model outputs was undertaken using LimA v11.2 against the Round 2 calculated model outputs. Given the calculation method for Round 4 (CNOSSOS-EU) is different to those used in Round 2 and Round 3 (where CRN 1995 was used for railways), it was therefore not considered appropriate to review LimA v2024 calculation outputs against those produced for Round 3 for the purpose of QA checking. However, LimA v2024 has been thoroughly tested and used by members of the project team for the Round 4 strategic noise mapping for England, and subsequently deployed to perform the Round 4 strategic noise map calculations for Scotland, Wales and the Republic of Ireland. It was therefore not considered necessary to further QA LimA v2024 for the purposes of delivering the Northern Ireland strategic noise maps.

8 Exposure Statistics

The Environmental Noise Regulations (Northern Ireland) 2006 (Regulations[15]), as amended by the Environmental Noise (Amendment) (NI) Regulations 2018[16], transposed European Commission Directive 2002/49/EC[17], known as the Environmental Noise Directive (END), into Northern Irish law. The Regulations make reference to Annex VI of the END, which sets out the exposure statistics that are required to be reported.

The END state that the following exposure statistics are required:

For Agglomerations:

"The estimated number of people (in hundreds) living in dwellings that are exposed to each of the following bands of values of L_{den} in dB 4 m above the ground on the most exposed façade: 55-59, 60-64, 65-69, 70-74, > 75, separately for noise from road, rail and air traffic, and from industrial sources. The figures must be rounded to the nearest hundred (e.g. 200 = between 150 and 249; 100 = between 50 and 149; 0 = less than 50)."

And:

"The estimated total number of people (in hundreds) living in dwellings that are exposed to each of the following bands of values of L_{night} in dB 4 m above the ground on the most exposed façade: 50-54, 55-59, 60-64, 65-69, > 70, separately for road, rail and air traffic and for industrial sources."

For major roads, major railways and major airports:

"The estimated total number of people (in hundreds) living outside agglomerations in dwellings that are exposed to each of the following bands of values of L_{den} in dB 4 m above the ground and on the most exposed façade: 55-59, 60-64, 65-69, 70-74, > 75."

And:

"The estimated total number of people (in hundreds) living outside agglomerations in dwellings that are exposed to each of the following bands of values of Lnight in dB 4 m above the ground and on the most exposed façade: 50-54, 55-59, 60-64, 65-69, > 70."

And:

"The total area (in km^2) exposed to values of L_{den} higher than 55, 65 and 75 dB respectively. 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. Those figures must include agglomerations."

8.1 Method

The sections below describe the method for assigning exposure levels to populations and dwellings. The number of dwellings and people in dwellings assigned to the buildings within the model were determined through analysis of OSNI Pointer, OSNI Fusion and CENSUS 2021 data, with full details provided in the Stage 1 Report.

8.1.1 Railway Exposure Statistics

The calculation of exposure statistics for railway sources requires that schools, hospitals and the estimated number of dwellings within buildings are identified, as well as the assignment of the estimated number of people to each dwelling, and the generation of building façade receivers. Details of the

[15] https://www.legislation.gov.uk/nisr/2006/387/contents/made (Accessed November 2024)
[16] https://www.legislation.gov.uk/nisr/2018/190/made (Accessed November 2024)
[17] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0049 (Accessed November 2024)

processing steps to provide this information required to enable exposure statistics to be calculated are set out in the Stage 1 Report.

The approach to assigning calculated levels at the façade receivers to dwellings and people in dwellings is set out in CNOSSOS-EU:2020. Three methods can be applied, summarised below:

Method 1: The location of individual dwellings is known

Where the location of individual dwellings is known, the dwelling and number of people within the dwelling is assigned to the façade receiver point at the most exposed façade of the dwelling. This applies to:

- Detached houses; or
- Semi-detached/terraced houses, or apartment buildings where the internal division of the buildings is known; or
- Buildings with a floor size that indicates a single dwelling per floor level; or
- Buildings with a floor size and height that indicates a single dwelling per building.

Method 2: Information is available showing that dwellings are arranged within an apartment such that they have a single façade exposed to noise

Method 2 applies to apartment blocks that have all windows within each apartment only facing one direction. Under this scenario, the dwellings and people in dwellings are assigned to all façade receivers associated with the building, weighted by the façade length that each façade receiver represents, resulting in the dwellings and number people within the dwellings being assigned the lowest, median and highest calculated noise levels around the building façade.

Method 3: Information is available showing that dwellings are arranged within an apartment such that they have more than one façade exposed to noise

Method 3 applies to:

- Buildings that have all windows within each dwelling facing more than one direction; or
- Buildings with courtyards or internal light wells; or
- Buildings that contain apartments that transverse the width of the building and have façades exposed to both sides of the building, or to courtyard or light well; or
- Buildings where the internal layout of the dwellings is not known

Under this scenario, the dwellings and people within dwellings are assigned the median or higher noise levels calculated around the building façades. This approach is to be considered the default approach in situations where the layout of dwellings within a building is unknown.

It has not been possible to consider Method 2, given that the layout of dwellings within the buildings considered in the Round 4 maps is unknown, therefore:

- **Method 1** has been applied to buildings with one dwelling; and
- **Method 3** has been applied to all other multi-dwelling residential buildings.

The noise levels were assigned to population and dwellings using the methods described above. A programming process was developed which read in all required attribute data from the building's dataset, façade receiver dataset and all required information within the model results files and output the required exposure statistics.

The exposure statistics were output in 1 dB noise exposure bands for the noise metrics L_{day}, L_{eve}, L_{night}, $L_{Aeq,16hr}$, $L_{Aeq,18hr}$, $L_{Aeq,6hr}$ and L_{den}.

8.2 Exposure Statistics

The tables in the following sections summarises the population exposure statistics from the railway sources as required by the Regulations.

Details of the area exposed, as well as the number of dwellings and noise sensitive buildings exposed to noise bands, in **Appendix A1**. The exposure statistics calculated in 1 dB bands across the noise metrics L_{day}, L_{eve}, L_{night}, $L_{Aeq,16hr}$, $L_{Aeq,18hr}$, $L_{Aeq,6hr}$ and L_{den} are provided in **Appendix A2**.

8.2.1 Agglomeration Railway Statistics

Table 2: Belfast Agglomeration Railways – Population Exposed

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	1,733	105
55-59	5,228	4,455	3,280	4,180	3,951	554	0
60-64	1,807	1,430	1,031	1,304	1,265	20	0
65-69	474	215	136	196	163	0	0
70-74*	16	3	3	3	3	0	0
>=75	0	0	0	0	0	N/A	N/A

*Represents >=70 dB for L_{night}

8.2.2 Major Railways Statistics

Table 3: Major Railways – Population Exposed

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	0	0
55-59	12	12	9	12	12	0	0
60-64	2	2	0	2	2	0	0
65-69	0	0	0	0	0	0	0
70-74*	0	0	0	0	0	0	0
>=75	0	0	0	0	0	N/A	N/A

*Represents >=70 dB for L_{night}

8.2.3 L_{den} Statistics higher than 55, 65 and 75 dB

As previously noted, in addition to the exposure statistics set out above, the END requires the following statistics to be reported:

"The total area (in km²) exposed to values of Lden higher than 55, 65 and 75 dB respectively. 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. Those figures must include agglomerations."

The exposure statistics above the 55, 65 and 75 dB Lden thresholds, including agglomerations, are presented in the tables below.

Railways

Table 4: Railways – Area of Noise Bands in km²

Noise Exposure (dB)	L_{den}
>55	5
>65	1
>75	0

Table 5: Railways – Population Exposed

Noise Exposure (dB)	L_{den}
>55	6,373
>65	470
>75	0

Table 6: Railways – Dwellings Exposed

Noise Exposure (dB)	L_{den}
>55	3,313
>65	264
>75	0

9 Discussion and Conclusions

It is important to reiterate that the datasets and calculation methodology, and therefore calculation extents for deriving the statistics found in the Round Four report differ from those used in previous rounds of noise mapping.

The first three rounds of strategic noise maps for railway sources have been developed using computation method set out in Environmental Noise Regulations 2006 (S.I. 140/2006) (CRN 1995), however Round 4 requires the use of the Common Noise Assessment Methods for Europe (CNOSSOS-EU) method. It is therefore not relevant to make direct comparisons between the exposure statistics derived for Round 4 with those derived for earlier rounds due to the changes both in the calculation and exposure assessment methodologies.

9.1 Key Observations

9.1.1 Belfast Agglomeration

The extent of the Round 4 Belfast Agglomeration covers 208.5km^2, with up to 5 km^2 (2.4% of the agglomeration area) exposed to railway noise levels greater than 55 dB L_{den} and 1 km^2 (<1% of the agglomeration area) is exposed to noise levels greater than 50 dB L_{night}.

An estimated total of 3,313 dwellings are exposed to noise levels greater than 55 dB L_{den} from railway sources within the Belfast Agglomeration, which statistically contain an estimated population of 6,373. During the night period, an estimated total of 1,172 dwellings are exposed to noise levels greater than 50 dB L_{night}, which statistically contain an estimated population of 2,307.

The total number of school buildings exposed to noise levels greater than 55 dB L_{den} and 50 dB L_{night} from rail sources within the Belfast Agglomeration are 18 and 7, respectively.

The total number of hospital buildings exposed to noise levels greater than 55 dB L_{den} and 50 dB L_{night} from rail sources within the Belfast Agglomeration are 23 and 10, respectively.

9.1.2 Major Railways outside the Belfast Agglomeration

Figure 2 shows the extents of the area within Northern Ireland, outside the Belfast Agglomeration, that has been modelled for exposure to railway noise from major sources.

Less than 1km^2 is exposed to railway noise levels greater than 55 dB L_{den} and less than 1km^2 is exposed to noise levels greater than 50 dB L_{night}.

An estimated total of 6 dwellings are exposed to noise levels greater than 55 dB L_{den} from major railway sources, which statistically contain an estimated population of 14. During the night period, it is estimated that no dwellings are exposed to noise levels greater than 50 dB L_{night}.

No school buildings are exposed to noise levels greater than 55 dB L_{den} or 50 dB L_{night} from major railway sources.

No hospital buildings are exposed to noise levels greater than 55 dB L_{den} or 50 dB L_{night} from major railway sources.

Appendices

A1 Exposure Statistics – 5 dB Bands

A1.1 Agglomeration Statistics

Table A1.1: Railways – Area of Noise Bands in km^2

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	2	0
55-59	3	3	3	3	3	0	0
60-64	2	1	1	1	1	0	0
65-69	0	0	0	0	0	0	0
70-74*	0	0	0	0	0	0	0
>=75	0	0	0	0	0	N/A	N/A

*Represents >=70 dB for L_{night}

Table A1.2: Railways – Number of Dwellings

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	844	64
55-59	2,591	2,260	1,675	2,139	2,023	316	0
60-64	977	791	587	722	699	12	0
65-69	265	116	76	106	89	0	0
70-74*	10	2	2	2	2	0	0
>=75	0	0	0	0	0	N/A	N/A

*Represents >=70 dB for L_{night}

Table A1.3: Railways – Number of School Buildings

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	5	0
55-59	11	12	11	10	9	2	0
60-64	4	3	1	3	3	0	0
65-69	3	2	2	2	2	0	0
70-74*	0	0	0	0	0	0	0
>=75	0	0	0	0	0	N/A	N/A

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
*Represents >=70 dB for L_{night}							

Table A1.4: Railways – Number of Hospital Buildings

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	8	0
55-59	13	9	7	9	10	2	0
60-64	6	8	4	7	6	0	0
65-69	4	1	1	1	1	0	0
70-74*	0	0	0	0	0	0	0
>=75	0	0	0	0	0	N/A	N/A
*Represents >=70 dB for L_{night}							

A1.2 Major Rail Statistics

Table A1.5: Major Railways – Area of Noise Bands in km²

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	1	0
55-59	3	2	2	2	2	0	0
60-64	2	1	1	1	1	0	0
65-69	0	0	0	0	0	0	0
70-74*	0	0	0	0	0	0	0
>=75	0	0	0	0	0	N/A	N/A
*Represents >=70 dB for L_{night}							

Table A1.6: Major Railways – Number of Dwellings

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	0	0
55-59	5	5	4	5	5	0	0
60-64	1	1	0	1	1	0	0
65-69	0	0	0	0	0	0	0

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
70-74*	0	0	0	0	0	0	0
>=75	0	0	0	0	0	N/A	N/A

*Represents >=70 dB for L_{night}

Table A1.7: Major Railways – Number of School Buildings

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	0	0
55-59	0	0	0	0	0	0	0
60-64	0	0	0	0	0	0	0
65-69	0	0	0	0	0	0	0
70-74*	0	0	0	0	0	0	0
>=75	0	0	0	0	0	N/A	N/A

*Represents >=70 dB for L_{night}

Table A1.8: Major Railways – Number of Hospital Buildings

Noise Exposure (dB)	L_{den}	L_{day}	$L_{evening}$	$L_{Aeq,16hr}$	$L_{Aeq,18hr}$	L_{night}	$L_{Aeq,6hr}$
50-54	N/A	N/A	N/A	N/A	N/A	0	0
55-59	0	0	0	0	0	0	0
60-64	0	0	0	0	0	0	0
65-69	0	0	0	0	0	0	0
70-74*	0	0	0	0	0	0	0
>=75	0	0	0	0	0	N/A	N/A

*Represents >=70 dB for L_{night}

A2 Exposure Statistics – 1 dB Bands

A2.1 Agglomeration Statistics

Table A2.1: Railways – Population Exposed

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
40-41	13,873.21	9,868.90	9,505.83	9,863.84	9,680.49	2,025.60	313.07
41-42	11,318.29	8,521.98	8,319.95	8,552.14	8,197.07	1,849.24	411.43
42-43	9,682.27	6,981.84	6,886.96	6,904.36	6,793.47	1,534.77	442.31
43-44	8,262.46	6,008.77	5,708.96	6,000.76	5,850.49	1,272.05	206.47
44-45	6,688.81	4,969.14	4,923.09	4,917.20	4,748.83	1,190.81	144.17
45-46	5,839.70	3,941.35	3,854.72	3,834.28	3,843.20	1,020.99	102.04
46-47	5,084.34	3,365.26	3,244.72	3,477.48	3,461.15	1,020.85	119.74
47-48	3,906.48	3,053.14	2,839.86	2,884.43	2,693.00	943.98	84.98
48-49	3,427.42	2,429.15	2,349.11	2,417.79	2,337.77	844.96	37.76
49-50	2,737.03	1,928.45	1,974.30	2,016.40	2,086.99	907.45	37.26
50-51	2,308.95	1,810.88	1,627.05	1,697.79	1,497.54	502.25	46.13
51-52	2,064.88	1,469.26	1,354.17	1,506.65	1,463.23	342.51	42.15
52-53	1,469.34	1,211.10	1,268.91	1,134.99	1,099.42	291.11	14.02
53-54	1,333.31	1,167.18	1,370.45	1,221.74	1,199.27	368.52	2.91
54-55	1,176.35	1,231.99	1,087.82	1,305.99	1,359.62	228.26	0.00
55-56	1,164.67	1,249.64	964.77	1,189.97	1,214.94	175.10	0.00
56-57	1,251.79	1,249.90	895.19	1,115.35	990.59	172.46	0.00
57-58	1,105.94	690.77	456.25	737.44	686.33	105.62	0.00
58-59	974.88	720.47	527.48	628.13	590.31	76.67	0.00
59-60	730.23	543.85	436.59	509.27	469.05	24.48	0.00
60-61	449.83	492.99	362.62	445.12	471.71	14.38	0.00
61-62	420.42	341.05	203.33	315.20	251.89	5.22	0.00
62-63	474.36	247.20	183.57	211.95	210.81	0.00	0.00
63-64	246.65	174.74	137.38	163.52	144.48	0.00	0.00
64-65	215.28	173.98	144.45	168.55	185.74	0.00	0.00
65-66	159.61	91.55	56.56	91.06	80.74	0.00	0.00

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
66-67	138.86	66.46	31.93	55.13	34.49	0.00	0.00
67-68	110.75	26.42	20.55	22.47	23.85	0.00	0.00
68-69	33.91	22.00	20.74	19.09	17.44	0.00	0.00
69-70	31.35	8.30	6.65	8.30	6.65	0.00	0.00
70-71	9.44	0.00	1.65	0.00	3.30	0.00	0.00
71-72	3.57	3.30	1.65	3.30	0.00	0.00	0.00
72-73	3.30	0.00	0.00	0.00	0.00	0.00	0.00
73-74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
74-75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75-76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
76-77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
77-78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
78-79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
79-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>=80	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A2.2: Railways – Number of Dwellings

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
40-41	7,139.92	5,145.47	4,972.93	5,160.28	5,046.93	1,049.13	131.26
41-42	5,874.92	4,472.12	4,341.51	4,493.76	4,325.31	1,004.77	167.24
42-43	5,012.58	3,733.88	3,667.10	3,701.23	3,625.51	819.86	270.01
43-44	4,303.41	3,192.67	3,024.50	3,164.70	3,088.51	686.80	124.39
44-45	3,568.38	2,570.16	2,594.76	2,570.97	2,471.74	622.53	80.76
45-46	3,086.97	2,069.87	2,014.37	2,005.08	2,019.87	504.51	51.55
46-47	2,697.00	1,767.62	1,702.43	1,821.41	1,822.32	535.71	68.64
47-48	2,063.07	1,576.72	1,500.71	1,494.25	1,391.82	457.42	52.97
48-49	1,801.87	1,289.14	1,216.92	1,264.73	1,229.84	422.78	21.75
49-50	1,414.26	991.80	1,040.02	1,074.38	1,112.87	480.64	23.22
50-51	1,211.83	964.57	867.84	888.58	759.67	187.96	27.73
51-52	1,086.33	719.39	682.76	751.35	738.53	180.78	25.96
52-53	773.14	656.21	668.82	611.13	599.88	151.45	8.75
53-54	677.11	589.52	710.88	624.28	607.85	200.42	1.88
54-55	640.70	622.32	473.93	626.73	648.56	123.51	0.00
55-56	608.92	630.11	531.31	612.18	627.11	98.37	0.00
56-57	595.14	590.93	393.04	520.12	458.39	98.74	0.00
57-58	532.59	362.15	244.20	398.38	370.90	58.36	0.00
58-59	538.60	386.84	274.82	336.35	314.53	45.61	0.00
59-60	316.13	290.06	231.21	272.21	252.09	14.88	0.00
60-61	238.91	266.78	202.82	235.90	251.83	8.75	0.00
61-62	221.08	188.47	119.37	177.42	140.99	3.00	0.00
62-63	258.20	137.39	102.82	120.16	119.47	0.00	0.00
63-64	135.63	96.33	78.76	89.44	80.27	0.00	0.00
64-65	123.22	102.32	83.21	99.13	106.75	0.00	0.00
65-66	88.49	48.06	30.25	48.25	42.75	0.00	0.00
66-67	78.13	34.38	16.88	28.38	17.88	0.00	0.00
67-68	62.11	14.75	11.75	12.75	13.75	0.00	0.00
68-69	17.88	13.88	13.00	12.00	11.00	0.00	0.00

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
69-70	18.75	5.00	4.00	5.00	4.00	0.00	0.00
70-71	6.00	0.00	1.00	0.00	2.00	0.00	0.00
71-72	2.00	2.00	1.00	2.00	0.00	0.00	0.00
72-73	2.00	0.00	0.00	0.00	0.00	0.00	0.00
73-74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
74-75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75-76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
76-77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
77-78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
78-79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
79-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>=80	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A2.3: Railways – Number of School Buildings

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
40-41	57	30	31	29	27	6	0
41-42	31	26	31	23	23	5	0
42-43	37	14	17	23	20	5	2
43-44	22	23	10	16	20	6	0
44-45	18	17	23	18	15	6	1
45-46	14	18	16	17	17	1	1
46-47	21	8	5	7	7	3	1
47-48	15	5	4	5	4	1	0
48-49	8	8	7	7	6	1	0
49-50	3	2	7	2	3	5	0
50-51	6	6	7	7	7	3	0
51-52	6	7	7	8	8	1	0
52-53	9	7	5	6	8	0	0
53-54	3	5	2	5	1	0	0
54-55	9	1	1	2	4	1	0
55-56	0	4	4	2	1	0	0
56-57	3	1	2	1	1	1	0
57-58	3	3	2	4	5	1	0
58-59	0	2	1	2	2	0	0
59-60	5	2	2	1	0	0	0
60-61	2	0	0	0	2	0	0
61-62	1	2	0	2	0	0	0
62-63	1	0	0	0	0	0	0
63-64	0	0	1	0	1	0	0
64-65	0	1	0	1	0	0	0
65-66	1	0	1	0	1	0	0
66-67	0	2	1	2	1	0	0
67-68	2	0	0	0	0	0	0
68-69	0	0	0	0	0	0	0

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
69-70	0	0	0	0	0	0	0
70-71	0	0	0	0	0	0	0
71-72	0	0	0	0	0	0	0
72-73	0	0	0	0	0	0	0
73-74	0	0	0	0	0	0	0
74-75	0	0	0	0	0	0	0
75-76	0	0	0	0	0	0	0
76-77	0	0	0	0	0	0	0
77-78	0	0	0	0	0	0	0
78-79	0	0	0	0	0	0	0
79-80	0	0	0	0	0	0	0
>=80	0	0	0	0	0	0	0

Table A2.4: Railways – Number of Hospital Buildings

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
40-41	11	20	12	17	17	6	1
41-42	20	12	12	10	12	7	0
42-43	15	20	18	18	21	1	0
43-44	14	17	16	19	16	0	2
44-45	21	12	20	14	13	1	1
45-46	18	13	7	9	13	4	0
46-47	11	10	9	13	7	2	1
47-48	12	6	5	5	7	5	0
48-49	7	3	3	3	2	2	0
49-50	6	8	9	8	9	0	0
50-51	8	7	10	7	7	1	0
51-52	4	4	4	4	2	2	0
52-53	6	0	3	0	0	3	0
53-54	2	0	3	3	3	0	0
54-55	0	5	2	3	3	2	0
55-56	5	1	1	1	4	1	0
56-57	1	5	1	6	3	0	0
57-58	6	2	1	0	0	0	0
58-59	1	0	2	0	0	1	0
59-60	0	1	2	2	3	0	0
60-61	0	3	0	3	2	0	0
61-62	4	2	1	1	1	0	0
62-63	1	0	0	0	0	0	0
63-64	1	2	2	2	2	0	0
64-65	0	1	1	1	1	0	0
65-66	2	0	0	0	0	0	0
66-67	1	0	0	0	0	0	0
67-68	0	1	1	1	1	0	0
68-69	0	0	0	0	0	0	0

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
69-70	1	0	0	0	0	0	0
70-71	0	0	0	0	0	0	0
71-72	0	0	0	0	0	0	0
72-73	0	0	0	0	0	0	0
73-74	0	0	0	0	0	0	0
74-75	0	0	0	0	0	0	0
75-76	0	0	0	0	0	0	0
76-77	0	0	0	0	0	0	0
77-78	0	0	0	0	0	0	0
78-79	0	0	0	0	0	0	0
79-80	0	0	0	0	0	0	0
>=80	0	0	0	0	0	0	0

A2.2 Major Railway Statistics

Table A2.1: Major Railways – Population Exposed

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
40-41	31.01	49.58	20.18	64.87	75.04	2.11	0.00
41-42	61.03	61.88	19.50	34.36	23.50	2.41	2.23
42-43	46.17	20.18	13.30	18.44	16.99	0.00	0.00
43-44	14.46	12.94	10.10	19.51	17.78	2.41	0.00
44-45	21.75	17.77	4.36	11.06	9.74	2.41	0.00
45-46	11.58	9.91	14.37	10.10	6.94	4.64	0.00
46-47	2.86	4.52	11.26	6.78	11.79	0.00	0.00
47-48	11.61	14.21	4.83	11.95	13.83	4.64	0.00
48-49	11.79	11.42	2.11	13.67	9.19	0.00	0.00
49-50	11.42	9.19	2.41	2.41	0.00	0.00	0.00
50-51	0.00	0.00	7.24	2.11	2.11	0.00	0.00
51-52	4.52	2.11	0.00	4.83	7.24	0.00	0.00
52-53	4.83	7.24	2.41	4.83	2.41	0.00	0.00
53-54	2.41	2.41	2.23	2.41	2.41	0.00	0.00
54-55	2.41	2.41	2.41	0.00	0.00	0.00	0.00
55-56	0.00	0.00	4.64	2.23	2.23	0.00	0.00
56-57	4.64	4.64	2.41	2.41	4.83	0.00	0.00
57-58	2.41	2.41	0.00	4.64	2.23	0.00	0.00
58-59	4.64	2.23	2.41	2.41	2.41	0.00	0.00
59-60	0.00	2.41	0.00	0.00	0.00	0.00	0.00
60-61	2.41	2.41	0.00	2.41	2.41	0.00	0.00
61-62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62-63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63-64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64-65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65-66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66-67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67-68	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
68-69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69-70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70-71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71-72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
72-73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73-74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
74-75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75-76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
76-77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
77-78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
78-79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
79-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>=80	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A2.2: Major Railways – Number of Dwellings

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
40-41	14.11	22.83	9.33	29.39	34.33	1.00	0.00
41-42	28.39	28.56	8.78	16.00	10.89	1.00	1.00
42-43	21.00	9.33	6.00	8.56	7.78	0.00	0.00
43-44	6.78	5.78	4.33	8.78	8.00	1.00	0.00
44-45	9.78	8.00	2.00	5.00	4.33	1.00	0.00
45-46	5.00	4.33	6.17	4.33	3.00	2.00	0.00
46-47	1.33	2.00	5.00	3.00	5.17	0.00	0.00
47-48	5.00	6.17	2.00	5.17	6.00	2.00	0.00
48-49	5.17	5.00	1.00	6.00	4.00	0.00	0.00
49-50	5.00	4.00	1.00	1.00	0.00	0.00	0.00
50-51	0.00	0.00	3.00	1.00	1.00	0.00	0.00
51-52	2.00	1.00	0.00	2.00	3.00	0.00	0.00
52-53	2.00	3.00	1.00	2.00	1.00	0.00	0.00
53-54	1.00	1.00	1.00	1.00	1.00	0.00	0.00
54-55	1.00	1.00	1.00	0.00	0.00	0.00	0.00
55-56	0.00	0.00	2.00	1.00	1.00	0.00	0.00
56-57	2.00	2.00	1.00	1.00	2.00	0.00	0.00
57-58	1.00	1.00	0.00	2.00	1.00	0.00	0.00
58-59	2.00	1.00	1.00	1.00	1.00	0.00	0.00
59-60	0.00	1.00	0.00	0.00	0.00	0.00	0.00
60-61	1.00	1.00	0.00	1.00	1.00	0.00	0.00
61-62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62-63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63-64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64-65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65-66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66-67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67-68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68-69	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
69-70	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70-71	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71-72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
72-73	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73-74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
74-75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75-76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
76-77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
77-78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
78-79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
79-80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>=80	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A2.3: Major Railways – Number of School Buildings

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
40-41	2	2	0	1	0	1	0
41-42	0	0	0	0	0	0	0
42-43	0	0	0	0	0	0	0
43-44	0	0	0	0	0	0	0
44-45	0	0	0	0	0	0	0
45-46	0	0	1	0	0	0	0
46-47	0	0	0	0	1	0	0
47-48	1	1	0	1	0	0	0
48-49	0	0	0	0	0	0	0
49-50	0	0	1	0	0	0	0
50-51	0	0	0	0	1	0	0
51-52	1	1	0	1	0	0	0
52-53	0	0	0	0	0	0	0
53-54	0	0	0	0	0	0	0
54-55	0	0	0	0	0	0	0
55-56	0	0	0	0	0	0	0
56-57	0	0	0	0	0	0	0
57-58	0	0	0	0	0	0	0
58-59	0	0	0	0	0	0	0
59-60	0	0	0	0	0	0	0
60-61	0	0	0	0	0	0	0
61-62	0	0	0	0	0	0	0
62-63	0	0	0	0	0	0	0
63-64	0	0	0	0	0	0	0
64-65	0	0	0	0	0	0	0
65-66	0	0	0	0	0	0	0
66-67	0	0	0	0	0	0	0
67-68	0	0	0	0	0	0	0
68-69	0	0	0	0	0	0	0

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
69-70	0	0	0	0	0	0	0
70-71	0	0	0	0	0	0	0
71-72	0	0	0	0	0	0	0
72-73	0	0	0	0	0	0	0
73-74	0	0	0	0	0	0	0
74-75	0	0	0	0	0	0	0
75-76	0	0	0	0	0	0	0
76-77	0	0	0	0	0	0	0
77-78	0	0	0	0	0	0	0
78-79	0	0	0	0	0	0	0
79-80	0	0	0	0	0	0	0
>=80	0	0	0	0	0	0	0

Table A2.4: Major Railways – Number of Hospital Buildings

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
40-41	0	0	0	0	0	0	0
41-42	0	0	0	0	0	0	0
42-43	0	0	0	0	0	0	0
43-44	0	0	0	0	0	0	0
44-45	0	0	0	0	0	0	0
45-46	0	0	0	0	0	0	0
46-47	0	0	0	0	0	0	0
47-48	0	0	0	0	0	0	0
48-49	0	0	0	0	0	0	0
49-50	0	0	0	0	0	0	0
50-51	0	0	0	0	0	0	0
51-52	0	0	0	0	0	0	0
52-53	0	0	0	0	0	0	0
53-54	0	0	0	0	0	0	0
54-55	0	0	0	0	0	0	0
55-56	0	0	0	0	0	0	0
56-57	0	0	0	0	0	0	0
57-58	0	0	0	0	0	0	0
58-59	0	0	0	0	0	0	0
59-60	0	0	0	0	0	0	0
60-61	0	0	0	0	0	0	0
61-62	0	0	0	0	0	0	0
62-63	0	0	0	0	0	0	0
63-64	0	0	0	0	0	0	0
64-65	0	0	0	0	0	0	0
65-66	0	0	0	0	0	0	0
66-67	0	0	0	0	0	0	0
67-68	0	0	0	0	0	0	0
68-69	0	0	0	0	0	0	0

Exposure Band	L_{den}	L_{day}	L_{eve}	$L_{Aeq,16h}$	$L_{Aeq,18h}$	L_{night}	$L_{Aeq,6h}$
69-70	0	0	0	0	0	0	0
70-71	0	0	0	0	0	0	0
71-72	0	0	0	0	0	0	0
72-73	0	0	0	0	0	0	0
73-74	0	0	0	0	0	0	0
74-75	0	0	0	0	0	0	0
75-76	0	0	0	0	0	0	0
76-77	0	0	0	0	0	0	0
77-78	0	0	0	0	0	0	0
78-79	0	0	0	0	0	0	0
79-80	0	0	0	0	0	0	0
>=80	0	0	0	0	0	0	0

A3 Strategic Noise Maps

A3.1 Belfast Agglomeration Figures

Figure A3.1: Belfast Agglomeration – Railway – L_{den}

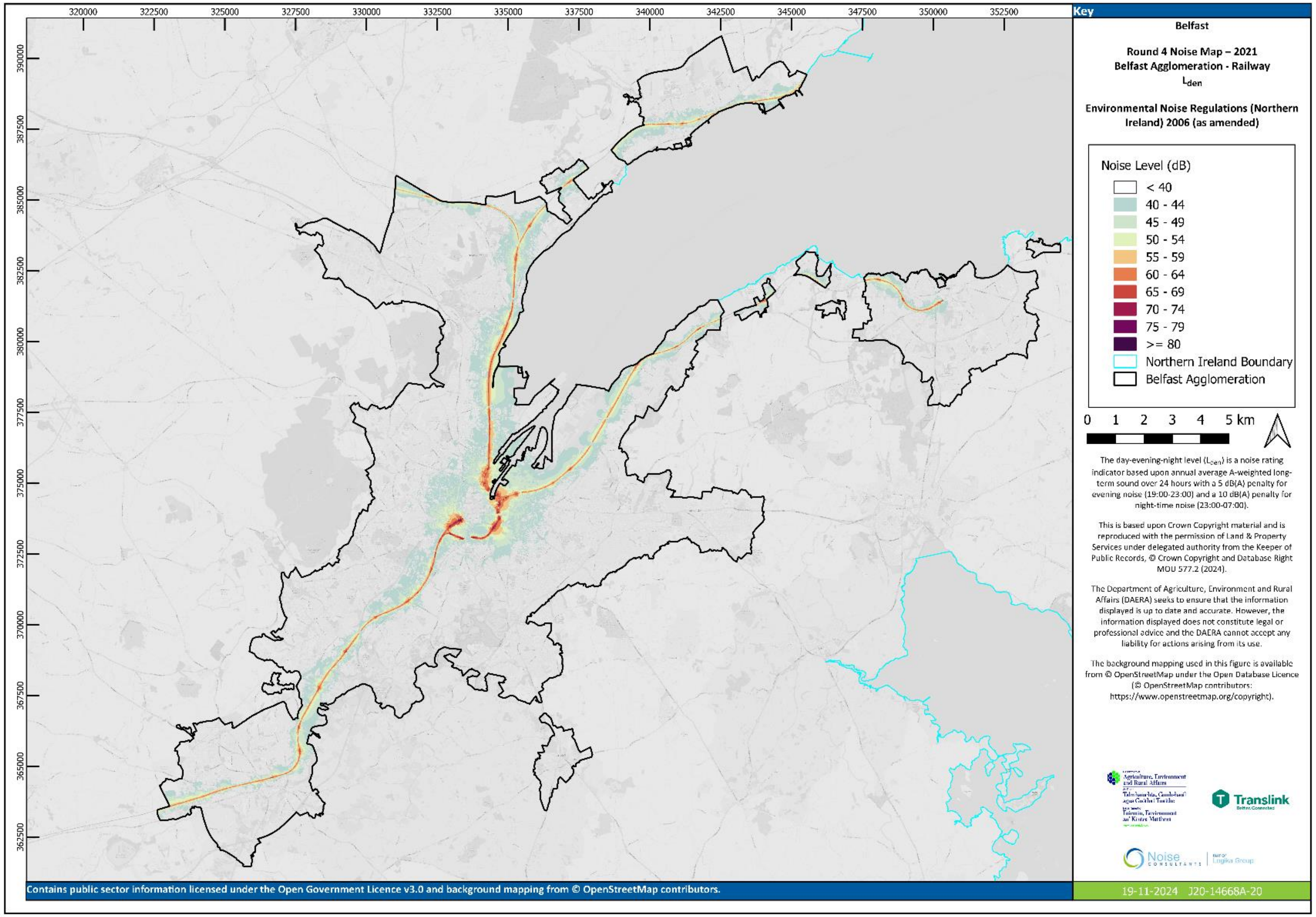


Figure A3.2: Belfast Agglomeration – Railway – L_{day}

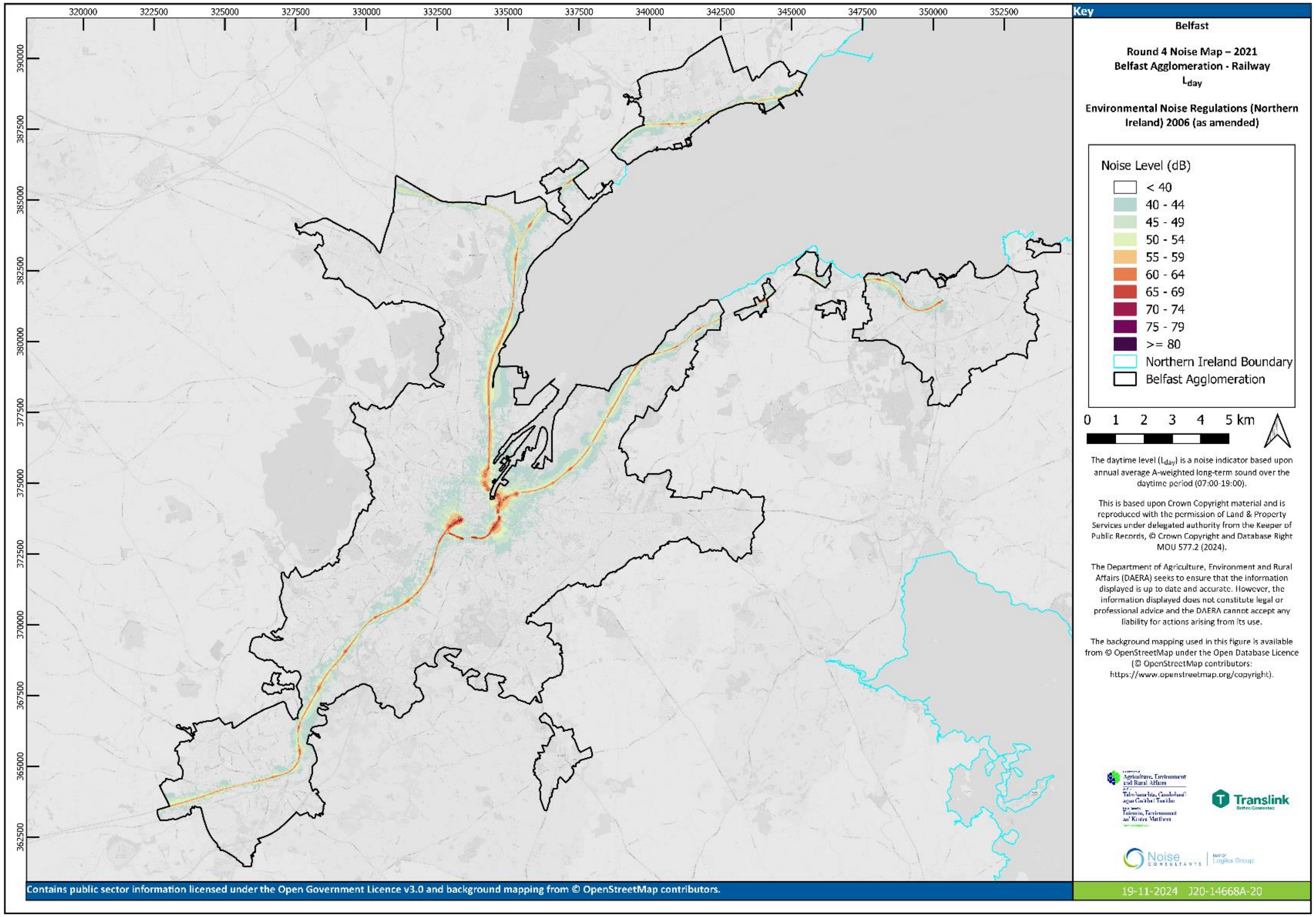


Figure A3.3: Belfast Agglomeration – Railway – L_{eve}

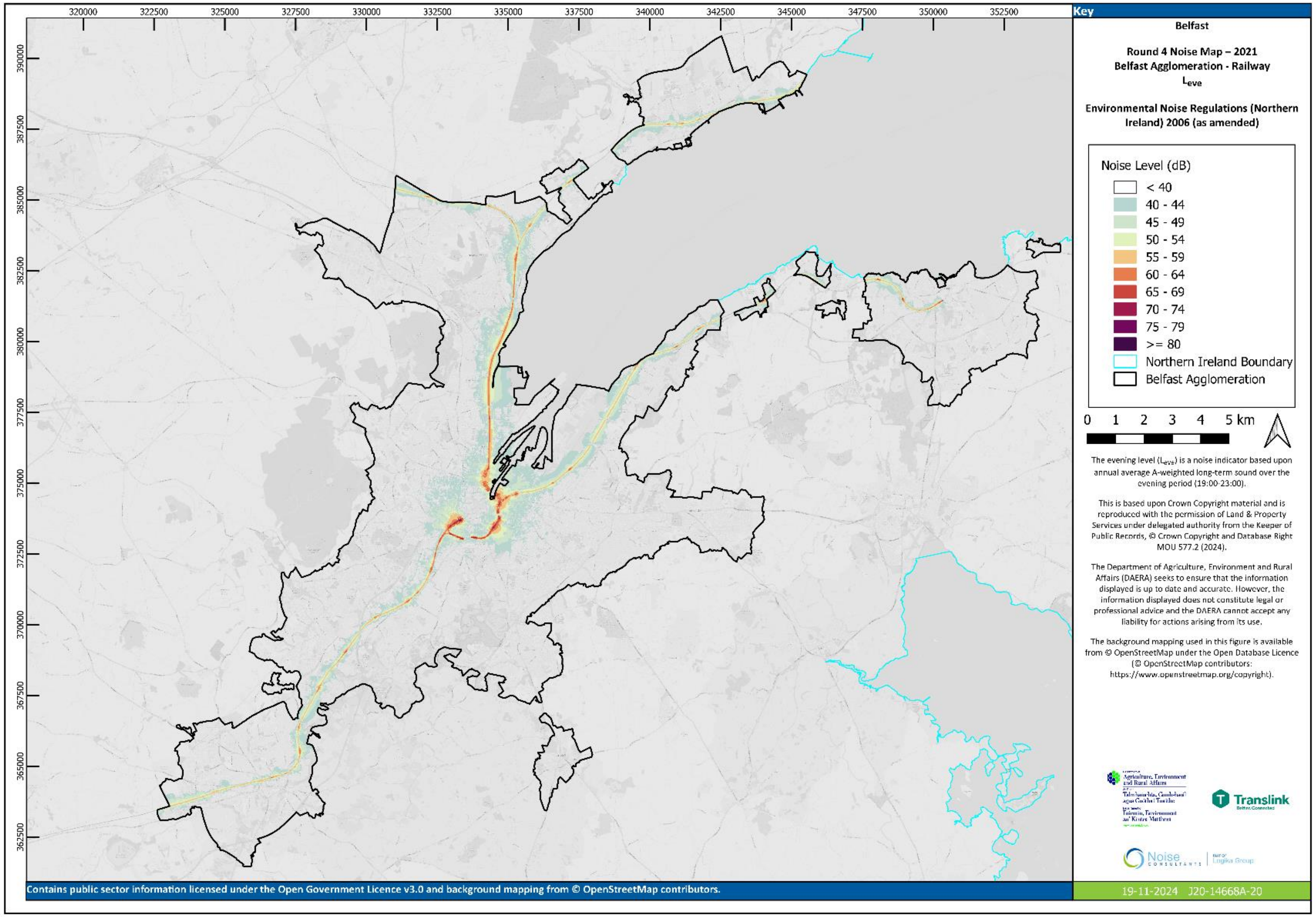


Figure A3.4: Belfast Agglomeration – Railway – L_{night}

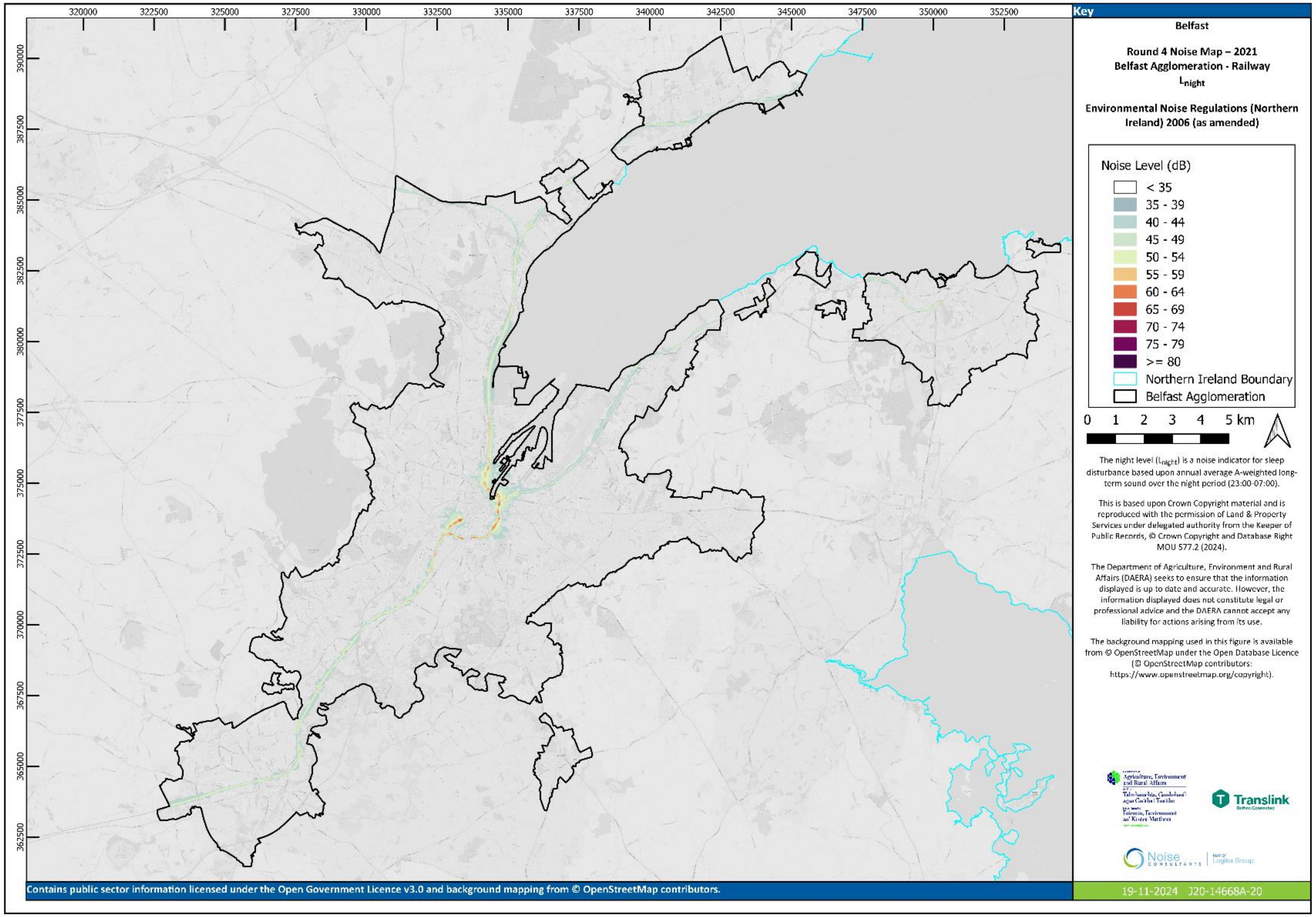


Figure A3.5: Belfast Agglomeration – Railway – $L_{Aeq,16h}$

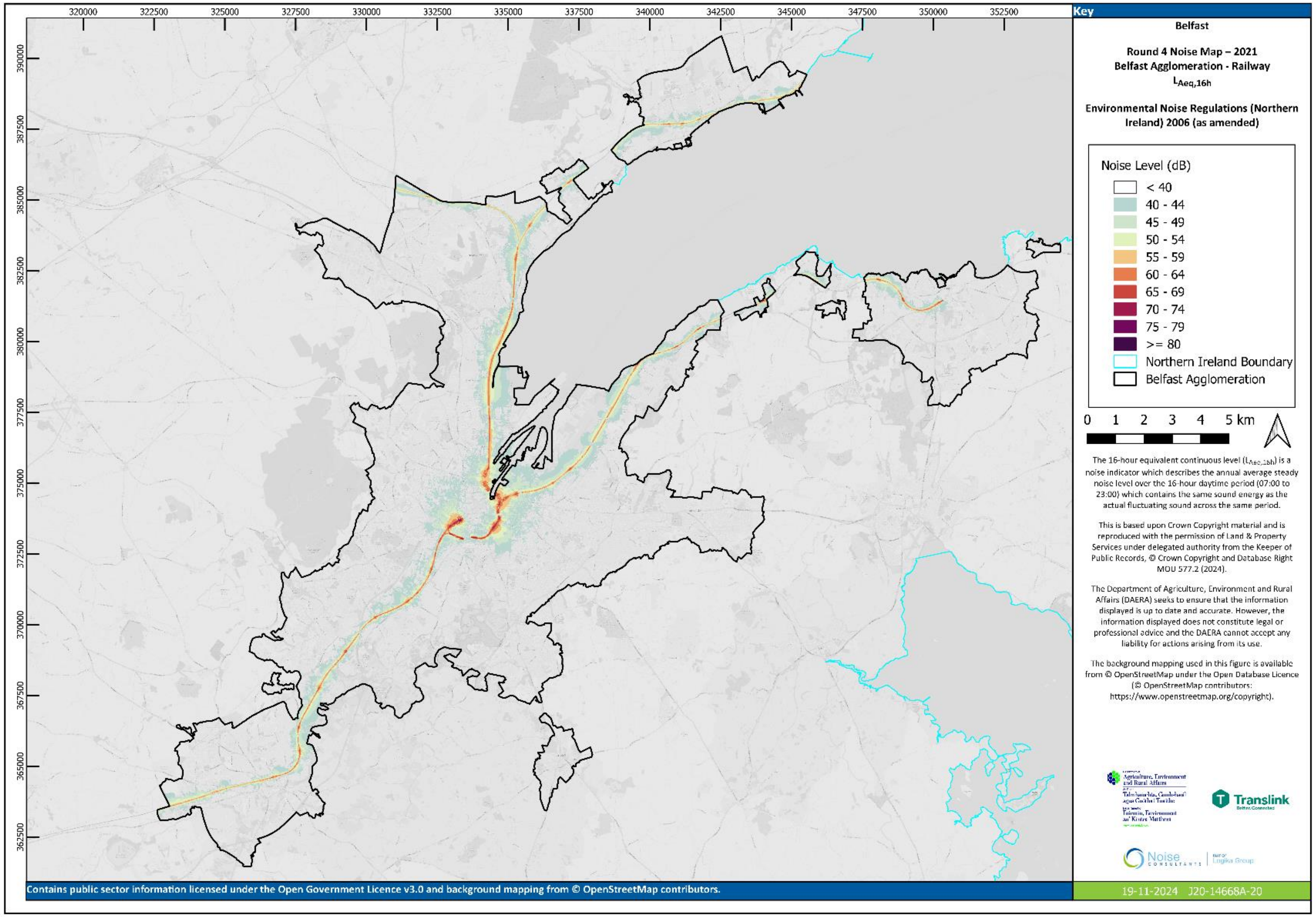


Figure A3.6: Belfast Agglomeration – Railway – $L_{Aeq,18h}$

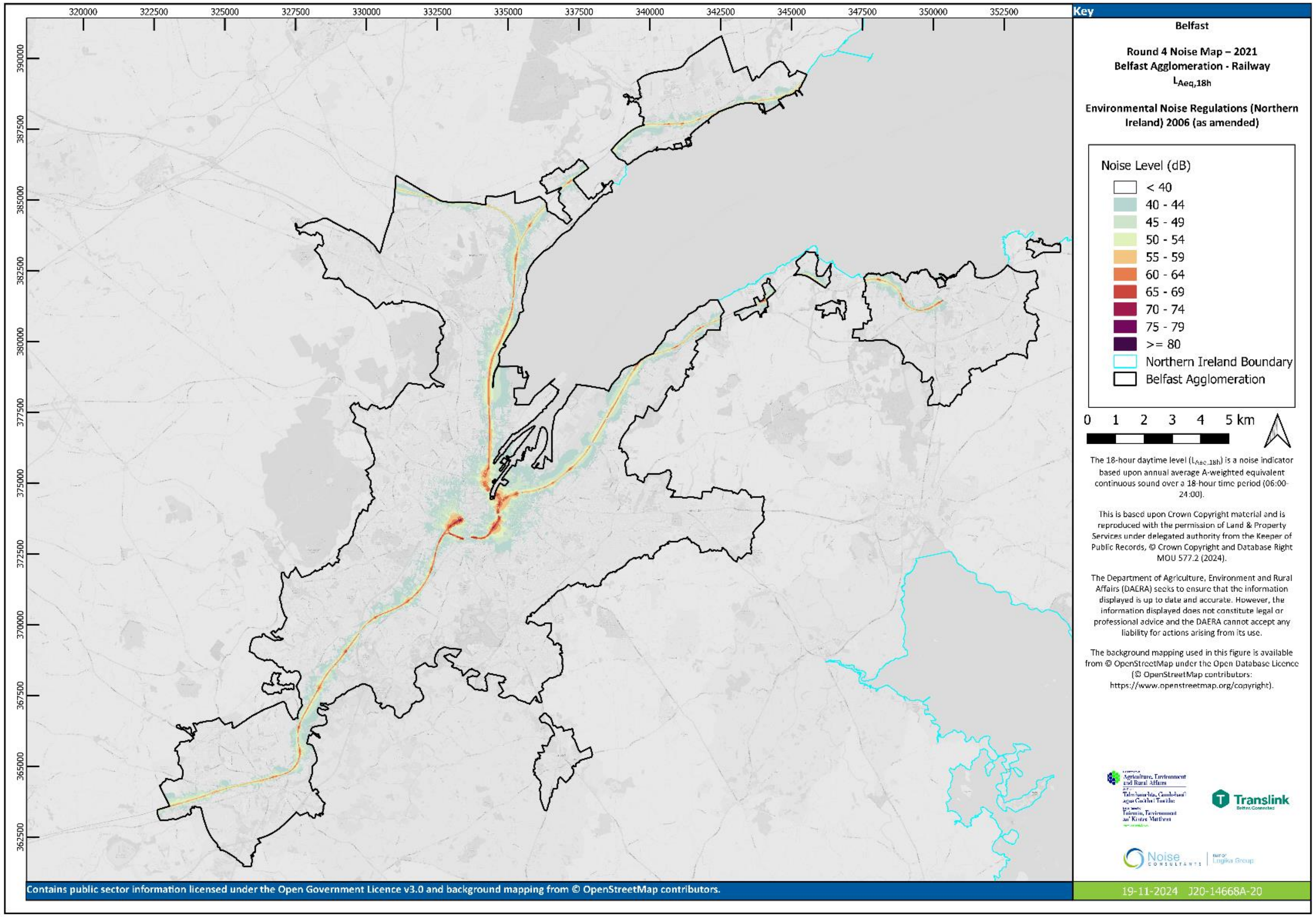
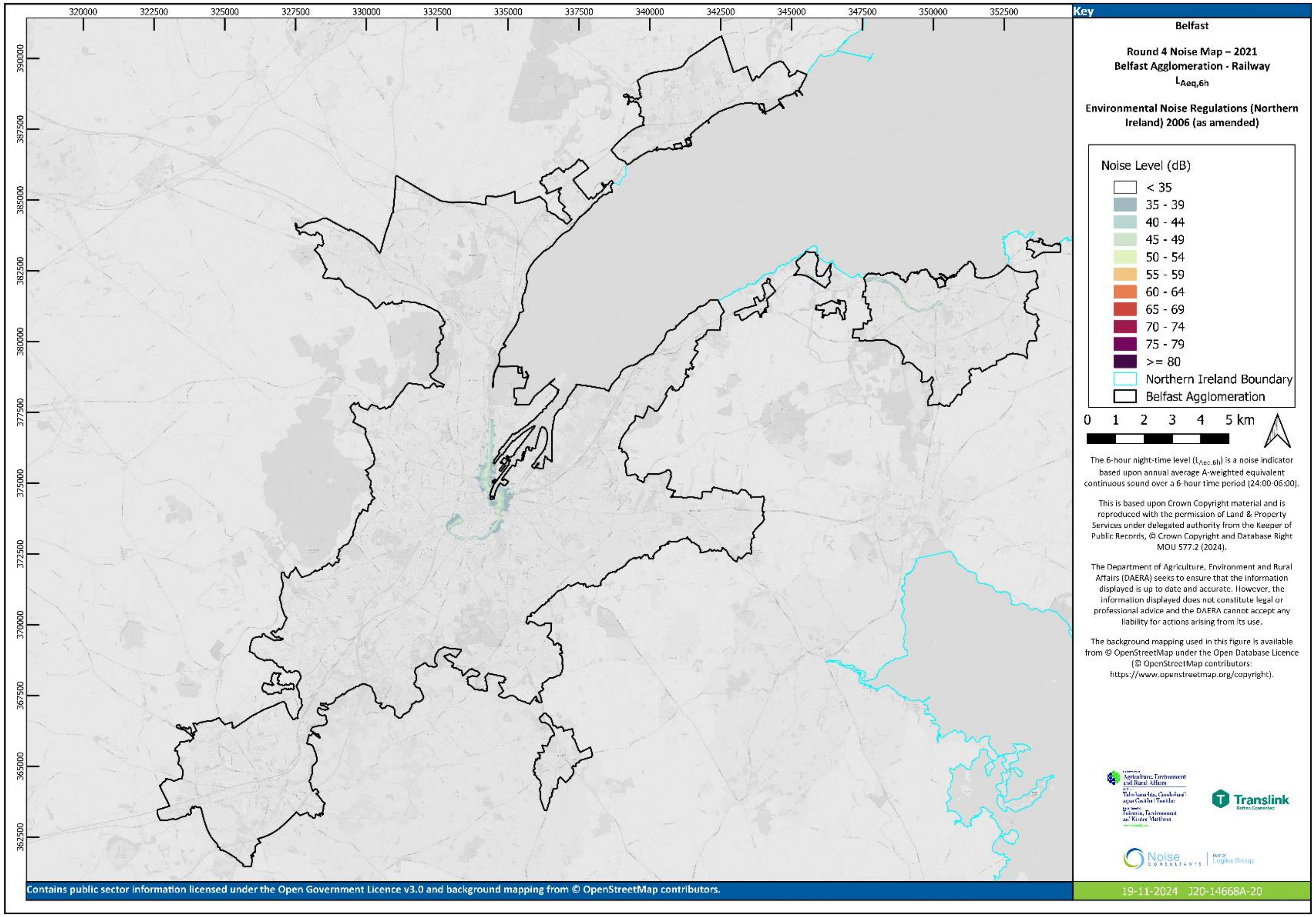


Figure A3.7: Belfast Agglomeration – Railway – $L_{Aeq,6h}$



A3.2 Northern Ireland National Figures – Major Sources

Figure A3.8: Northern Ireland – Major Railway – L_{den}

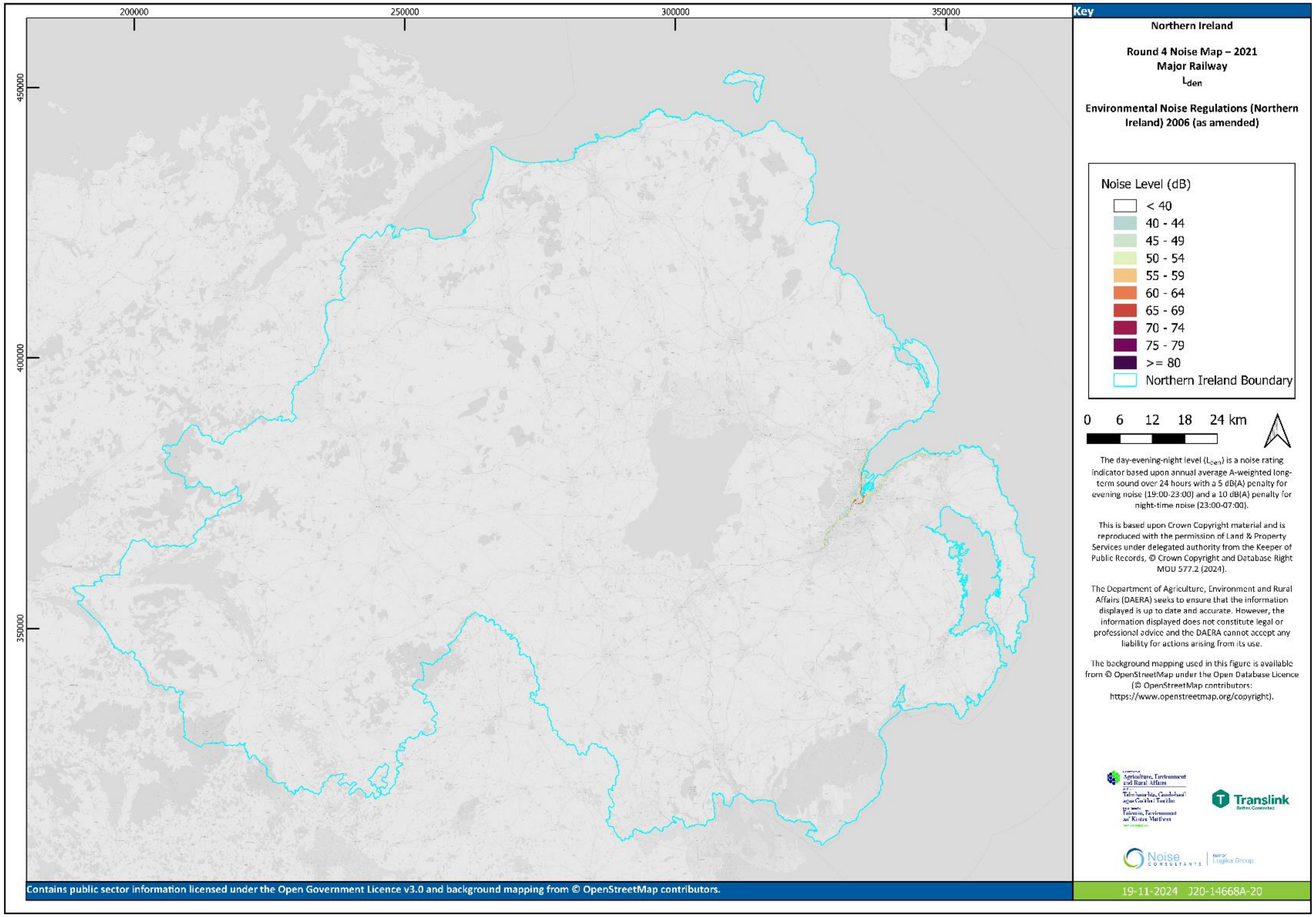


Figure A3.9: Northern Ireland – Major Railway – L_{day}

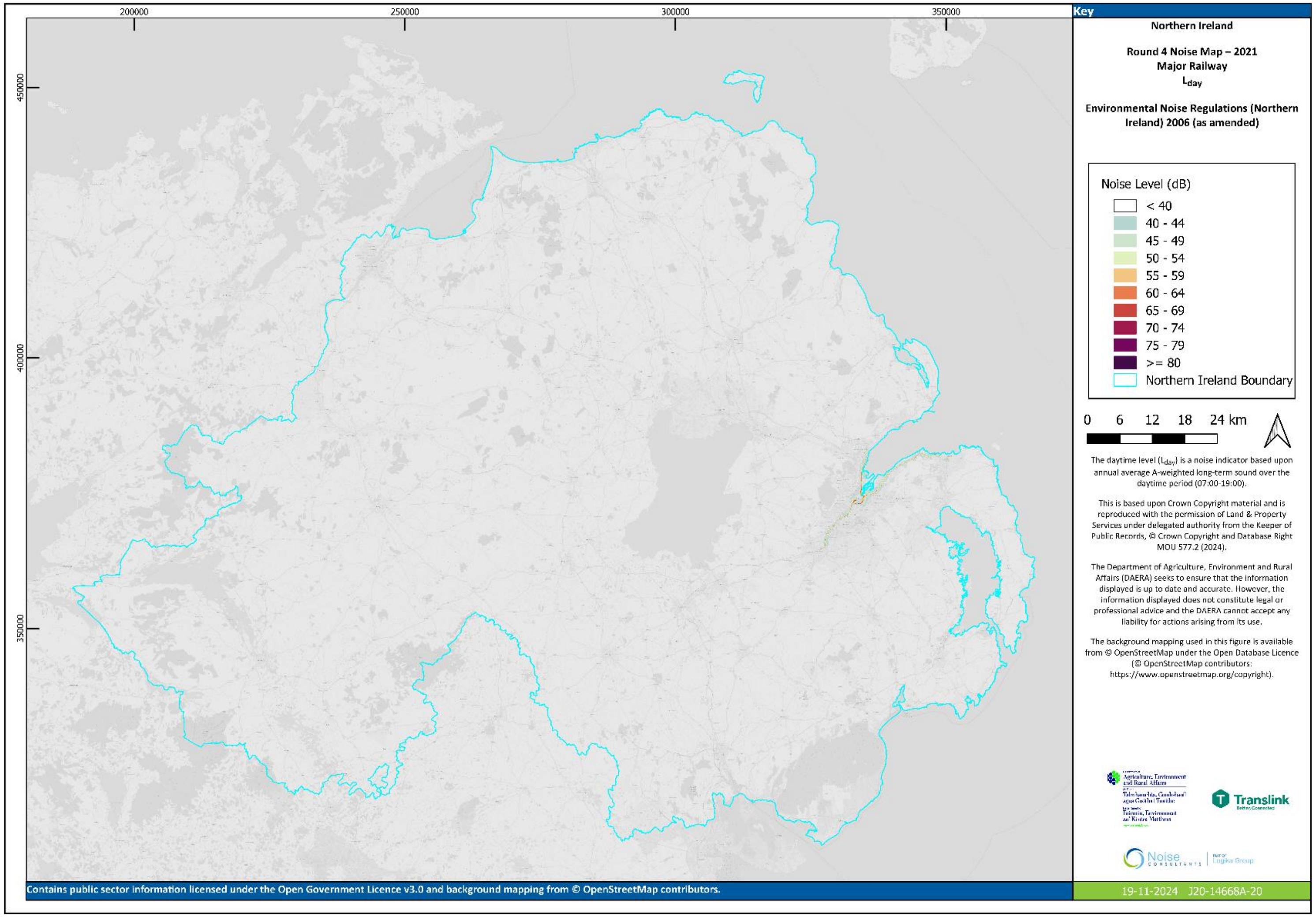


Figure A3.10: Northern Ireland – Major Railway – L_{eve}

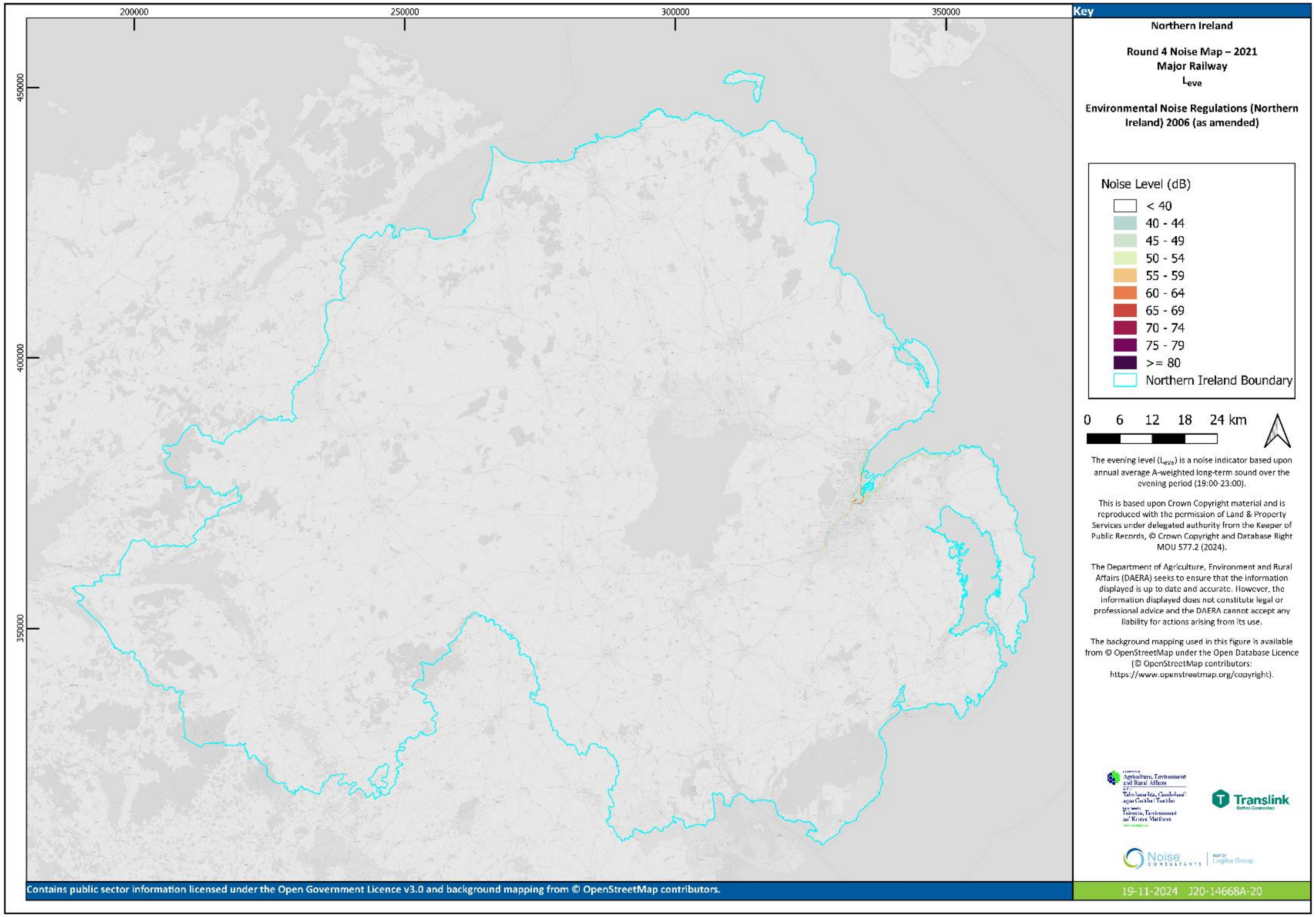


Figure A3.11: Northern Ireland – Major Railway – L_{night}

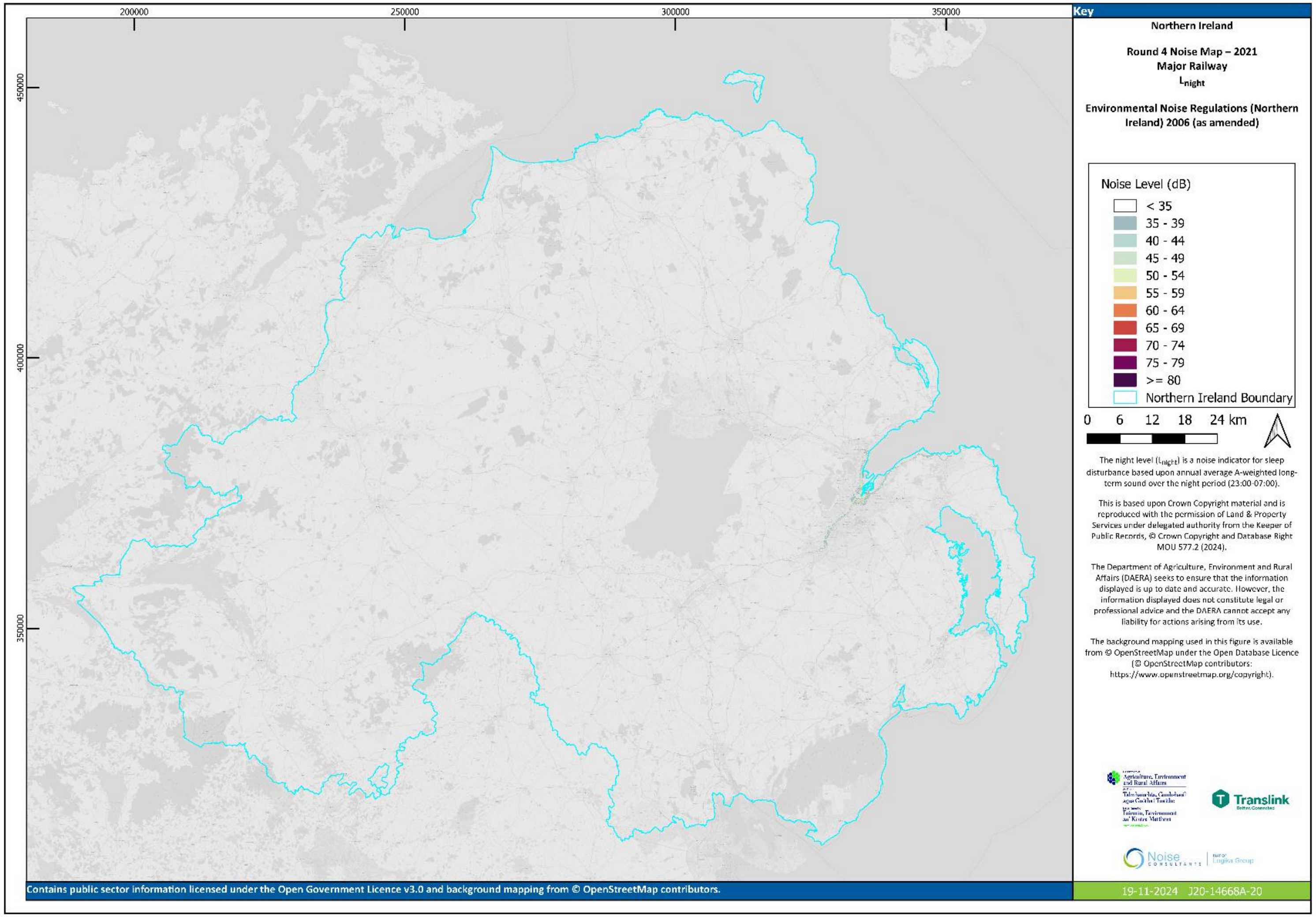


Figure A3.12: Northern Ireland – Major Railway – $L_{Aeq,16h}$

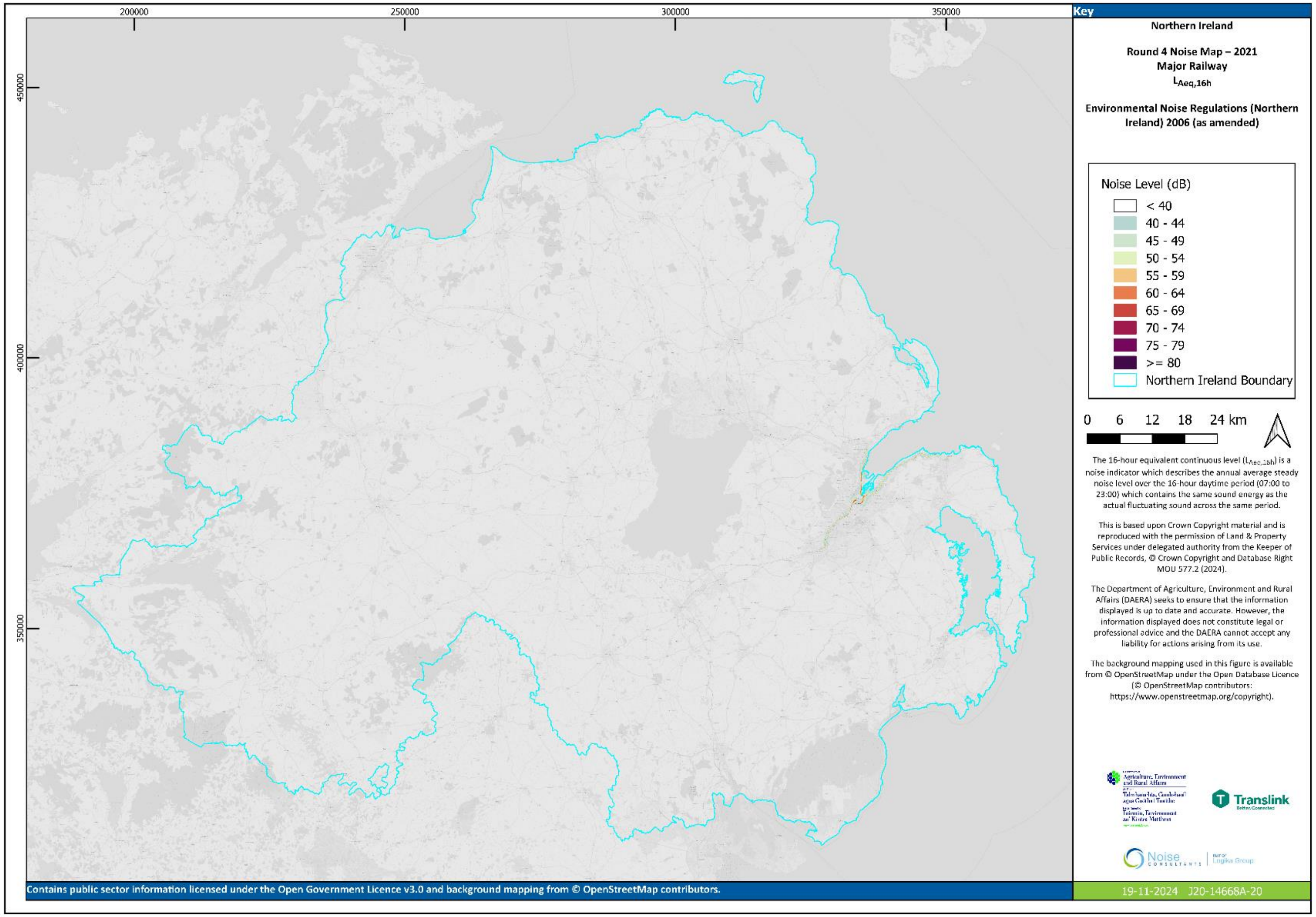


Figure A3.13: Northern Ireland – Major Railway – $L_{Aeq,18h}$

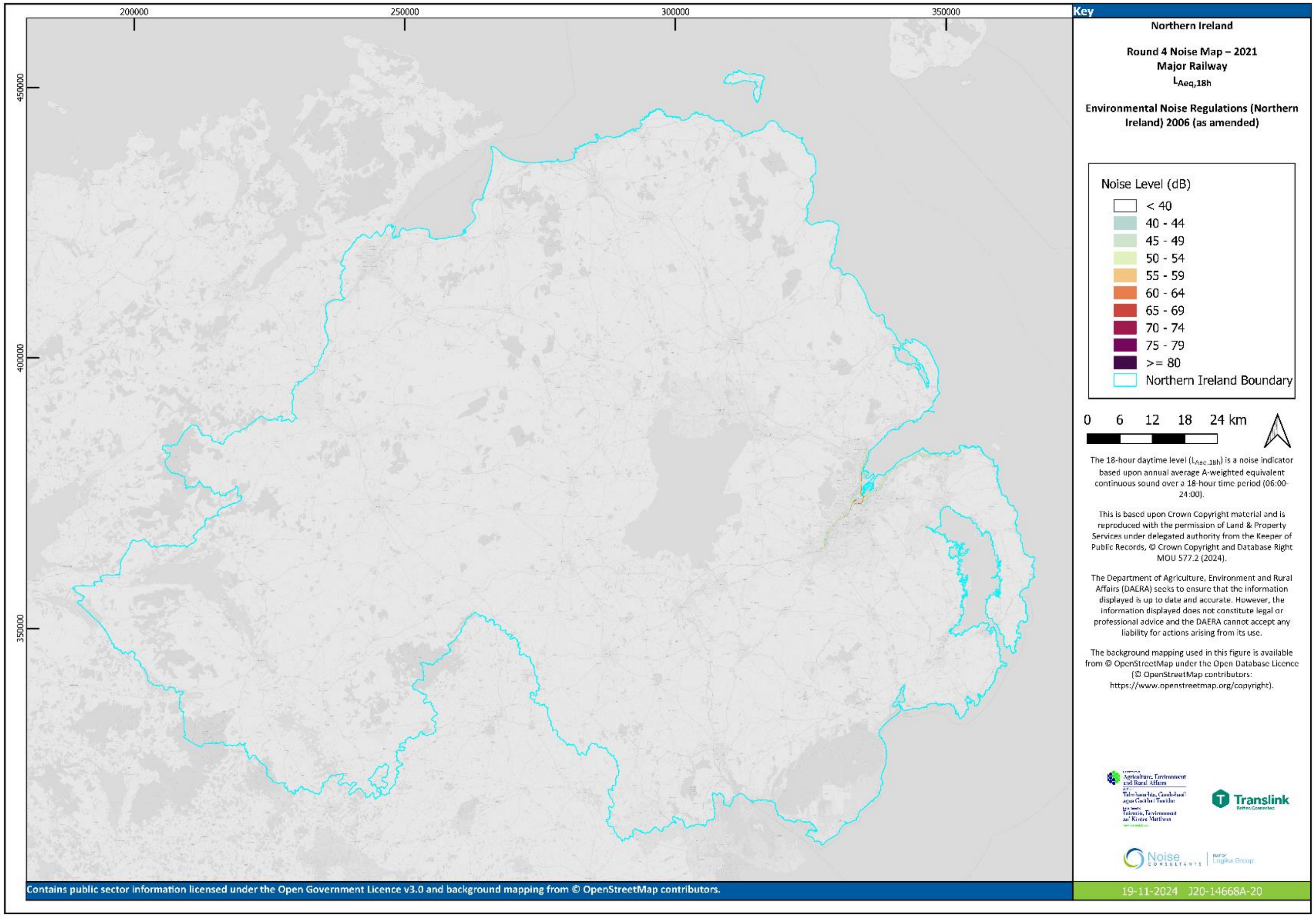
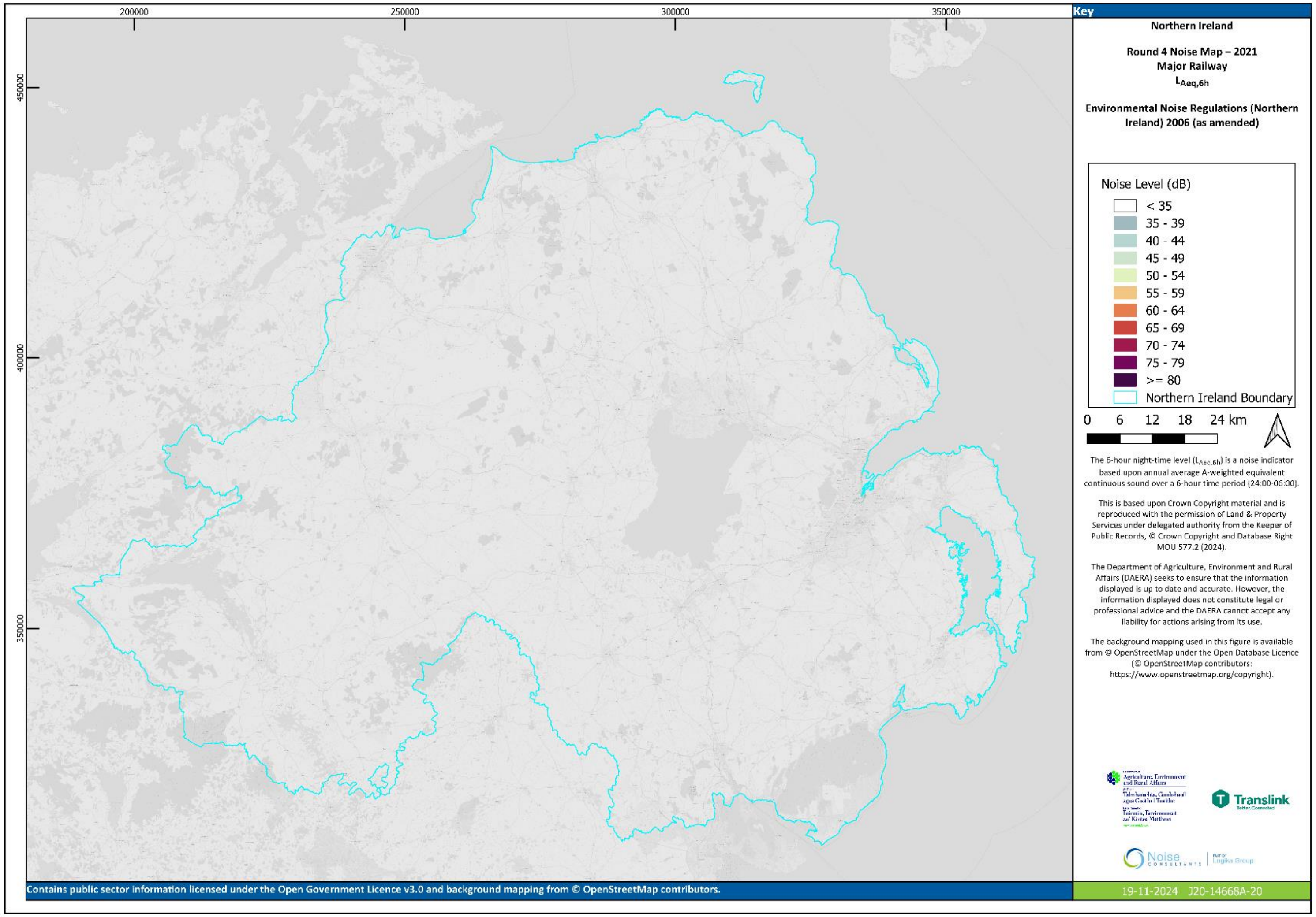


Figure A3.14: Northern Ireland – Major Railway – $L_{Aeq,6h}$



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