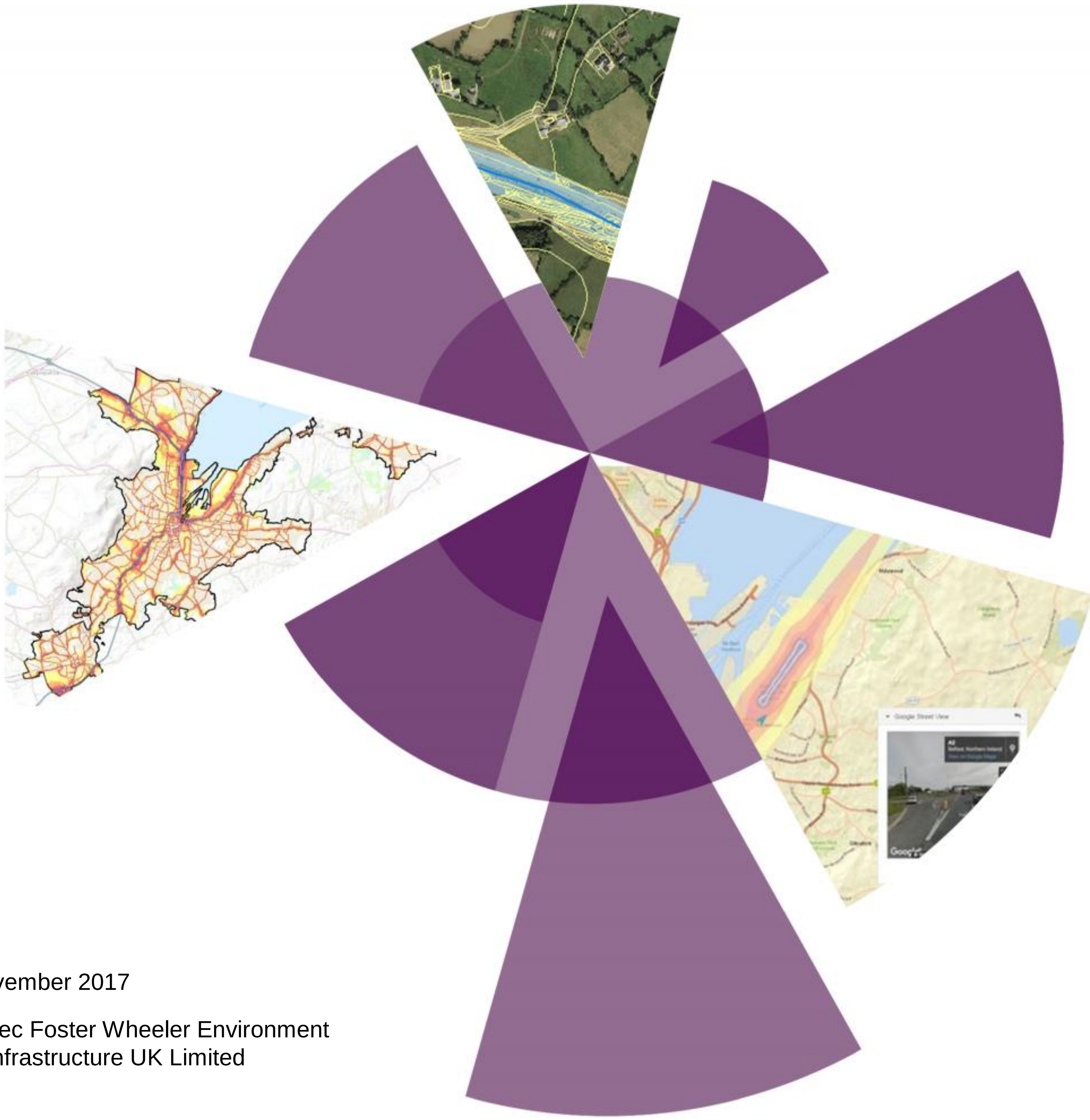
Department of Agriculture, Environment and Rural Affairs – Northern Ireland

Noise Mapping and Action Planning Contract Round 3 - 2016/2017

Belfast International Airport Modelling Report - Final



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Executive summary

This document outlines the processes that have been adopted to develop the airport noise model for Belfast International Airport (BIA) as used within Round Three of noise mapping within Northern Ireland under the Environmental Noise Regulations (Northern Ireland) 2006. The results of the noise mapping process are also presented.

This document aims to give the Northern Ireland Department of Agriculture, Environment and Affairs (DAERA) and BIA an understanding of the model development process including data capturing and processing, development of the noise model and related QA procedures.

The report begins with introducing the requirements of the mapping exercise (**Section 1**) and outlining the extents of the Round Three data capture areas (**Section 2**). This provides the setting for the specific calculation methods used to develop the Round Three airport noise model for BIA (**Section 3**) and the data needed to develop the final noise maps (**Section 4**).

The report also outlines the methods used to develop the aircraft noise model (**Section 5**). This includes confirming airfield definitions; average meteorological conditions; route definitions; ground terrain around the airport; and reviewing 2011 air traffic movements and runway modal splits. This section also outlines the automated and manual checks that were completed to ensure that the final datasets are both ‘fit for purpose’ and optimised for the final modelling exercise.

The penultimate sections of the report (**Section 6-8**) detail the final calculation outputs of the updated INM model and preliminary results of the Round Three noise exposure analysis for BIA. This includes providing area analysis of the different noise levels with the more detailed analysis of population and dwelling noise exposure.

The final section of the report (**Section 9)** includes an assessment of the key differences between the outputs of the Round Two and Round Three noise mapping exercises. The key differences discussed include:

- A significant increase in aircraft using the easterly Runway 07 (+127%) and a decrease in aircraft using all other runways;
- An overall increase in total aircraft movements (+3%), including:
  - A large increase in total aircraft movements during the evening (+16%);
  - A minor increase in total movements during the night period (+0.1%);
  - A minor decrease in total movements during the day period (-0.6%);
  - An increase in the Scheduled/Chartered/Freight aircraft, including a 9% increase in the day period, a 22% increase in the evening period and a 3% increase in the night period;
- A change in aircraft fleet particularly:
  - An increase in the Boeing 737 family aircraft (+89%), including a significant increase in the classic Boeing 737-300 (+22%) and the introduction of the Boeing 737-400, and an increase in the newer Boeing 737-800 (+480%); and
  - A minor growth in the most prominent aircraft type, the Airbus A320 family (+3.6%), including a reduction in the A319 (-9%) and an increase in both the larger A320 (+42%) and the A321 (+150%).

The final modelled results for Round 3 have been presented in map form (see **Appendix A and B**) and indicate, like many other UK airports an overall growth in the extent of the noise contours when compared to those modelled for Round 2 and this growth reflects the increase in aircraft movements and the changes in aircraft fleet. The increased extent of noise contours is also reflected in a corresponding numbers of buildings and population exposed to different noise levels when compared with Round Two.

Contents

Glossary

Term	Definition
Agglomeration	Major Continuous Urban Area as set out within the Regulations
Amec Foster Wheeler	Amec Foster Wheeler 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
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
DAERA	Department for Agriculture, Environment and Rural Affairs
DEM	Digital Elevation Model
DoE	Department of Environment
DSM	Digital Surface Model
DTM	Digital Terrain Model
DWG/DXF	Autodesk AutoCAD Drawing (DWG) or Data Exchange File (DXF) format
EC	European Commission
EEA	European Environment Agency
EIONET	EIONET is a partnership network of the European Environment Agency (EEA) and its member and cooperating countries. The network supports the collection and organisation of data and the development and dissemination of information concerning Europe's environment
END	Environmental Noise Directive (2002/49/EC)
ENDRM	Environmental Noise Directive Reporting Mechanism
ENDRM DF8	Environmental Noise Directive Reporting Mechanism Data Flow 8
ESRI	Environmental Systems Research Institute
FDMI	Final Modified Data Inputs
GIS	Geographic Information System
INM	The Integrated Noise Model

Term	Definition
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.
Land Cover Map 2015 / LCM2015	CEH Land Cover Map 2015 depicting 22 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):
	Lden - 50 - 54, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >75
	Lday - 50 - 54, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >75
	Levening - 50 - 54, 55 – 59, 60 – 64, 65 – 69, 70 – 74, >75
	Lnight - 45 - 49, 50 – 54, 55 – 59, 60 – 64, 65 – 69, >70
Noise Levels	Free-field values of L_{den} Ld, Le, Ln, and $L_{A10,18h}$ at a height of 4m above local ground level
Noise Level - Lday - Daytime	Ld (or Lday) = LAeq,12h(07:00 to 19:00)
Noise Level - Levening - Evening	Le (or Levening) = LAeq,4h(19:00 to 23:00)
Noise Level - Ln - Night	Ln (or Lnight) = LAeq,8h(23:00 to 07:00)
Noise Level - Lden – Day/Evening/Night	A noise rating indicator based upon Ld. Le and Ln as follows: Lden = 10 * lg 1/24 {12 * 10^((Lday)/10) + 4 * 10^((Levening+5)/10) + 8 * 10^((Lnight+10)/10)}
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
Round Three	Round Three 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
TransportNI	TransportNI is a business unit within the Department for Infrastructure, (formerly Department for Regional Development), playing a significant role in facilitating the safe and convenient movement of people and goods throughout the province and the safety of road users, through the delivery of road maintenance services and the management and development of the transport network. It also informs the Department's policy development process to ensure that measures to encourage safe and sustainable travel are practical and can be delivered.
WG - AEN	Working Group – Assessment of Exposure to Noise

1. Introduction

In accordance with Regulation 30 of the Environmental Noise Regulations (Northern Ireland) 2006, as amended ("the Regulations"), Belfast International Airport ("BIA") is required to produce maps of the noise levels arising from aircraft departing from and arriving at the airport.

The Regulations transpose Directive 2002/49/EC into UK law. Amongst the requirements of the Environmental Noise Directive (END) is the need for 'major' airports to produce noise action plans based upon the results of noise mapping every 5 years. This report presents the methodology used to produce the noise maps for BIA for Round 3 of the noise mapping process.

1.1 EU Directive 2002/49/EC

The EU Directive 2002/49/EC on the management and assessment of environmental noise, commonly referred to as the END, has provided a driving force behind noise mapping and noise action planning within the European Community.

The aim of the END is to provide a common approach across the European Union to avoid, prevent and reduce on a prioritised basis the harmful effects of exposure to environmental noise from transportation and industrial sources. The Directive imposes a requirement on Member States to:

- Inform the public about environmental noise and its effects;
- Produce strategic noise maps for the following areas:
  - Agglomerations;
  - Major roads;
  - Major railways;
  - Major airports; and
- Produce noise action plans (based on the results of noise mapping) to manage and reduce environmental noise where necessary and to preserve environmental noise quality where it is good.

The qualification of such sources and agglomerations are summarised in **Table 1.1**. The table highlights the differing requirements of the first and subsequent rounds of mapping and action planning.

Table 1.1 Thresholds stipulated by the END directive

	First Round Threshold	Thresholds for Subsequent Rounds of Mapping
Major Roads	≥ 6 million vehicles / year	≥ 6 million vehicles / year; and ≥ 3 million vehicles / year and < 6 million vehicles / year
Major Railways	≥ 60,000 trains / year	≥ 60,000 trains / year; and ≥ 30,000 trains / year and < 60,000 trains / year
Major Airports	≥ 50,000 movements / year	≥ 50,000 movements / year
Agglomerations[1]	≥ 250,000 inhabitants	≥ 250,000 inhabitants; and ≥ 100,000 and < 250,000 inhabitants

[1] For agglomerations all sources of transportation (including airports) and industry within the agglomerations are to be considered

END Reporting Requirements

Under the END, it is the responsibility of Member States to report information from the strategic noise maps and summaries of the action plans to the European Commission. Following submission, the Commission collates all information and uses it to support the publication of information for the public. This reporting process is achieved through the Environmental Noise Directive Report Mechanism (ENDRM), which is managed by the European Environment Agency (EEA).

END Reporting Programme

The END stipulates that the noise mapping and action planning process be taken forward on a five-yearly rolling programme. In keeping with the cycle set by the END, the third round of noise mapping and action planning is now required.

The thresholds set by the END will remain unchanged between this coming third round and the previous second round. This means that the majority of the sources and agglomerations considered in the Second Round will need to be reconsidered for the Third Round. Any new agglomerations or major sources of noise may need to be mapped if these have relocated or have increased to beyond the thresholds,

1.2 Implementation in Northern Ireland

The Environmental Noise Regulations (Northern Ireland) 2006 (“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 (“the Directive”).

The Regulations also set out the Competent Authorities who have been made responsible for producing noise maps and action plans. These authorities are:

- Road noise – Department of Infrastructure;
- Railway noise – Translink;
- George Best Belfast City Airport noise - George Best Belfast City Airport;
- Belfast International Airport noise - Belfast International Airport; and
- Industrial noise – Northern Ireland DAERA.

The regulations also identify the Department of Agriculture, Environment and Rural Affairs (DAERA) (formerly the Department of Environment (DoE)) as the named Authority responsible for overseeing the implementation of the Regulations. This role includes active engagement with the individual competent authorities and the management of this contract on behalf of the Competent Authorities.

Amec Foster Wheeler’s approach recognises the important role both the DAERA and competent authorities play in the development and delivery of the updated maps and new END noise action plans.

1.3 Requirement for Belfast International Airport

The Regulations require Round 3 noise maps to be produced for 2016’s annual aircraft movements for the following metrics and showing noise levels down to 50 dB(A) for L_{den} and down to 45 dB(A) for L_{night}. The noise maps are required to be produced on 10 metre by 10 metre grids, with the results aligned to 10 metre vertices of the Irish National Grid reference system.

- $L_{Aeq,16h}$ (0700hrs to 2300hrs);
- L_{day} (0700hrs to 1900hrs);
- $L_{evening}$ (1900hrs to 2300hrs);
- L_{night} (2300hrs to 0700hrs) and

- L_{den} (24-hours).

2. Purpose of this report

In September 2016, Amec Foster Wheeler was commissioned to prepare noise maps for the Component Authorities reporting directly to DAERA. As part of the commission, Amec Foster Wheeler 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. The following document is one of seven report deliverables produced for DAERA.

The key purpose of this report is to detail the processes used to develop the Round Three airport noise model for BIA. The aim of this report is to provide BIA and DAERA with an understanding of the processes involved in the development of the noise model and the datasets that have used to support the assessment of noise for the second round of mapping. The results of the mapping are also presented.

The Round 3 mapping contract was delivered in two stages. Stage 1 was undertaken to the following scope:

- Review of the necessary Competent Authority data to ensure completeness (including a data Quality Assurance);
- Appraisal of data provided by DAERA (and other stakeholders) with gaps identified with Quality Assuring of the data.
- 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.

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

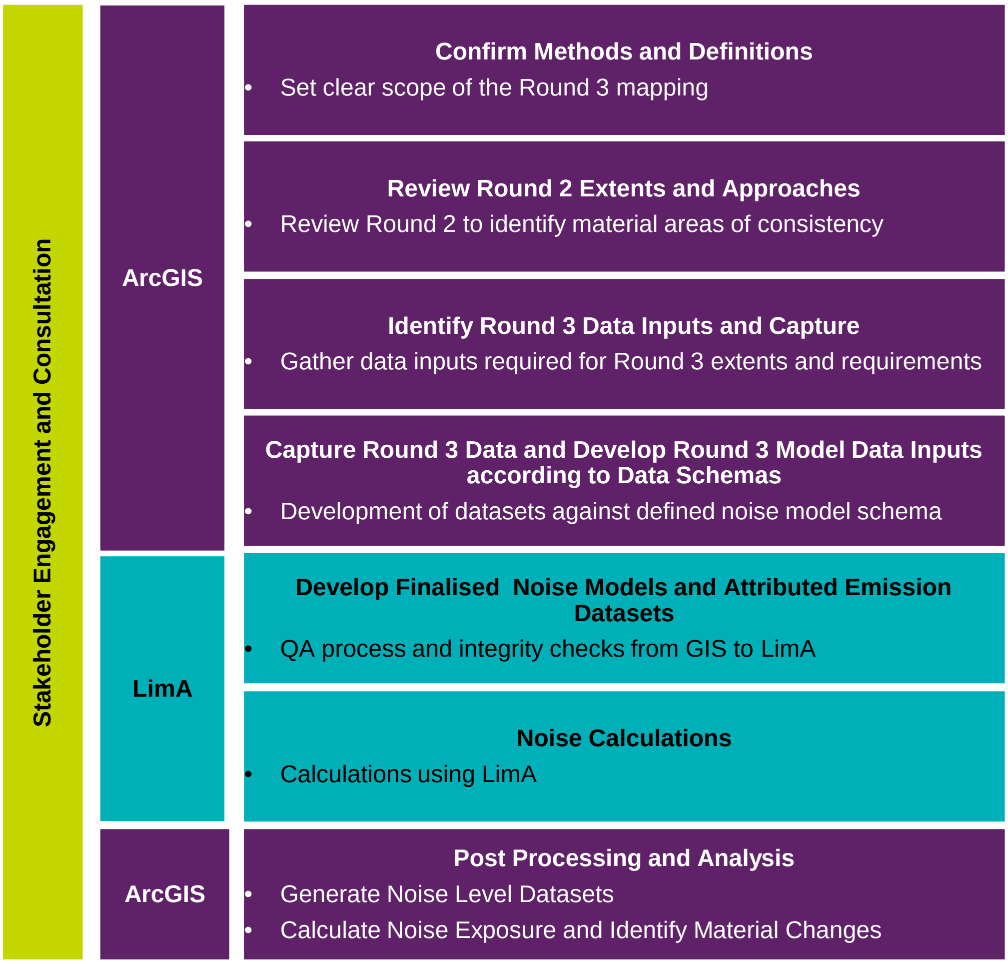
- Descriptions of the processes and approaches adopted for the collection, collation, validation, verification, integration and creation of the noise model;
- Description of the datasets to be generated;
- Detailed description of the noise modelling methodology to be applied to each noise source;
- Acceptable 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.

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

The key stages of the process are summarised in **Plate 2.1.**

Plate 2.1 Generalised approach to R3 mapping



3. Choice of Noise Model

For Round 3, the noise modelling was undertaken using the US Federal Aviation Administration's (FAA) Integrated Noise Model (INM) version 7.0d. It should be noted that for Round 2, INM v.7b was used. However, both v7.0d and 7.0b are derived from the same methodology prescribed in ECAC.CEAC Doc 29[1] (2005). The main change between v7.0b and version v.7.0d are database modifications to the noise-power-distance (NPD) curves for some aircraft and the addition of newer aircraft types.

Airports in the UK generally use one of two noise models to calculate air noise; ANCON, developed and maintained by the UK Civil Aviation Authority (CAA) or INM. There are significant similarities between the INM and ANCON models in terms of their calculation methodologies. Both models are based on the same guidance material produced by the International Civil Aviation Organization, (ICAO), European Civil Aviation Conference (ECAC) and Society of Automotive Engineers (SAE), namely SAE-AIR-1845 (1986)[2] and ECAC Doc.29 (2016). SAE-AIR-1845 describes the methodology used by aircraft noise modelling software for calculating sound exposure levels from aircraft and ECAC Doc. provides guidance on aircraft noise modelling, and is consistent with the methodology presented in SAE-AIR-1845.

In simple terms, both noise models work by using the characteristics and routes of the airport in question, together with information on the numbers and types of aircraft that will use the airport to calculate noise levels at points on a grid surrounding the airport. The grid of noise results is then used to plot noise contours that identify locations of equivalent noise exposure.

The relative merits of ANCON and INM have been the subject of much debate within the acoustics and aviation communities. The INM software is commercially available from the FAA, and has been used extensively in Australia, Belgium, Greece, Hong Kong, Spain and the USA, as well as in the UK. ANCON has been used at some UK airports, including Gatwick, Heathrow and Stansted, however it is not commercially available and, as such, any modelling undertaken using ANCON must be undertaken by the CAA.

The main differences in noise contours produced using INM and ANCON are due to two factors: the treatment of flight profile data and noise-power-distance data. Flight profile data within ANCON is taken from measurements made at London airports and flight tracking information. INM on the other hand often relies on data to be manually input into the model. In addition, the models have different handling of take-off power and thrust/flap management assumptions. In terms of the noise-power-distance data, INM is based on manufacturer's data whereas ANCON is based on measurements taken at London airports, measurements that contain meteorological variations.

It has been reported by the Environmental Research and Consultancy Department (ERCD) that the "*overall potential difference in contour area can be in the order of 20-30%*" (Jopson et al)[14] between the ANCON version 2 and INM version 6 models. This however is highly dependent upon the settings used within each of the models. ERCD have therefore made recommendations regarding the use of INM in the CAA document CAP 725. Whilst acknowledging the potential differences between INM and ANCON contours, ERCD have stated that they do consider INM as *"suitable for relative assessment – that is, comparing options or assessing the situation before and after a change has been implemented"* (4ER/3/39)[16].

[1] ECAC Doc.29 4th Edition, 2016
[2] SAE-AIR-1845 Procedure for the Calculation of Airplane, Noise in the Vicinity of Airports, 1986

4. Noise Modelling

As discussed in **Section 3,** noise modelling was undertaken using INM v.7d and the development of an INM noise model requires several key data inputs. These key data inputs can be split into five broad categories:

- Airport Layout;
- Average Meteorological Conditions;
- Terrain.
- Aircraft flight paths;
- Aircraft Movement data; and

4.1 Airport Layout

The airport layout refers to the INM definitions used for the airport infrastructure, including the modelled airport centre point and the runway geometry. The airport layout is an important factor for the model as it defines the locations that aircraft noise emissions occur.

After comparing the Round 2 model with most recent airfield layout as presented on the aerodrome plan and found in the AIP[3] it was apparent that there had been no changes to the airport layout and hence the Round 2 model airport layout was retained. **Table 4.1** presents the model settings used for the airport layout.

Table 4.1 Airfield Layout Model Settings

Location	Latitude	Longitude	Elevation (AMSL)	Runway Width	Glide slope	Displaced Approach Threshold	Displaced Departure Threshold	Threshold Crossing Height
Airport Centre	54.657520°	-6.215710°	81.6 m	N/A	N/A	0 m	0 m	15.2 m
Runway 07 End	54.652260°	-6.235239°	81.5 m	45 m	3°	0 m	0 m	15.2 m
Runway 25 End	54.662781°	-6.196176°	81.7 m	45 m	3°	0 m	0 m	15.2 m
Runway 17 End	54.657918°	-6.228617°	62.8 m	45 m	3°	0 m	0 m	15.2 m
Runway 35 End	54.641780°	-6.219532°	78.6 m	45 m	3°	90 m	90m	15.2 m

4.2 Average Meteorological Conditions

Meteorological conditions can influence the propagation of sound and therefore to model representative noise levels for the relevant END periods, ambient weather conditions for the period are required. BIA has several weather stations on site and the data from the airport's Bravo monitoring station (id = 687) has been used to inform the model. The Bravo monitoring station measures the following parameters:

- Ambient air temperature (in °C);
- Relative humidity (as %); and

[3] www.nats-uk.ead-it.com/public/index.php%3Foption=com_content&task=blogcategory&id=18&Itemid=73.html

- Wind speed (in m/s) and wind direction (as bearing).

The data provided by BIA was converted to the relevant INM settings and summarised for each relevant period modelled. A summary of the model settings applied to the INM model are shown in **Table 4.2.** It should be noted that no data was supplied for ambient air pressure and therefore the INM default setting was utilised.

Table 4.2 Modelled Meteorological Conditions

Meteorological Parameters	Unit	LAeq,16hr (92-day)	LAeq, 16hr (365-day)	Lday	Lden	Leve	Lnight
Airport Temperature	Degrees Celsius (°C)	16	11	11	10	9	9
Pressure	mmHg	759.97	759.97	759.97	759.97	759.97	759.97
Humidity	%	79	82	81	84	85	88
Headwind	kmh^{-1}	11.5	11.7	12.2	11.0	10.1	9.7

4.3 Terrain

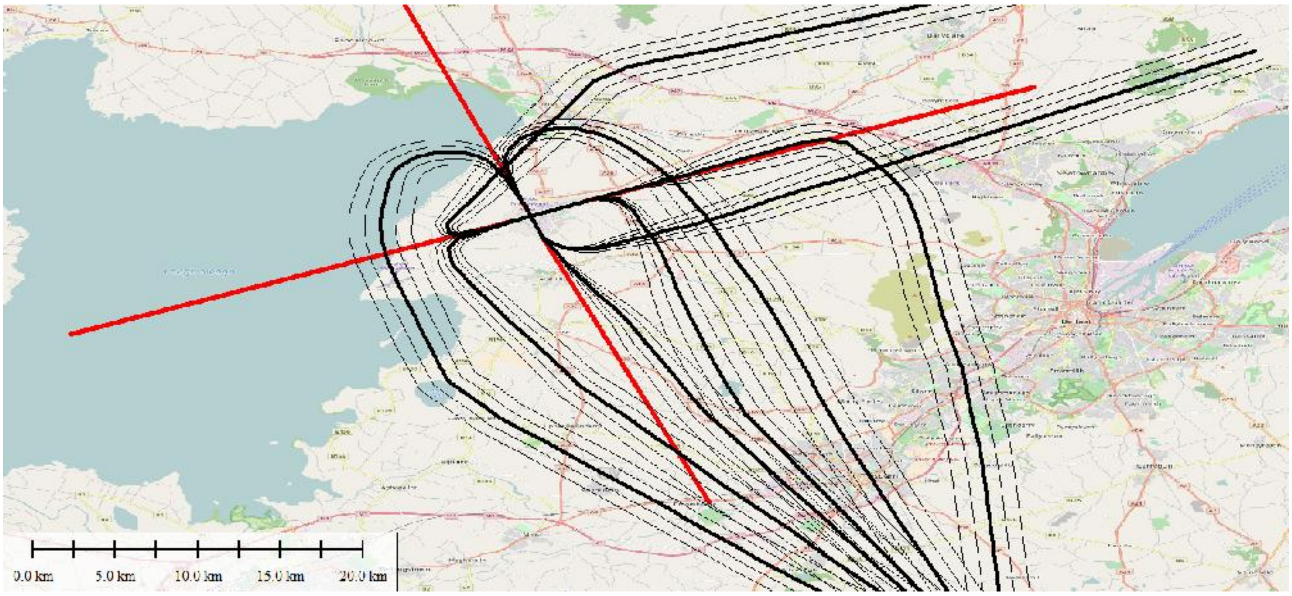
The surrounding terrain can influence propagation of sound, particularly where the landform can produce reflections and shielding. For BIA, terrain data has been obtained from the OSNI 10m DTM product provided under licence for this contract and converted into the relevant file type for INM (i.e. ESRI Grid Float contours). The terrain used for the INM model is shown in **Plate 4.1**.

Plate 4.1 Terrain

4.4 Aircraft Flight Paths

The aircraft flight paths define the ground tracks taken by aircraft in the INM model and hence locations of noise emissions from aircraft in flight. BIA does not have a noise and track keeping system and therefore no radar data is available. Therefore, to inform the aircraft flight paths utilised in Round Three those used for Round One and Round Two were retained. The INM flight paths used are presented in **Plate 4.1** and show the arrival tracks in red and the departure central tracks in bold black. Furthermore, because departures are typically dispersed laterally a 'dispersed' track was used in INM and these are shown by a narrow black line.

Plate 4.2 INM Flight Paths



Departure Routes

The Round Three INM tracks are identical to those used for Round One and these were digitised using annotated aeronautical charts provided by BIA at a meeting. These aeronautical charts were then geo-rectified within a GIS system. Further information provided by BIA during Round One was used to facilitate the modelling of departure by routing and this information is summarised in **Table 4.3**.

Table 4.3 Departure Route Information

Runway	Departure Route	Description
Runway 25	1	North headed flights to Scotland turn right after 2nmi at a height of around 1000-2000 ft.
Runway 25	2	All other flights heading south turn left after 2nmi at a height of 1000-2000 ft.
Runway 07	1	Early turn south used around 20% of the time on Runway 07 mode by aircraft at 1.5nmi from departure.
Runway 07	2	Right turn south around 6nmi from departure used around 80% of the time on Runway 07 mode. Aircraft around 3000 ft.
Runway 17	1	Straight on departures used around 80% of the time on Runway 17
Runway 17	2	Right turn at 1nmi from departure for flight heading to Scotland
Runway 35	1	Right turn around 3nmi from departure used by around 50% of aircraft when on Runway 35 mode
Runway 35	2	Left turn around 3nmi from departure used by around 50% of aircraft when on Runway 35 mode

Lateral Dispersion

Lateral dispersion takes into consideration that not all aircraft will follow identical flight paths. This dispersion is typically a result of prevailing weather conditions and instructions from Air Traffic Control (ATC). The INM model therefore allows dispersion around a “main” route or track to be modelled. In locations where noise levels are dominated by aircraft departures, dispersion has the effect of widening the air noise contours. As discussed previously, no radar data was provided and therefore the standard INM dispersion pattern was assumed and this is presented in **Table 4.4**.

Table 4.4 Assumed Dispersion Pattern for all departure routes at BIA

Distance From Start of Roll (km)	Half Width (m)	Total Dispersion (m)	Total Dispersion (nmi)
0.0	0	0	0.0
1.0	0	0	0.0
2.0	0	0	0.0
3.0	20	40	0.022
3.5	39	77	0.042
4.0	78	156	0.084
4.5	119	238	0.128
5.0	160	320	0.173
5.5	205	410	0.221
6.0	250	500	0.270
6.5	292	585	0.315
7.0	334	668	0.360
7.5	372	743	0.401
8.0	409	818	0.441
8.5	437	874	0.471
9.0	465	930	0.501
9.5	489	977	0.527
10.0	512	1024	0.552
10.5	533	1066	0.574
11.0 and above	554	1107	0.597

Arrival Routes

The arrival routes defined in INM assume that aircraft establish on the ILS from approximately 10 km out and therefore have a straight-in approach from 10 km and follow a 3° glide slope.

4.5 Aircraft Movement Data

The identification of aircraft operations that inform the model was undertaken using operational logs supplied by the airport and recorded on the airport's operational monitoring system. The operational logs used to determine the INM type and supplied by BIA contained the following fields:

- Operator (IATA two letter code and name);
- Flight number;
- Aircraft type (IATA 3 letter code);
- Runway date and time (dd/mm/yyyy hh:mm:ss);

- Arrival or departure designator (A or D);
- Flight category (local code e.g. 1 - chartered);
- Runway (Runway 07/25 and 17/35); and
- Destination / origin airport (IATA three letter code and name).

Traffic Distribution

The operational logs contained information on the runway used and this information was used by the INM model. Based on the operational logs the following modal splits by relevant period were determined and are shown in **Table 4.5.**

Table 4.5 Runway Modal Split

	07		25		17		35	
	Arrival	Departure	Arrival	Arrival	Departure	Departure	Arrival	Departure
$L_{Aeq,16\ hr\ (92\text{-}day)}$	328	341	5069	5145	155	201	36	60
$L_{Aeq,16h}$	5328	5946	23646	24810	612	908	428	514
L_{day}	2664	2973	11823	12405	306	454	214	257
$L_{evening}$	982	964	4880	4524	78	117	38	44
L_{night}	417	347	3622	2635	59	253	37	24
L_{den}	4063	4284	20325	19564	443	824	289	325

Allocation of departures to routes

No information on the actual departure route was supplied in the operational logs and therefore the assumptions as shown in **Table 4.6** were made. These assumptions are the same as those used for Round One and Round Two and informed by discussions with the airport's operational teams.

Table 4.6 Allocation of Departures

Runway	Departure Route	Description	Movement Allocation
Runway 25	1	Turn right after 2nmi	Departures to Scottish and northern destination.
Runway 25	2	Turn left after 2nmi	All other Runway 25 departures
Runway 07	1	Early turn south	20% of Runway 07 departures
Runway 07	2	Right turn south	80% of Runway 07 departures
Runway 17	1	Straight out departures	80% Runway 17 departures
Runway 17	2	Right turn at 1nmi	Departures to Scottish and northern destination.
Runway 35	1	Right turn around 3nmi	50% of Runway 35 departures

Runway 35	2	Left turn around 3nmi	50% of Runway 35 departures

INM Aircraft Type and Engine Variant

The operational logs for BIA do not contain the aircraft registration and therefore the INM modelled aircraft type has been assigned using the IATA aircraft contained in the logs and applying the assumptions used in Round Two. A look-up table showing the IATA type against INM modelled aircraft type is shown in **Appendix C**.

Aircraft Weight

INM does not have a setting for aircraft weight, and instead adjusts the noise based on the aircraft stage. Using the stage length it assumed that the longer the sector, the heavier the aircraft would be due to the increase in fuel load required. Stage length is only applicable to departing aircraft as it is assumed that aircraft burn all the fuel before arrival. The stage length was determined using the typical flight distance from BIA to the destination airport using the Great Circle Mapper website[4]. The stage length categorisation and equivalent sector distance used by the INM are shown in **Table 4.7**.

Table 4.7 INM Stage Lengths

INM Stage	Sector Distance (km)	Example Destination
1	<926	Amsterdam (EHAM)
2	<1852	Bratislava (LKIB)
3	<2778	Sofia (LBSF)
4	<4630	Luxor (HELX)
5	<6482	Qatar (OTBH)
6	<8334	San Francisco (KSFO)
7	<10186	Bangalore Kempegowda (VOBL)

Aircraft Vertical Profiles

Depending on number of factors, including ground tracks, obstacles and standard operating procedures for airlines aircraft climb differently at different aerodromes. Therefore, to account for this difference the INM model contains several flight profiles for aircraft, and typically, the most relevant profile for the aircraft is assigned based on radar data from the airport. However, no radar data is available for BIA and therefore for consistency with Round One and Round Two, the INM standard aircraft profile has been assumed.

[4] www.gcmap.com/

5. Noise Contours

5.1 Noise Contour Grids

The INM model was set to produce noise grids for the relevant metric on a 50m by 50m grid. The grid was set to extend -20 km to the south of the airport and -20km to the west of the airport, and then 40 km across in the X-axis and 40km up in the Y-axis.

Projection to Irish National Grid

The INM grid outputs are not geo-referenced and therefore Blue Marble Geographic's Global Mapper environment (Version 15.2) was used to project Geographic latitude and longitude (WGS84 Datum) to Irish National Grid datum. Furthermore, because the INM grids were run on 50m by 50m grid spacing, the grids were interpolated to 10m by 10m grids using a TIN model and bilinear interpolation tools within ArcGIS 3D Analyst.

5.2 Production Noise Contours

The first post-processing step that was undertaken on the raw continuous output noise grids was a reclassification of the grids into bands, These were classified in 5 dB bands starting at 50 dB(A) for L_{den}, $L_{Aeq,16h}$, L_{day} and L_{eve} and down to 45 dB(A) for the L_{night} metric. The noise contour map are included in **Appendix A.**

5.3 Population and Dwelling Exposure Methodology

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

Four primary datasets were used within the population exposure assessment developed in the Round Three study. The datasets used were:

- Detailed individual building polygons recorded in the 2016 version of the OSNI large scale mapping[5]. However it is important to note that the date of the imagery used to update the detailed OSNI mapping varies from 2013-2015. Further information is provided in the accompanying Round 3 Ground model report.
- The OSNI Pointer dataset that provides details of the residential, public-use and commercial classifications of individual buildings across Northern Ireland[6]. The Pointer data set is described by OSNI as the primary address database for Northern Ireland and is maintained by Land & Property Services (LPS), with input from Local Councils and Royal Mail. This dataset was supplied to Amec Foster Wheeler in September 2016 and contains records until this date.
- Geographical boundary file for the 4537 Small Areas (SAs) which were introduced in Northern Ireland after the 2011 Census[7]. Small Areas are generally created by amalgamating 2011 Census Output Areas which were built from clusters of adjacent postcodes. This is the smallest

[5] https://www.nidirect.gov.uk/articles/large-scale-vector
[6] https://www.nidirect.gov.uk/publications/pointer-technical-specification
[7] https://www.nisra.gov.uk/support/geography/northern-ireland-small-areas

spatial unit for which annual population estimates are produced for Northern Ireland – see below, and

- Northern Ireland Statistics and Research Agency 2015 population estimates for the 4,537 census small areas (SAs) across Northern Ireland[8]. The total estimated usual resident population across these areas was 1,828,971. This represents a 3% increase in population from Round 2.

The key steps used to create the final population dataset used in the population exposure assessment are summarised below. This builds upon the methodology adopted for Round Two but introduces a more robust approach to the assessment of the number of residential addresses within individual buildings and ultimately the distribution of population across residential buildings in Northern Ireland.

Step A - Assessment of the number of addresses in each residential building object

- A1 - Identification of all individual buildings within the OSNI large scale dataset which were either defined by OSNI as being residential and/or a mixed function building containing at least one residential address as defined in the OSNI Pointer dataset. The total number of residential building objects was 774,424.
- A2 – GIS query run to identify all built residential property addresses within the LPS Pointer dataset. The criteria used for selection is shown in **Table 9.1**. Please note that the number of records for A2 was larger than A1 due to the presence of buildings with multiple addresses (e.g. apartments and flats).

Table 9.1 Criteria for selection of LPS Pointer data

Classification	Address Status	Used in development of the population dataset	No of LSP Pointer records
Domestic (DO_)	Approved	Yes	757,064
Domestic (DO_)	Provisional, Candidate, Historical or Rejected	No	112,361
Non Domestic (ND_) or Null	All values	No	87,075
Total			956,500

- A3 - GIS tool used to count the number of completed domestic residential “built” LPS Pointer address within each OSNI building object identified in Step A1. This number ranged from 1 (majority of buildings) to 282 (large apartment type buildings). It should also be noted that the analysis only considered LPS Pointer records that had a confirmed Address Status of “Approved”, which effectively means a completed building rather than a building under construction.

Step B – Assessment of population per address for each Small Area in Northern Ireland

- B1 – GIS tool used to spatial join the 2015 population estimates to each of the 4,537 census small areas (SAs);
- B2 - GIS spatial join tool used to assign the Small Area (SA) reference code to each of the buildings identified in Step A1. This was achieved using the centroid of the building object.
- B3 – GIS aggregation tool used to count the total number of residential address in each of the 4,537 Small Areas across Northern Ireland; and

[8] https://www.nisra.gov.uk/publications/2015-mid-year-population-estimates-small-areas

- B4 – Final estimate of a population per address calculated by dividing the 2015 population estimate by the total number of address in each of the 4257 Small Areas across Northern Ireland.

Step C – Estimating a total population for each residential building in Northern Ireland

- A final estimate of population in each residential building was calculated by multiply the number of individual residential addresses in the building (Step A3) by the estimate of population per address (Step B4).

These final estimates were subject to a final set of QA checks to ensure a representative distribution of the 1,828,971 population recorded by the NISRA in the 2015 population estimate dataset. The mean value per residential building is 2.36.

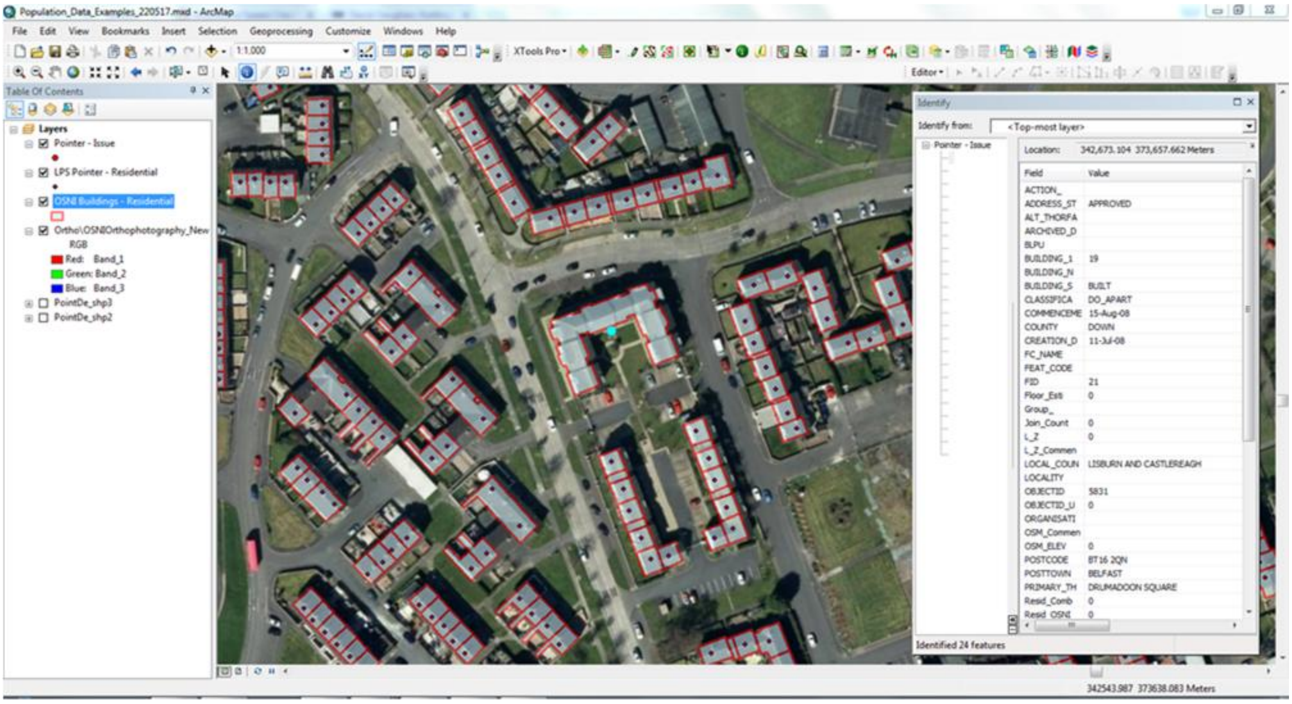
As per the assumptions used in the Round One study, Annex I (1) of the END indicates that noise exposure assessments should be at the most exposed façade. The most exposed façade is defined as the external wall facing onto and nearest to the specific noise source. For the purposes of this assessment, the highest overall value assigned to a dwelling is to be considered the most exposed façade as per recommendations set out within the WG-AEN Good Practice Guide v2.

To calculate the level of exposure the residential dwelling building extents were intersected with the reclassified noise grids using an automated GIS processing script. From this process, the number of dwellings and the number of people exposed in the required 5dB END noise intervals was calculated. The results of this analysis are presented in Section 9.2.

In reviewing the final exposure results, it is important to consider the various factors that influence the final exposure analysis. These factors include: improvements in the calculation of populations for buildings with multiple dwellings; differences in the age of the OSNI building, LPS Pointer and NIRAS population datasets used in the analysis; changes and improvements in the OS Pointer address dataset since Round Two; and the remaining limitations of the OSNI Pointer address dataset. These limitations include the absence of an attribute code to distinguish communal residences (i.e. student residence, army living accommodation) from standard residential accommodation, and potential mis-alignment of Pointer records in relation to the OSNI detailed large scale mapping.

This last issue is illustrated below in **Plate 6.1**, where the Pointer centroid is located just outside the OSNI building object rather than located within the boundary of the building object. This means that the 24 address located at the point location have not been automatically assigned to the adjacent building. Further manual edits where applied to the population database to address this issue in key locations.

Plate 6.1 Spatial mismatch between the LSP Pointer and OSNI building data



6. Results

An estimate of the area, number of dwellings and population exposed to noise sources from the airport is provided in **Table 6.1** to **Table 6.6**. These results have been produced using the methodology described in **Section 5**.

Table 6.1 Belfast International Airport – Noise contour areas (All flights – including military)

Noise Level (dB)	$L_{Aeq, 16-hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
50-54	13.5	27.6	12.8	15.3	**45-49**	15.4
55-59	5.6	10.9	5.3	6.4	**50-54**	6.9
60-64	2.3	4.7	2.2	2.6	**55-59**	2.7
65-69	0.8	1.7	0.8	1.0	**60-64**	0.9
70-74	0.4	0.7	0.4	0.4	**65-69**	0.4
>75	0.2	0.4	0.2	0.2	**>=70**	0.3
Total	**22.8**	**45.9**	**21.7**	**25.8**	**Total**	**26.5**

Table 6.2 Belfast International Airport – Noise contour areas (Commercial flights only)

Noise Level (dB)	$L_{Aeq, 16-hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
50-54	13.1	27.2	12.3	15.2	**45-49**	15.3
55-59	5.5	10.8	5.2	6.4	**50-54**	6.9
60-64	2.2	4.6	2.0	2.6	**55-59**	2.7
65-69	0.8	1.7	0.7	1.0	**60-64**	0.9
70-74	0.3	0.6	0.3	0.4	**65-69**	0.4
>75	0.2	0.4	0.2	0.2	**>=70**	0.3
Total	**22.0**	**45.3**	**20.7**	**25.7**	**Total**	**26.3**

Table 6.3 Belfast International Airport – Dwellings (All flights – including military)

Noise Level (dB)	$L_{Aeq, 16-hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
50-54	536	1,027	461	737	**45-49**	529
55-59	103	651	89	125	**50-54**	118
60-64	15	134	15	19	**55-59**	16
65-69		16			**60-64**	2
70-74					**65-69**	
>75					**>=70**	
Total	**654**	**1,828**	**565**	**881**	**Total**	**665**

Table 6.4 Belfast International Airport – Dwellings (Commercial flights only)

Noise Level (dB)	$L_{Aeq, 16-hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
50-54	505	1,027	408	736	**45-49**	524
55-59	99	281	82	124	**50-54**	115
60-64	13	45	12	19	**55-59**	16
65-69		7			**60-64**	2
70-74					**65-69**	
>75					**>=70**	
Total	**617**	**1,360**	**502**	**879**	**Total**	**657**

Table 6.5 Belfast International Airport – Population (All flights – including military)

Noise Level (dB)	$L_{Aeq, 16-hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
50-54	1,086	2,028	950	1,428	**45-49**	1,143
55-59	250	651	224	293	**50-54**	303
60-64	39	134	39	52	**55-59**	44
65-69	-	16		-	**60-64**	4
70-74	-				**65-69**	
>75					**>=70**	
Total	**1,376**	**2,829**	**1,213**	**1,772**	**Total**	**1,494**

Table 6.6 Belfast International Airport – Population (Commercial flights only)

Noise Level (dB)	$L_{Aeq, 16-hour}$	L_{den}	L_{day}	L_{eve}	Noise Level (dB)	L_{night}
50-54	1,014	2,023	836	1,428	**45-49**	1,132
55-59	243	631	210	293	**50-54**	296
60-64	33	133	31	52	**55-59**	44
65-69		14			**60-64**	4
70-74					**65-69**	
>75					**>=70**	
Total	**1,290**	**2,801**	**1,077**	**1,772**	**Total**	**1,476**

7. BIA – 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 that cover the first two implementation rounds of the END. The results of the noise mapping including the population and the dwelling are reported via Data Flow 4 and 8.

The results from this round were entered into the relevant Data Flow 4 and 8 data tables that are available from the EC (http://dd.eionet.europa.eu/datasets/2906). For the BIA report, the relevant table references are DF4_8_Agg_Air and DF4_8_Agg_Air_Major. Additional spatial datasets will be projected into ETRS89 Lambert Azimuthal Equal Area 52N 10E grid in line with EEA guidance (www.eionet.europa.eu/gis/).

It is important to note that only certain elements (mandatory fields) in Data Flow 4 and 8 are required to be reported and these fields are detailed in **Table 8.1**.

Table 7.1 ENDRM Mandatory Fields for Table DF4_8_Agg_Air and DF4_8_Agg_Air_Major

Required Reporting Element	Description
UniqueAgglomerationId	Unique Agglomeration ID assigned by the reporting entity to each agglomeration.
*** Lden5559**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
*** Lden6064**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
*** Lden6569**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 65-69 dB(A), 4 m above the ground and on the most exposed façade.
*** Lden7074**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden between 70-74 dB(A), 4 m above the ground and on the most exposed façade.
*** Lden75**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lden from a Major Source >75 dB(A), 4 m above the ground and on the most exposed façade.
*** Lnight5054**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 50-54 dB(A), 4 m above the ground and on the most exposed façade.
*** Lnight5559**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 55-59 dB(A), 4 m above the ground and on the most exposed façade.
*** Lnight6064**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 60-64 dB(A), 4 m above the ground and on the most exposed façade.
*** Lnight6569**	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight between 65-69 dB(A), 4 m above the ground and on the most exposed façade.

Required Reporting Element	Description
* Lnight70	The estimated total number of people (rounded to the nearest hundred) living inside agglomerations in dwellings that are exposed to values of Lnight >70 dB(A), 4 m above the ground and on the most exposed façade
* ComputationAndMeasurementMethodsReportDetails	The full name of the report, the author/publisher and date of production.

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

8. Comparisons between Round Two and Three

As can be seen from the development of the model in **Sections 4 and 5**, airport noise modelling requires a significant number of data inputs. Changes to these data inputs can result in both increases and decreases in air noise exposure levels and statistics. There are number of key factors that must be considered when attempting to compare the results of one airport noise contouring exercise to another. For the comparison of Round 2 with Round 3, the following key factors should be considered:

- Change in airport fleet mix and air traffic movements;
- Change in runway modal split between 2011 and 2016; and
- Change in demographic (i.e. change in population).

The changes in modelling factors are discussed below in **Section 8.1**.

8.1 Changes in modelling approach and data inputs

Aircraft Movements

Table 8.1 presents the headline movements in each modelled period for Round 2 and Round 3, typically at an airport, and if the aircraft fleet mix remained consistent, an increase in aircraft movements would result in a growth in contour size.

Table 8.1 Annual Aircraft Movements for Round Two (2011) and Round Three (2016)

Round of Mapping	Day (0700 – 1900hrs)	Evening (1900 – 2300hrs)	Night (2300 – 0700hrs)
Round Two (2011)	34774	10954	7767
Round Three (2016)	34580	12685	7777
Change	**-0.6%**	**+15.8%**	**+0.1%**

Overall, there has been an increase in total aircraft movements and of significance is the large increase in movements during the evening for the L_{den} metric. In the L_{den} metric, the evening and night-time periods have a significant influence upon noise contours due to the respective +5 dB and +10 dB penalties that are applied to the noise levels.

Aircraft Fleet Mix

Although it is not possible to directly link changes in fleet mix to changes in noise exposure, some understanding can be gained by reviewing the aircraft responsible for the majority of movements at an airport. **Table 8.2** presents this comparison for the top five modelled aircraft at BIA during Round Two and Round Three mapping.

Table 8.2 Comparison of Top 5 Aircraft in Terms of Movements between Round Two and Round Three

Order	Round Two (2011)		Round Three (2016)	
	Aircraft	Number of Movements (24-hours)	Aircraft	Number of Movements (24-hours)
1	Airbus A319	23244	Airbus A319	21166
2	Airbus A320	6044	Airbus A320	8600

Order	Round Two (2011)		Round Three (2016)	
	Aircraft	Number of Movements (24-hours)	Aircraft	Number of Movements (24-hours)
3	Boeing 737-300	4422	Boeing 737-300	4623
4	Boeing 737-800	996	BAe 146	3664
5	Airbus A321	632	Boeing 737-800	996

The comparisons show for Round Three a reduction in the most prominent type, the Airbus A319, however a large increase in the larger Airbus A320, Boeing 737-300, Boeing 737-800 and Airbus A321. This large increase in aircraft types suggests a significant fleet change at the airport with airline adopting larger aircraft types.

Due to the change in aircraft fleet, a further comparison has therefore been made which categorises the aircraft into a broad category, i.e. large, medium, small, general aviation, helicopter and military. A summary of total aircraft movements by these categories is presented in **Table 8.3** and confirms that there has been an increase in the larger aircraft types, particularly medium sized aircraft. The exception to this is the large aircraft category, which has seen a large reduction, mainly due to a decline in Boeing 767 and Airbus A300 aircraft.

Table 8.3 Comparison of Top 5 Aircraft in Terms of Movements between Round Two and Round Three

Aircraft Category	Example	Round 3	Round 2	Change
Large	Boeing 767-300	1206	1459	-17.3%
Medium	Boeing 757-200	1644	1282	+28.2%
Small	Airbus A320	38751	33728	+14.9%
General Aviation	Cessna Citation X	2307	2954	-21.9%
Helicopter	Eurocopter EC135	9972	10502	-5.0%
Military	Lockheed C-130 Hercules	262	90	+191.1%

Change in Modal Split

Table 8.4 presents a comparison of the runway modal split in terms of a 24-hour measure as modelled during Round Two and Round Three for 2011 and 2016 respectively.

Table 8.4 Change in Modal Split between Round Two and Round Three

	Runway 07	Runway 25	Runway 17	Runway 35	Runway 0 (Helipad)
Round Two Modal Split (2011)	3670	42935	1652	794	4444
Round Three Modal Split (2016)	8347	39889	1267	614	4925
Change in modal split	+127%	-7%	-23%	-23%	11%

Table 8.4 shows that for Round Three there has been an increase in aircraft using Runway 07/25 (+3.5%) especially those operating in an easterly mode (i.e Runway 07). Whereas there has been a decrease in usage of Runway 17/25.

Routine assessment of airport noise often requires the consideration of 'actual' and 'standard' modes. Actual modes are the modal splits in a given year or time period, whereas standard modes are an average modal split of an airports operations over a period of several years. Best practice is to assess standard modals splits over a period of 20 years. However, it is important to note that there is no requirement under the Directive or Regulations to produce air noise contours for standard modes, as the contours are expected to represent actual operations from the calendar year.

8.2 Differences in Round 2 and Round 3 contours

The impact of these data inputs and modelling changes upon the extent of the noise contours are presented in the figures presented in **Appendix B**. These figures highlight the overall increase in the size of the contours for all five END indicators when compared with Round Two.

9. Summary and Conclusions

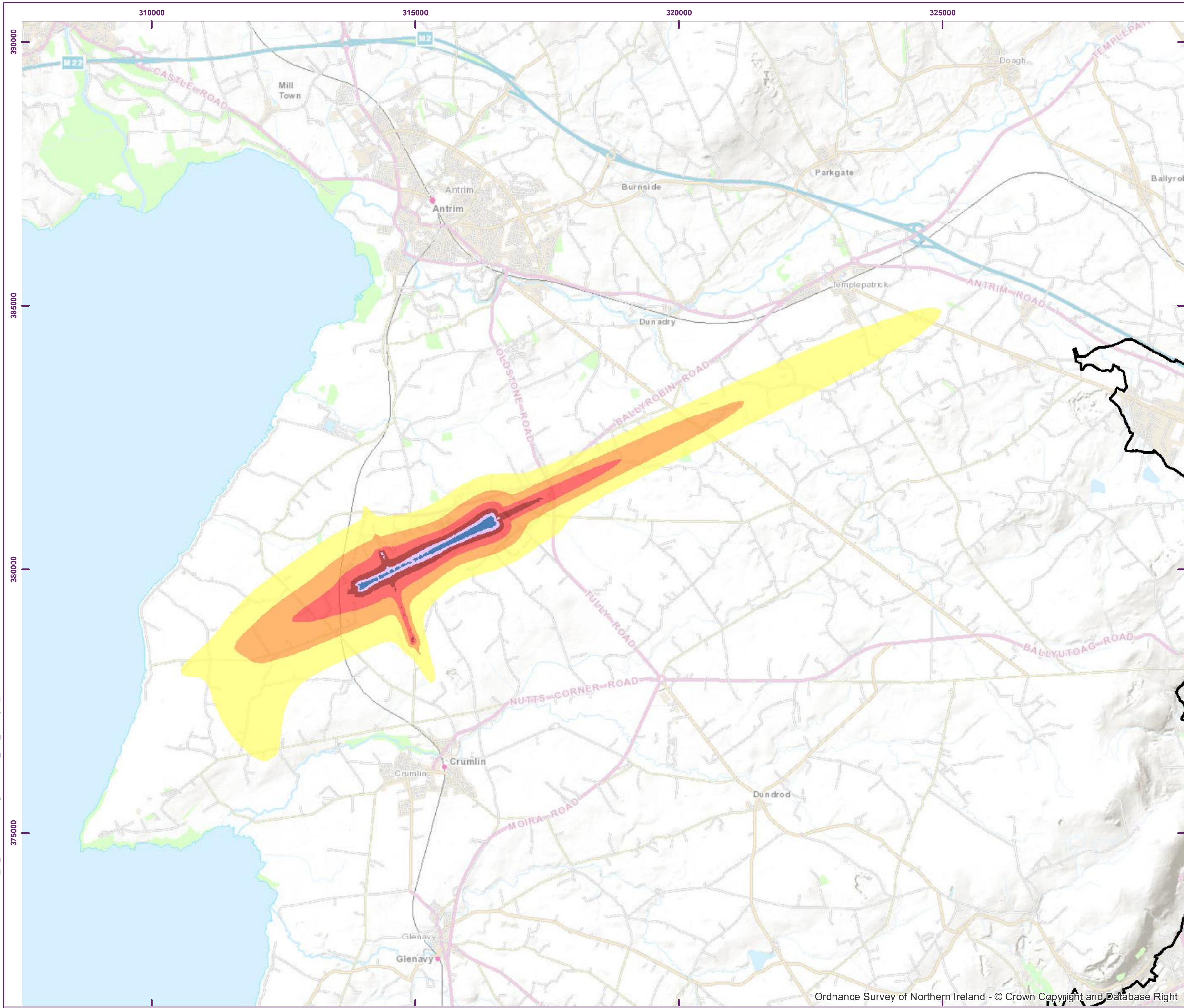
As outlined earlier, an updated INM model has been created for Round three, which incorporates OSNI terrain data and updated annual average aircraft data (including movements, aircraft type and routes) for the required modelling period. The key differences from Round Two were:

- A significant increase in aircraft using the easterly Runway 07 (+127%) and a decrease in aircraft using all other runways;
- An overall increase in total aircraft movements (+3%), including:
  - A large increase in total aircraft movements during the evening (+16%);
  - A minor increase in total movements during the night period (+0.1%);
  - A minor decrease in total movements during the day period (-0.6%);
  - An increase in the Scheduled/Chartered/Freight aircraft, including a 9% increase in the day period, a 22% increase in the evening period and a 3% increase in the night period;
- A change in aircraft fleet particularly:
  - An increase in the Boeing 737 family aircraft (+89%), including a significant increase in the classic Boeing 737-300 (+22%) and the introduction of the Boeing 737-400, and an increase in the newer Boeing 737-800 (+480%); and
  - A minor growth in the most prominent aircraft type, the Airbus A320 family (+3.6%), including a reduction in the A319 (-9%) and an increase in both the larger A320 (+42%) and the A321 (+150%).

The Round Three END noise model has been set-up to generate 50m by 50m noise grids and these have been interpolated to 10m by 10m grids using the bilinear interpolation calculation method. The interpolated noise grids have then been cross-referenced with the INM grids to ensure the interpolation has not resulted in spurious levels of noise.

The final modelled results have been presented in map form (see Appendix A and B) and indicate an overall increase in the extent of the noise contours when compared to those modelled for Round 2. This reflects the changes aircraft model splits, movements and aircraft types observed in the development of the report. The reduced extent of noise contours is also reflected in a corresponding reduction in the numbers of buildings and population exposed to different noise levels when compared to Round 2.

Appendix A
Round 3 Noise Contours



Key

Belfast International Airport Noise Map L_{day} - All Flights

END Round Three - 2017 The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

	50 - 54
	55 - 59
	60 - 64
	65 - 69
	70 - 74
	> = 75
	Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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Signature

Director

The L_{day} is the equivalent continuous sound level in dB(A) that, over the period 07:00 – 19:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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Belfast International Airport

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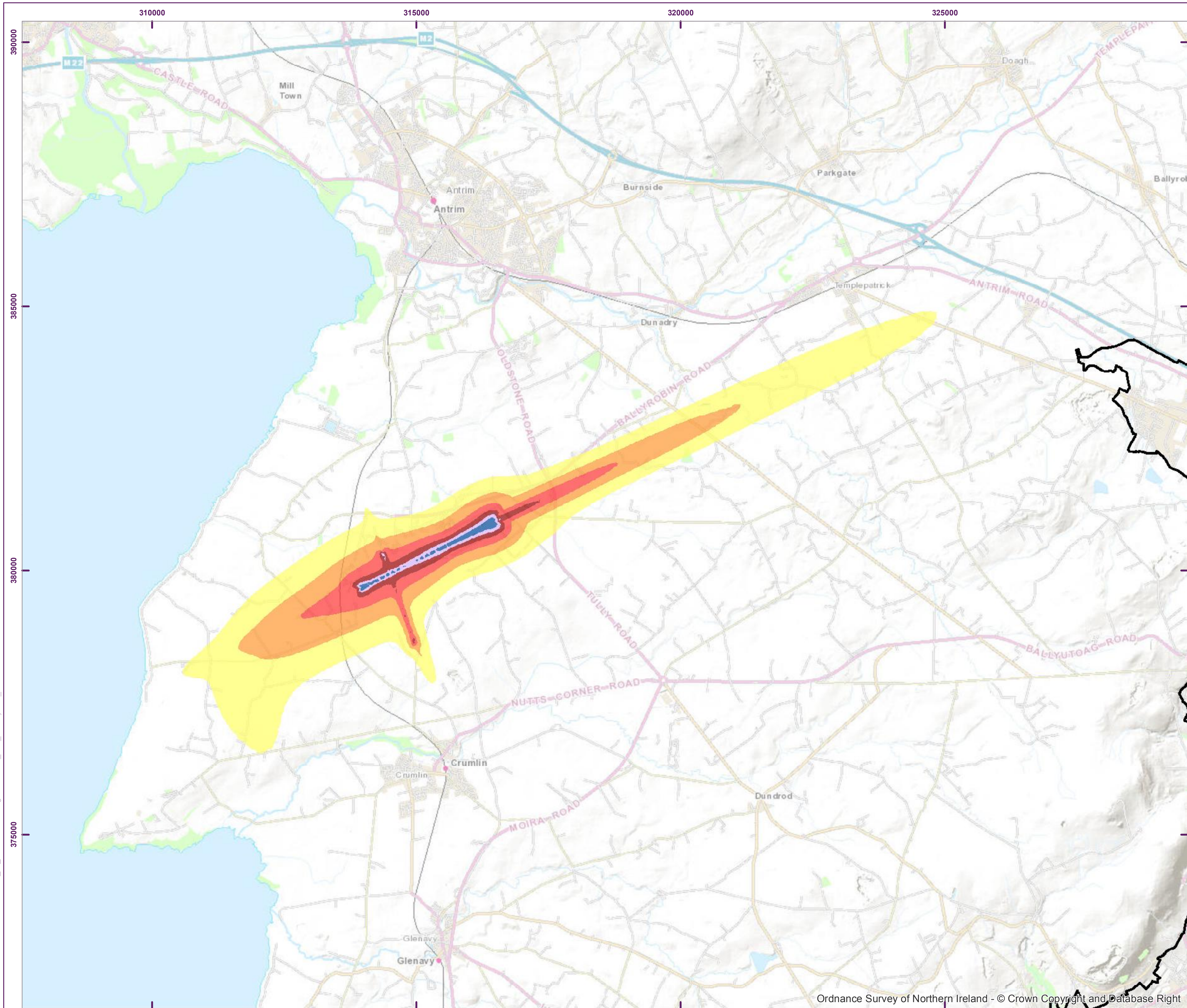
Key

Belfast International Airport Noise Map
L_{day} - Commercial Flights

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006



Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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Belfast International Airport

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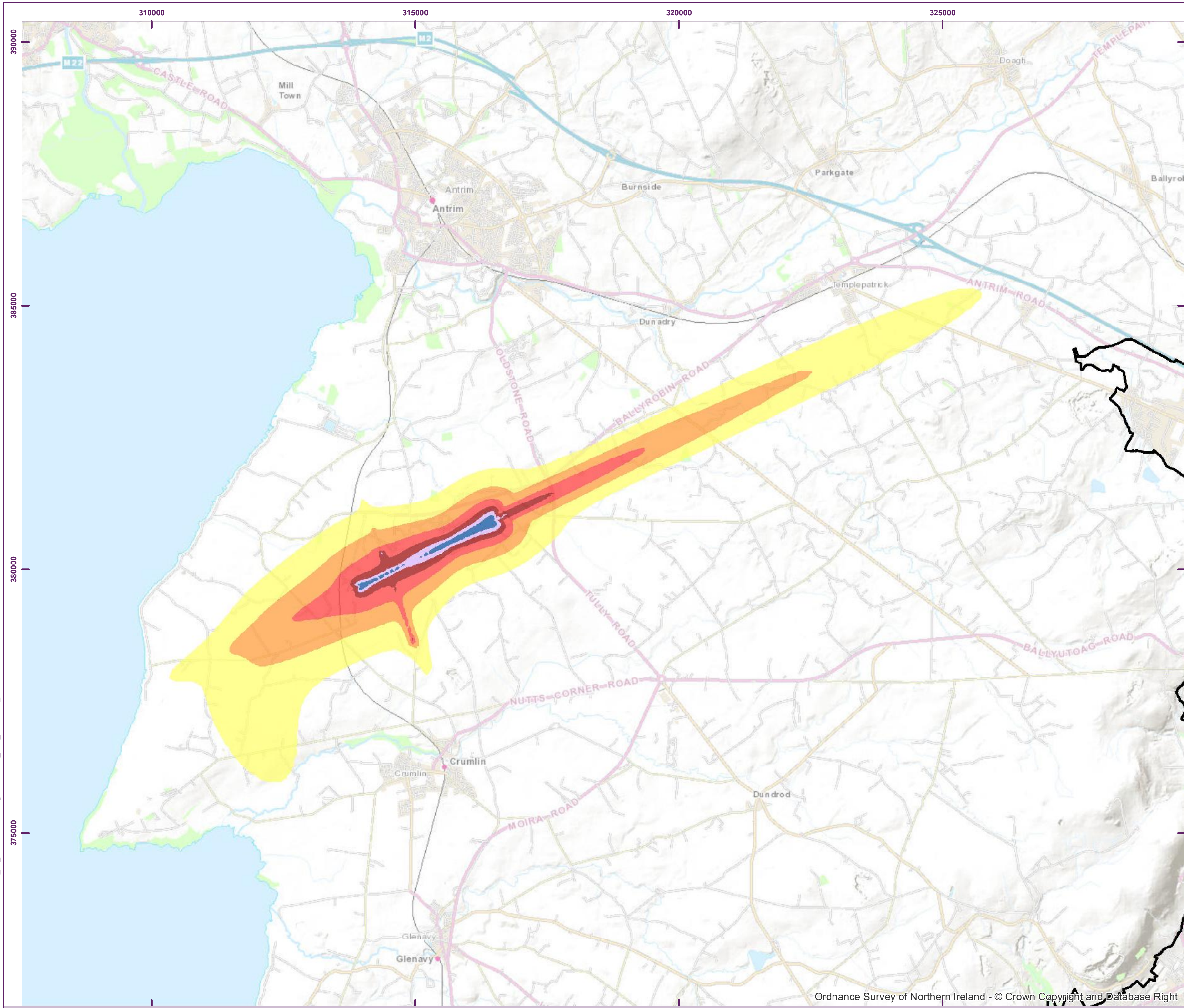

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file: G:\MODEL\PROJECTS\HM-250\38600_NI_END3\ArcGIS\Figures\38600_S16_bialeveall_XA.mxd

Key

Belfast International Airport Noise Map L_{eve} - All Flights

END Round Three - 2017 The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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Signature

Director

The L_{eve} is the equivalent continuous sound level in dB(A) that, over the period 19:00 – 23:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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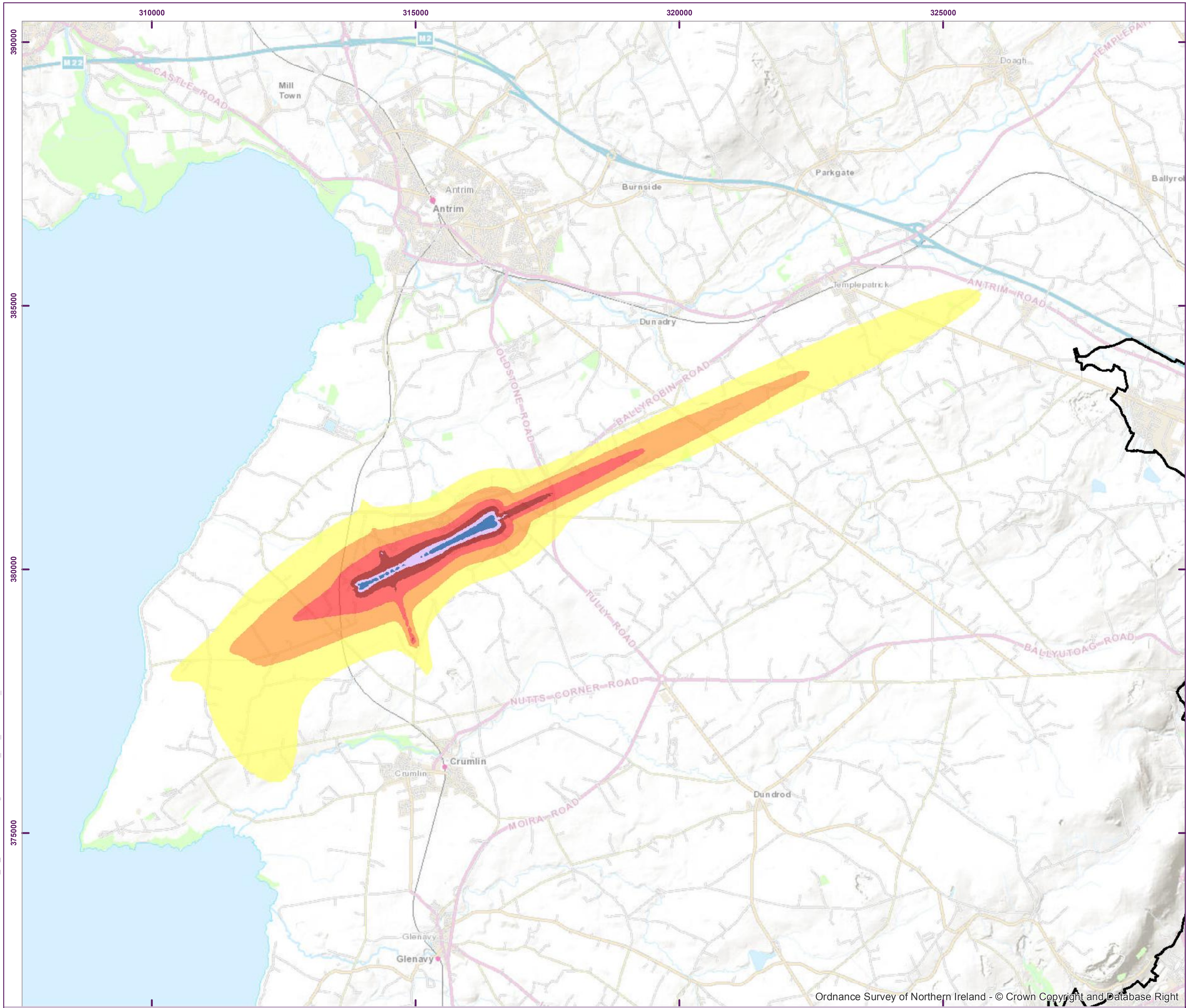
November 2017 38600_S16_bialeveall_XA.mxd eastr



Key

Belfast International Airport Noise Map
L_{eve} - Commercial Flights

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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Director

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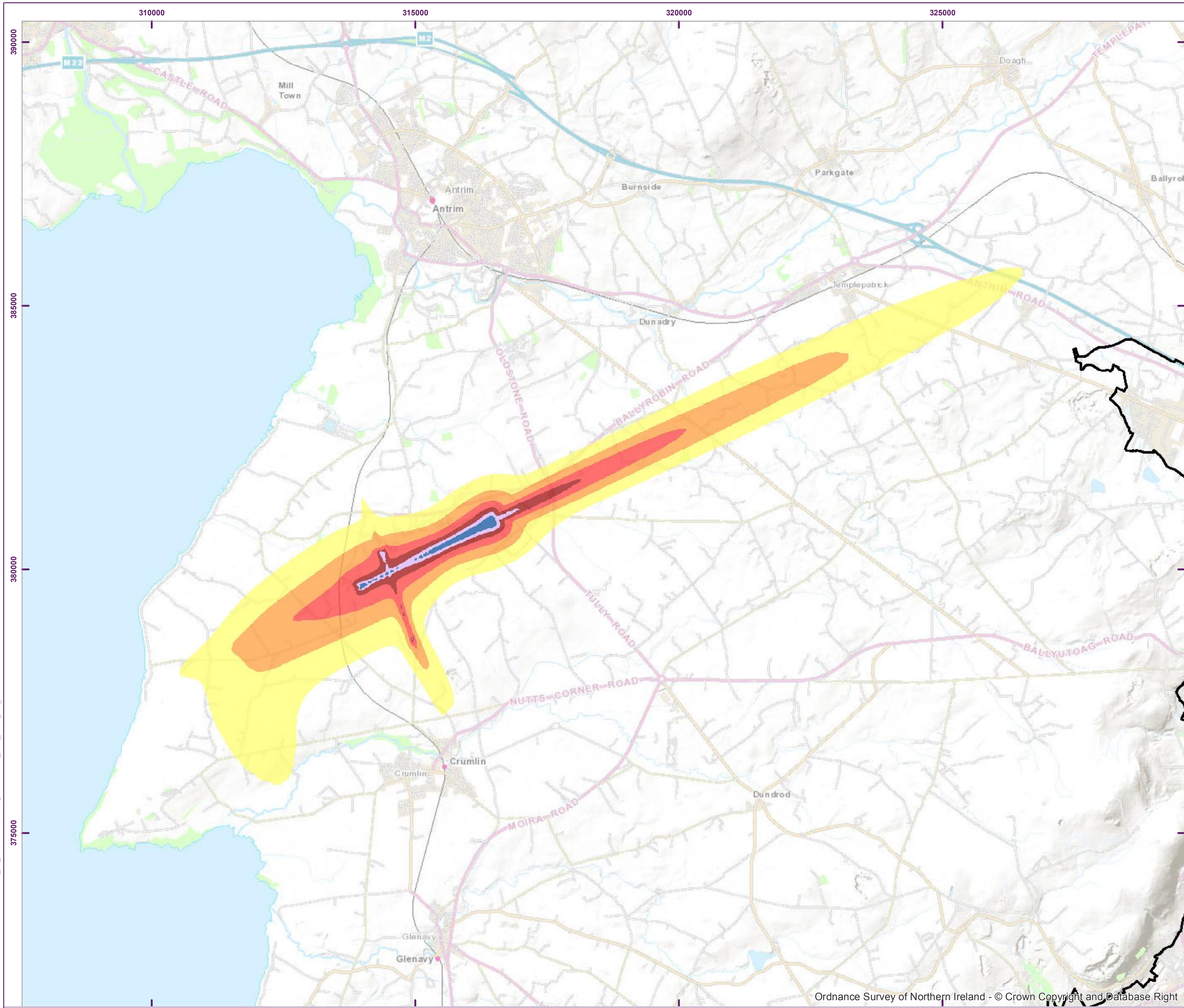

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Key

Belfast International Airport Noise Map
L_{night} - All Flights

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 45 - 49
- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- > = 70
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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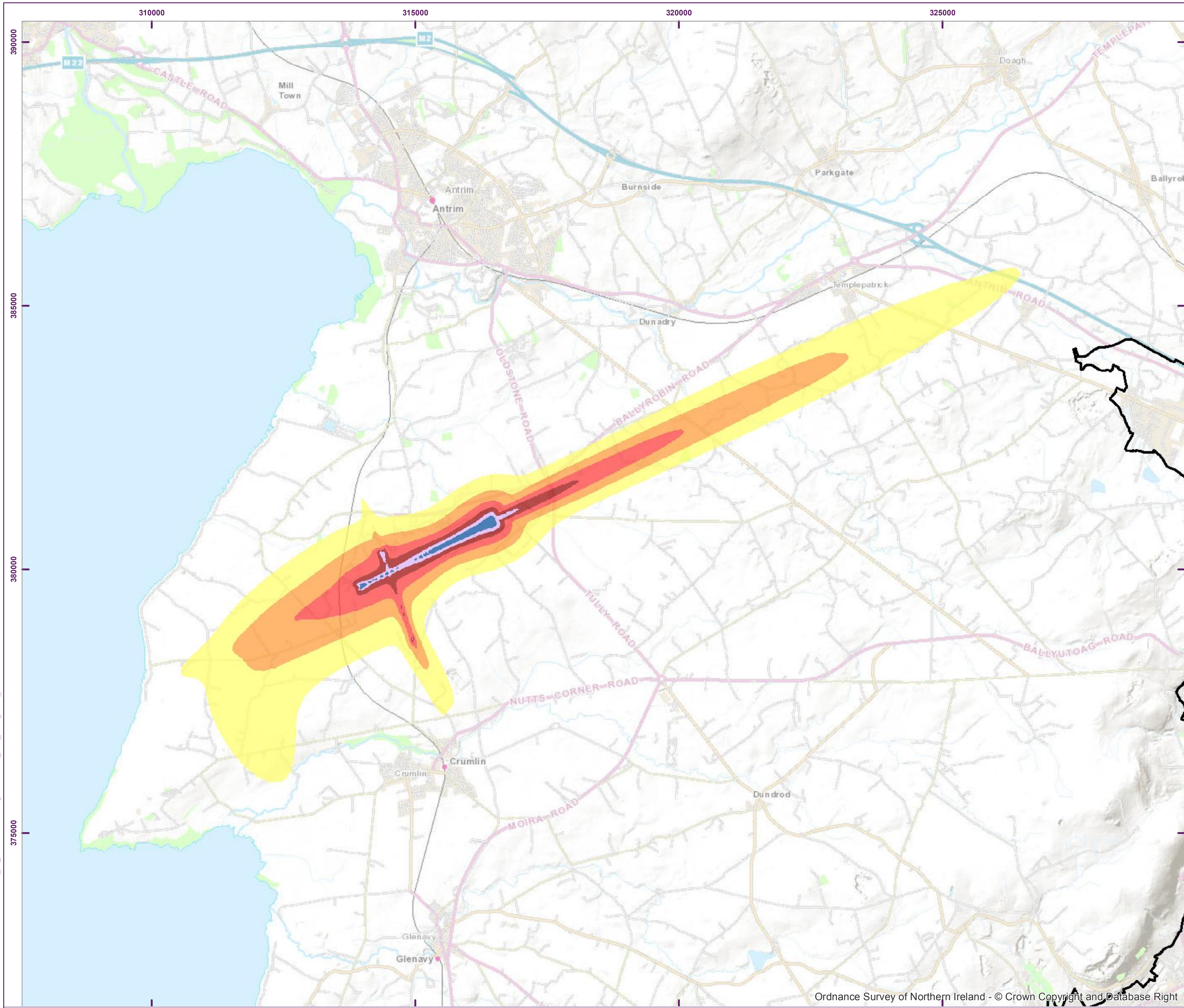
Key

Belfast International Airport Noise Map L_{night} - Commercial Flights

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006



Key

Noise Level (dB)

- 45 - 49
- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- > = 70
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

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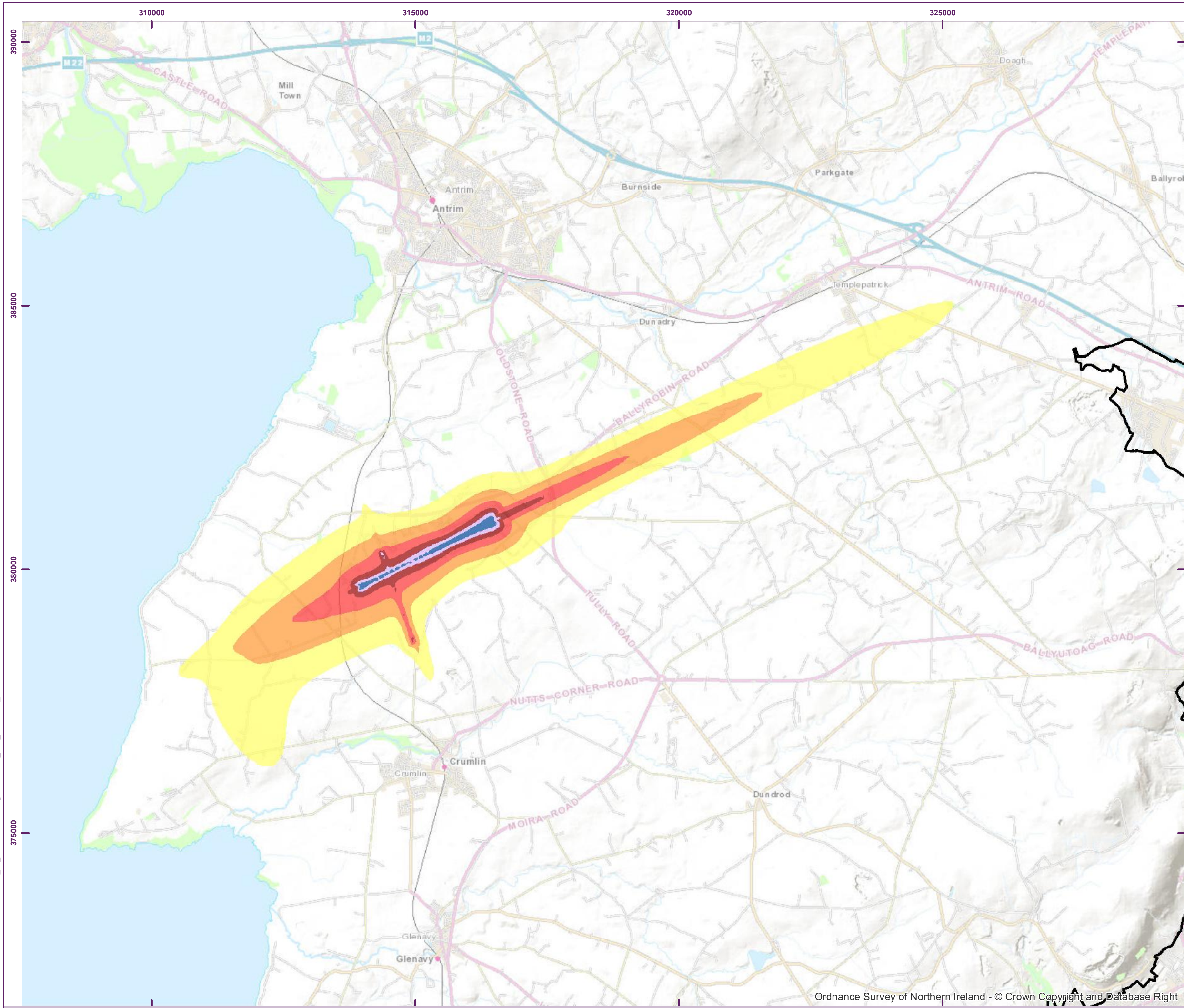

Key

Belfast International Airport Noise Map

$L_{aeq,16h}$ - All Flights

END Round Three - 2017

The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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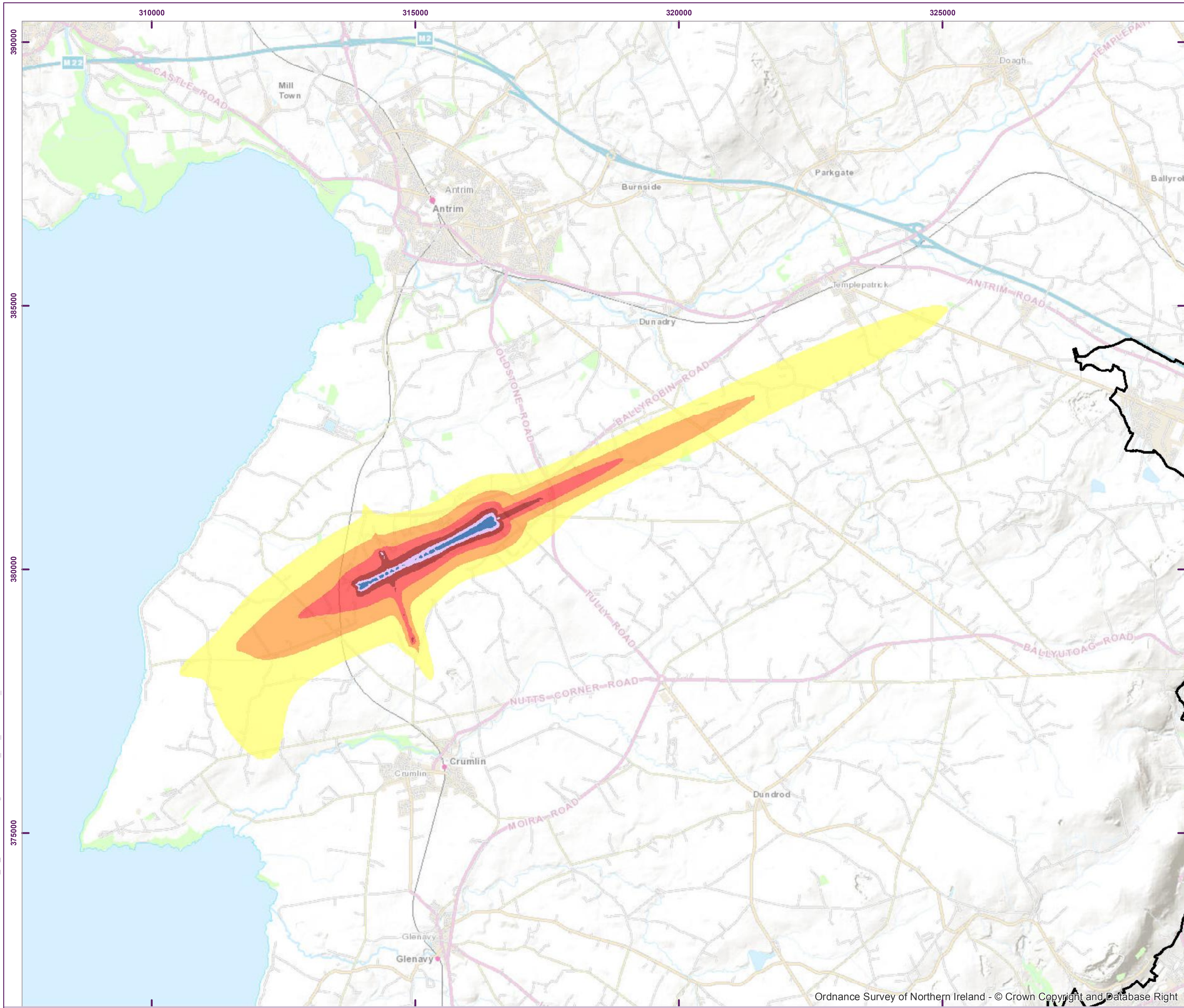
Key

Belfast International Airport Noise Map $L_{aeq,16h}$ - Commercial Flights

END Round Three - 2017

The Environmental Noise Regulations (Northern Ireland) 2006



Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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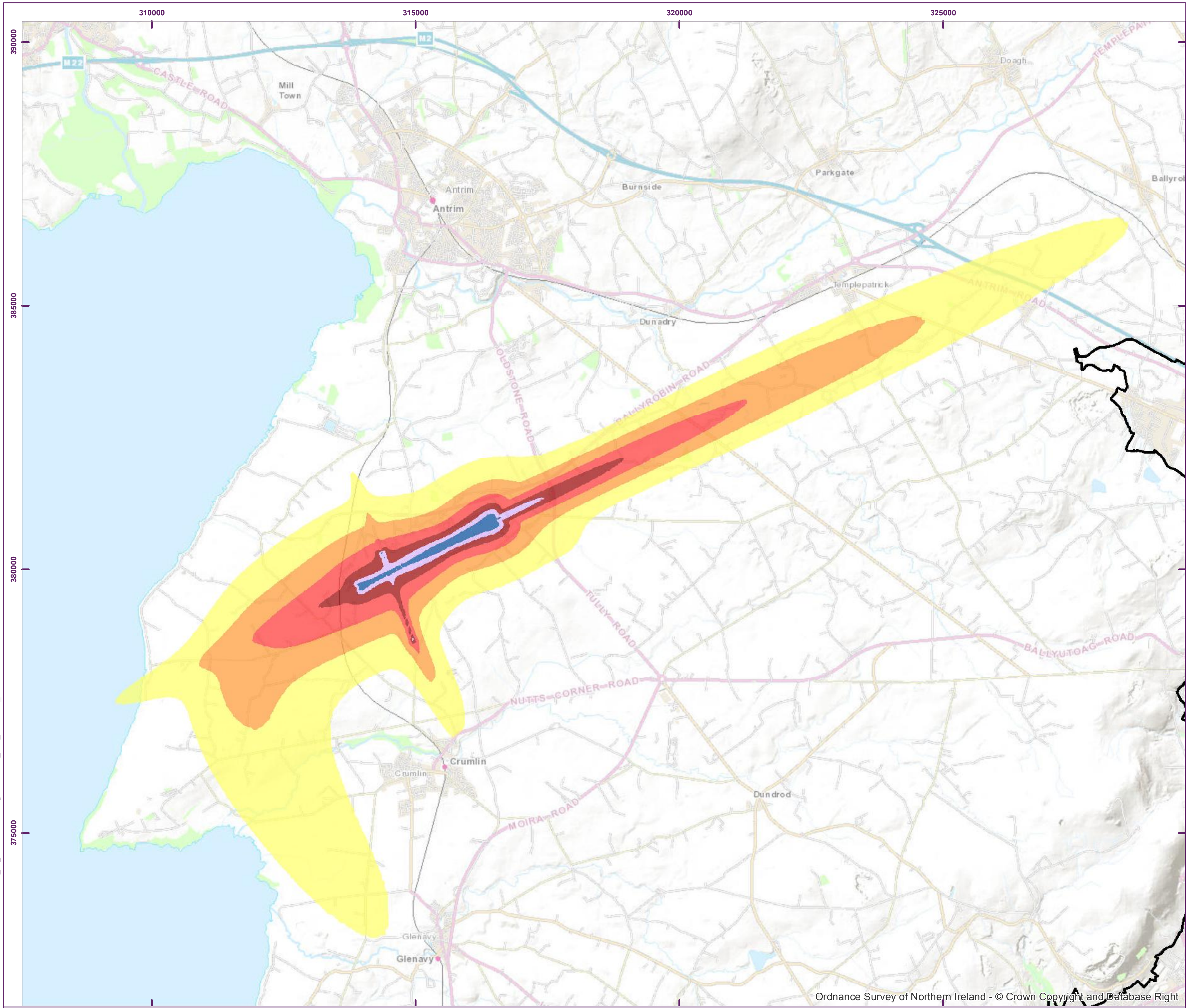
November 2017 38600_S11_bial16hnom_XA.mxd eastr



Key

Belfast International Airport Noise Map
L_{den} - All Flights

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km
Scale at A3: 1:70,000

N

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The day-evening-night (L_{den}) is a noise rating indicator based upon an annual average 24 hour noise level (L_{Aeq}) with a 5 dB(A) penalty for evening noise (i.e. 19.00 - 23.00) and a 10 dB(A) penalty for night-time noise (23.00 - 07.00).

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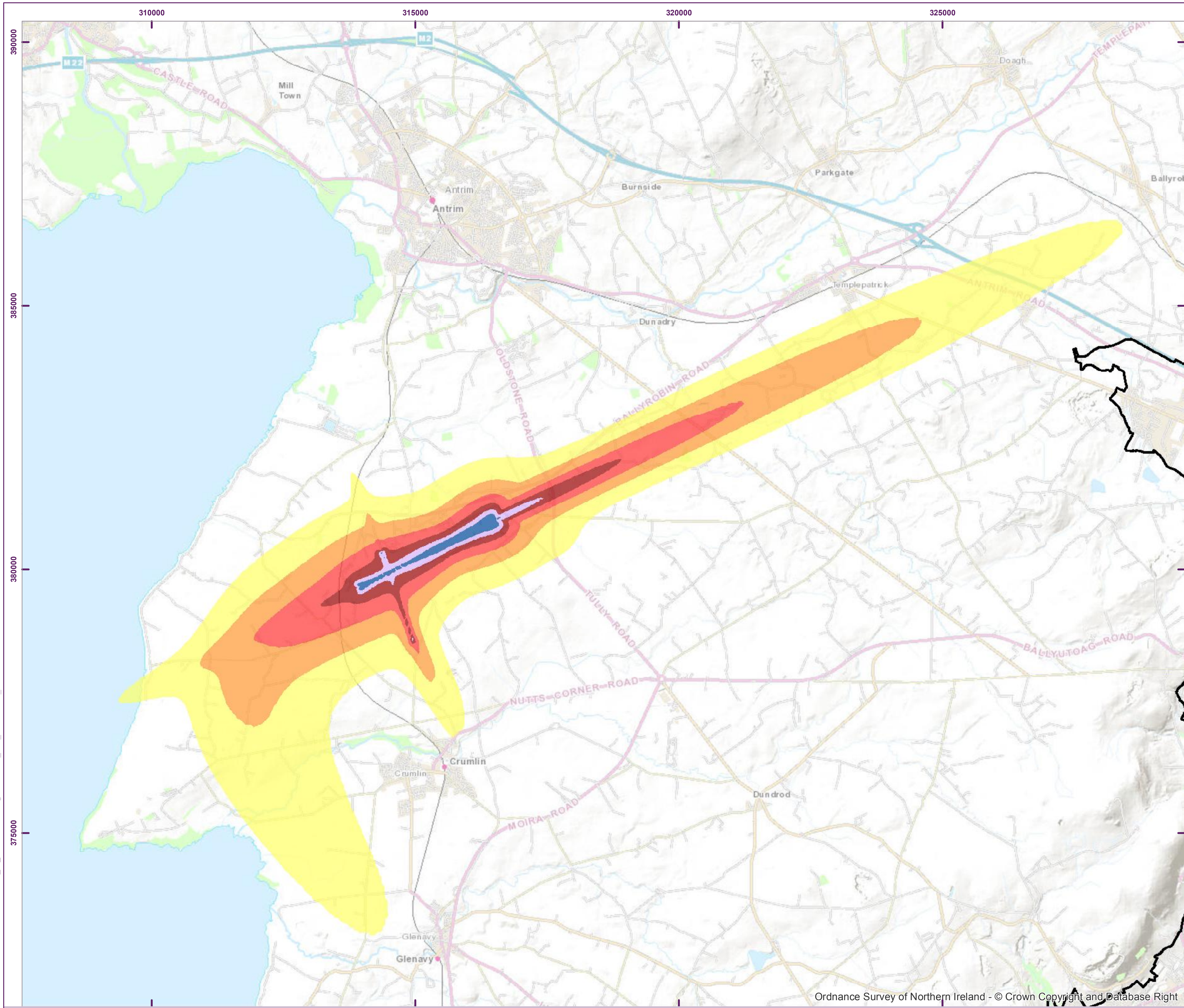

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Key

Belfast International Airport Noise Map

L_{den} - Commercial Flights

END Round Three - 2017

The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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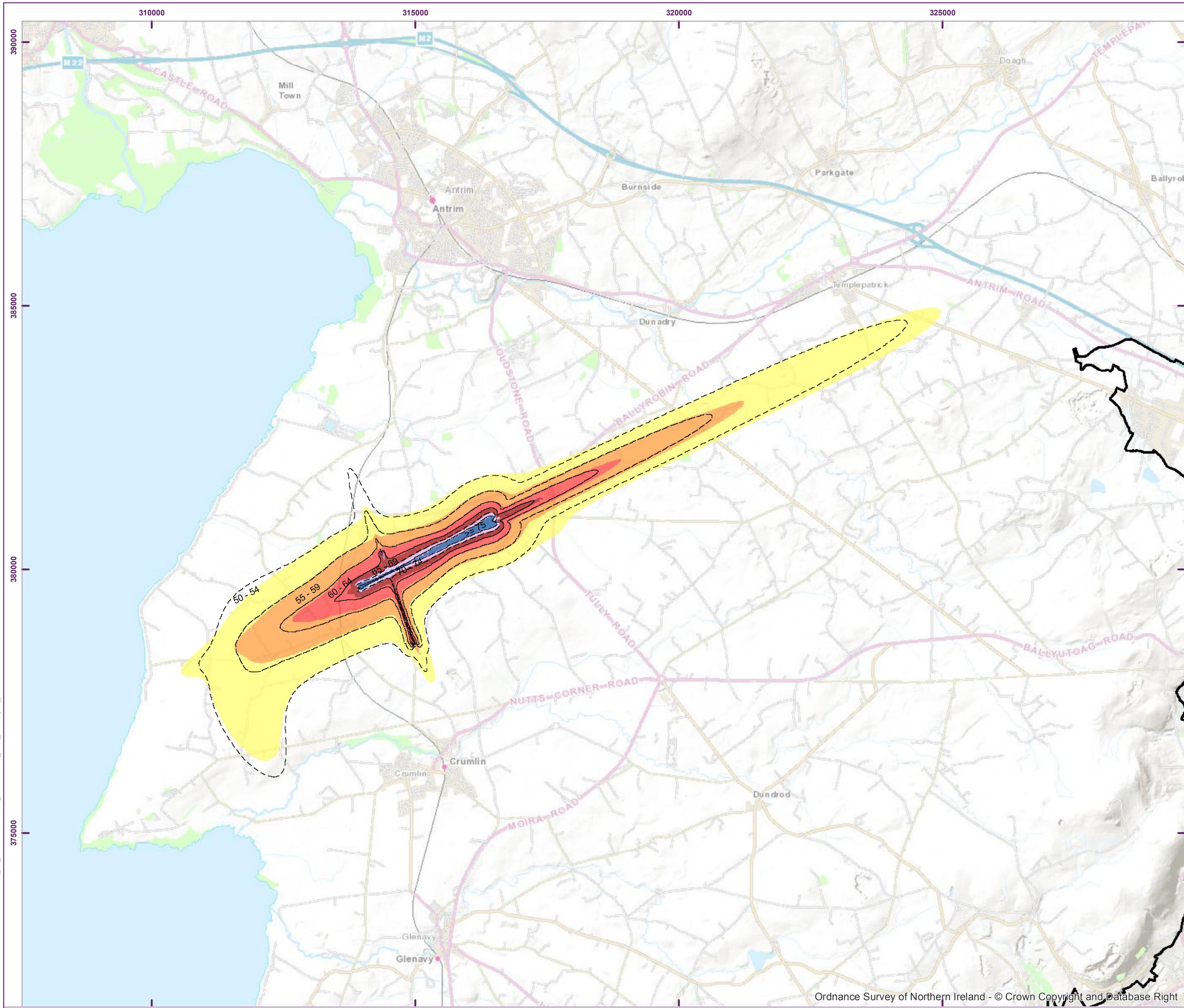
Appendix B
Round 2 Vs. Round 3 Comparison



Key

Belfast International Airport Noise Map L_{day} - All Flights

END Round Three - 2017 The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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The L_{day} is the equivalent continuous sound level in dB(A) that, over the period 07:00 – 19:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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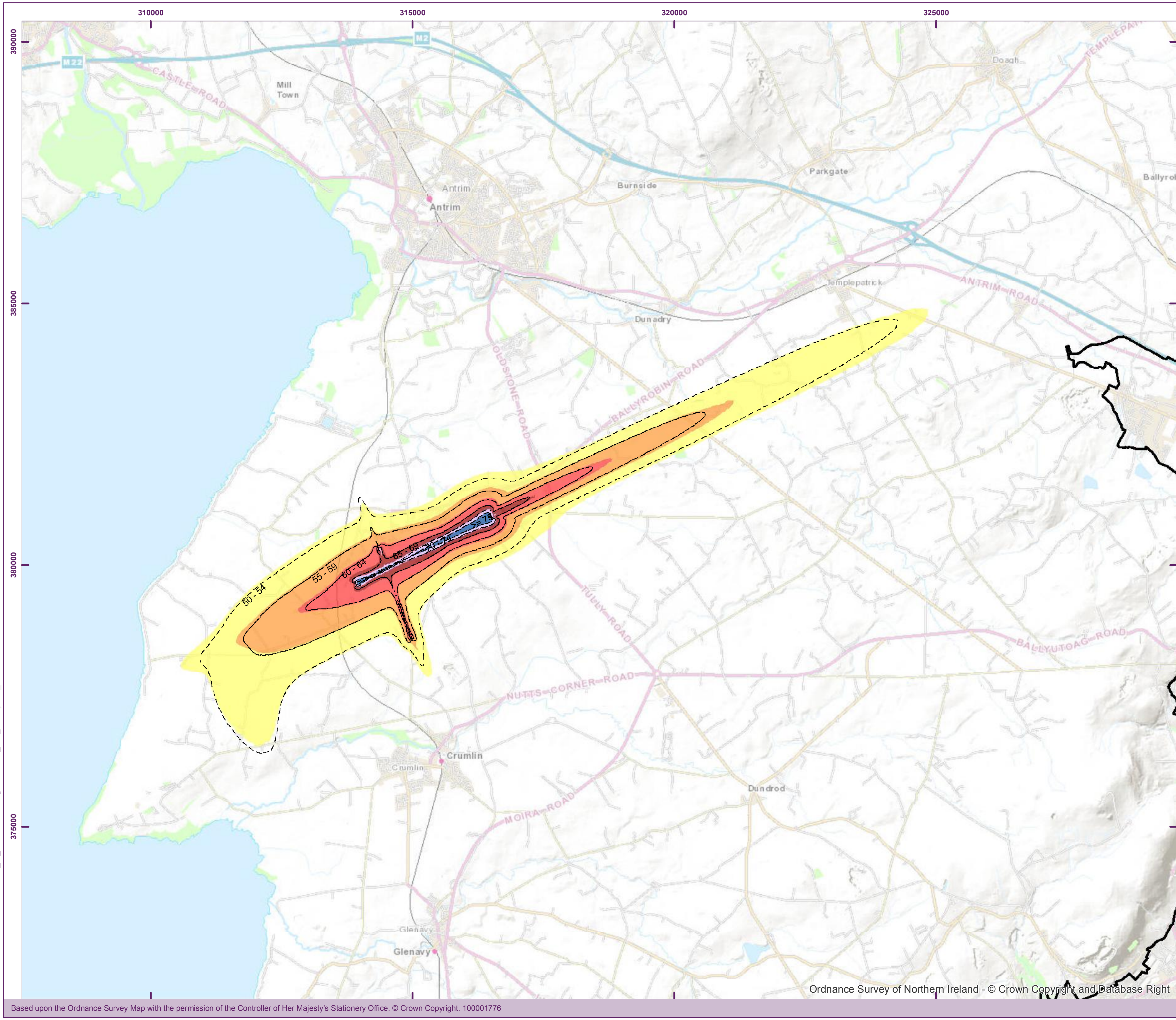

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Key

Belfast International Airport Noise Map L_{day} - Commercial Flights

END Round Three - 2017 The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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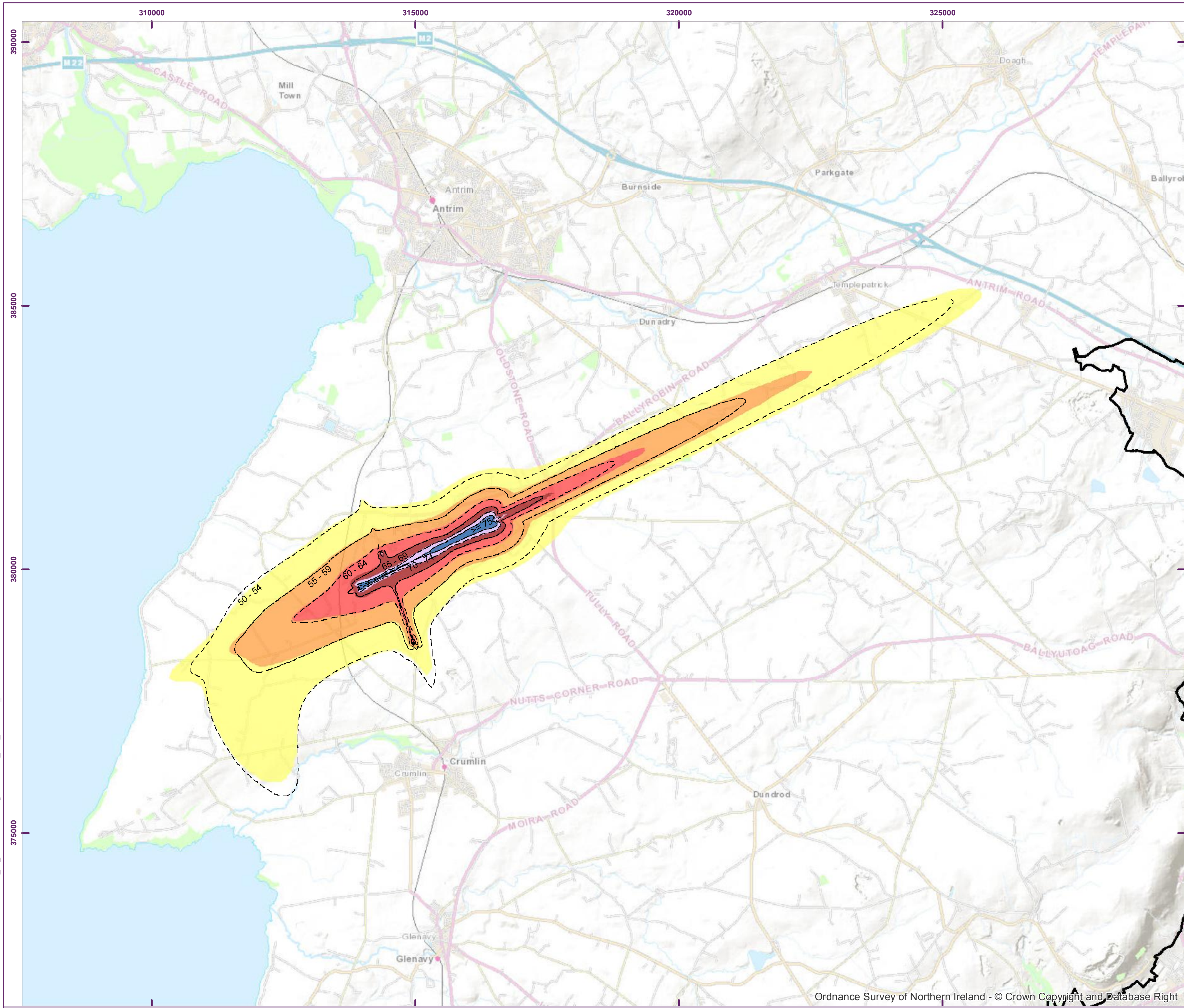

Key

Belfast International Airport Noise Map
L_{eve} - All Flights

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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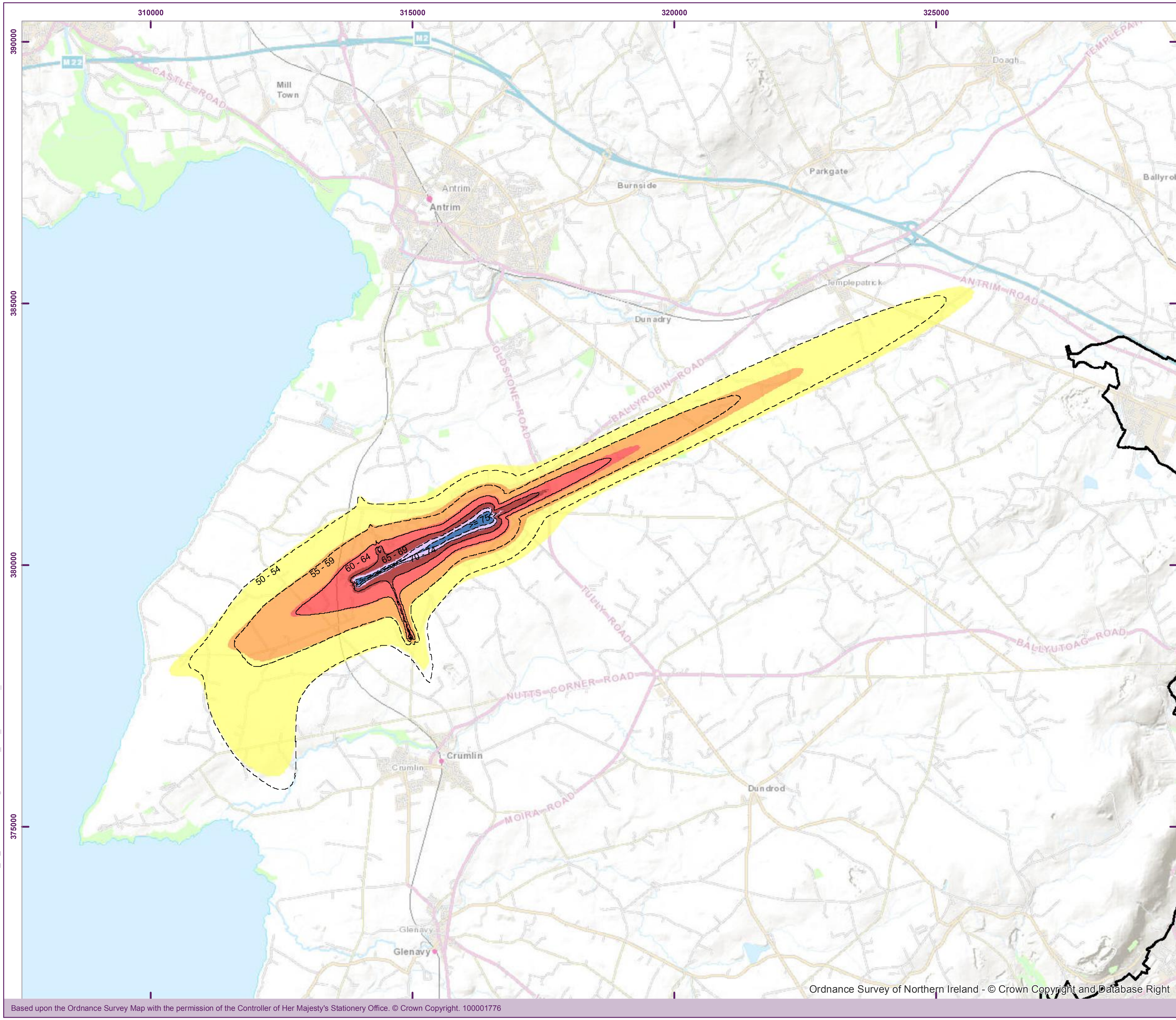

Key

Belfast International Airport Noise Map
L_{eve} - Commercial Flights

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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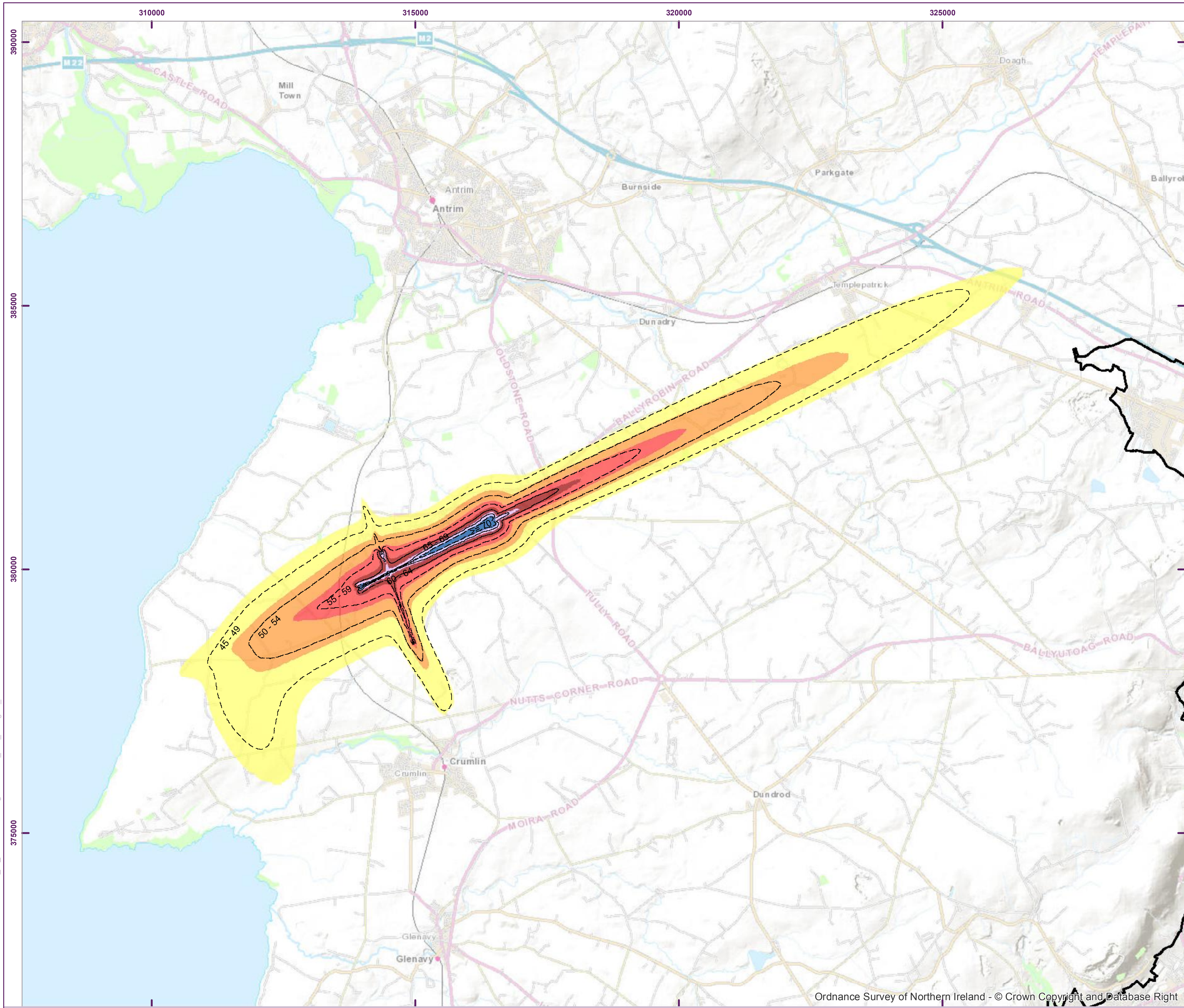
Key

Belfast International Airport Noise Map
L_{night} - All Flights

END Round Three - 2017
The Environmental Noise Regulations (Northern Ireland) 2006



Key

Noise Level (dB)

- 45 - 49
- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- > = 70
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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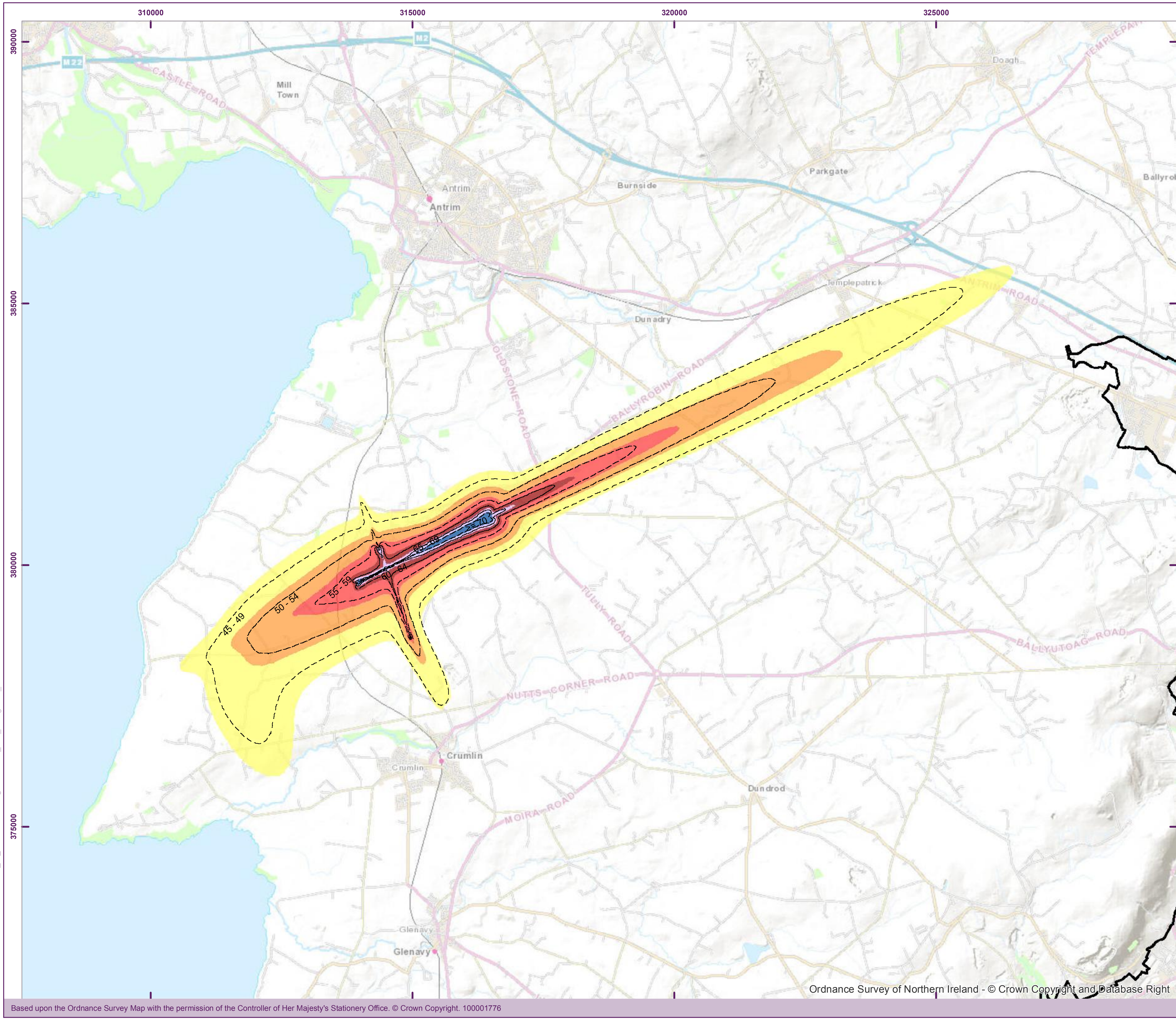

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Key

Belfast International Airport Noise Map L_{night} - Commercial Flights

END Round Three - 2017 The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 45 - 49
- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- > = 70
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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The L_{night} is the equivalent continuous sound level in dB(A) that, over the period 23:00 – 07:00 hours, contains the same sound energy as the actual fluctuating sound that occurred in that period.

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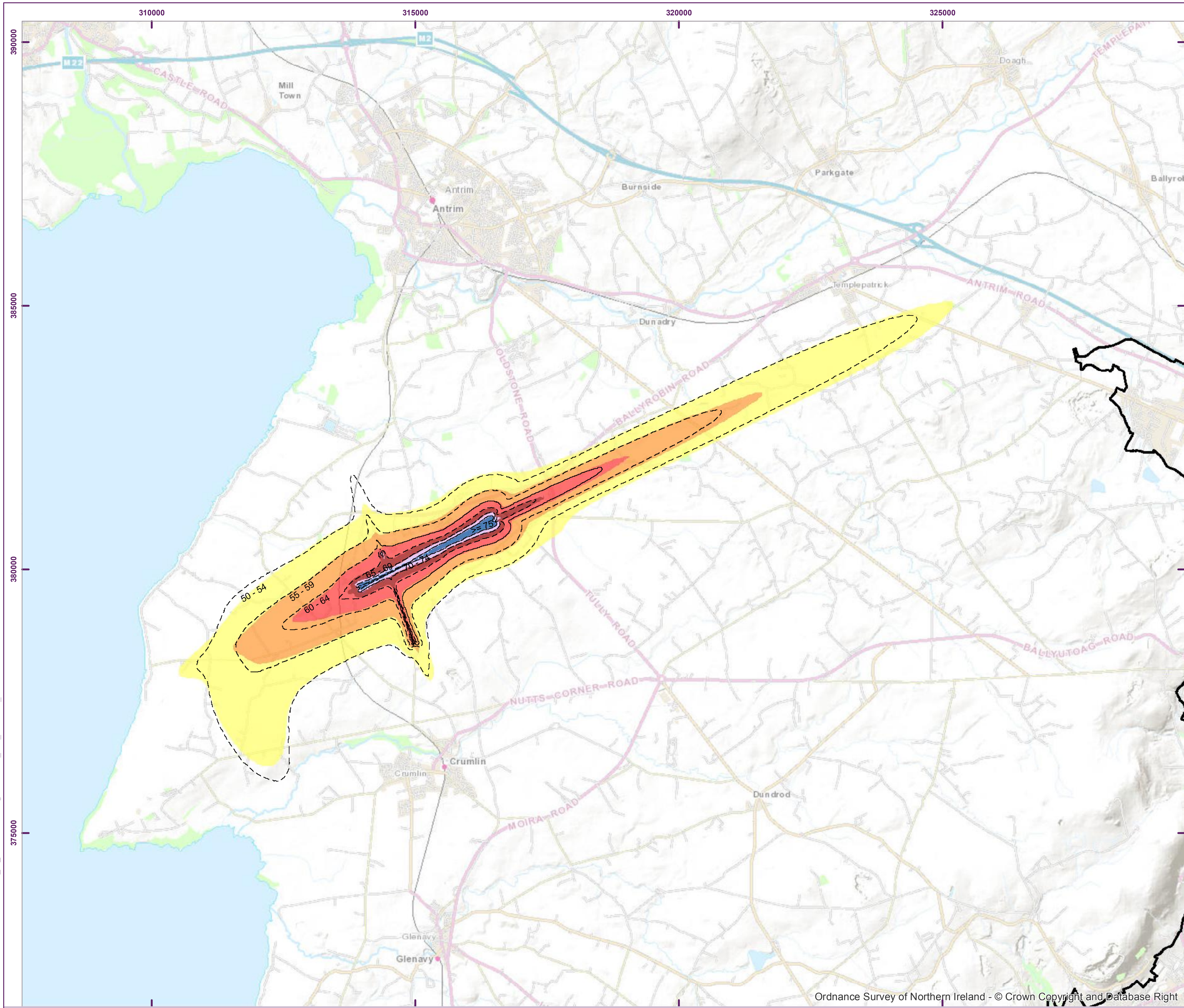
Key

Belfast International Airport Noise Map $L_{aeq,16h}$ - All Flights

END Round Three - 2017 The Environmental Noise Regulations (Northern Ireland) 2006



Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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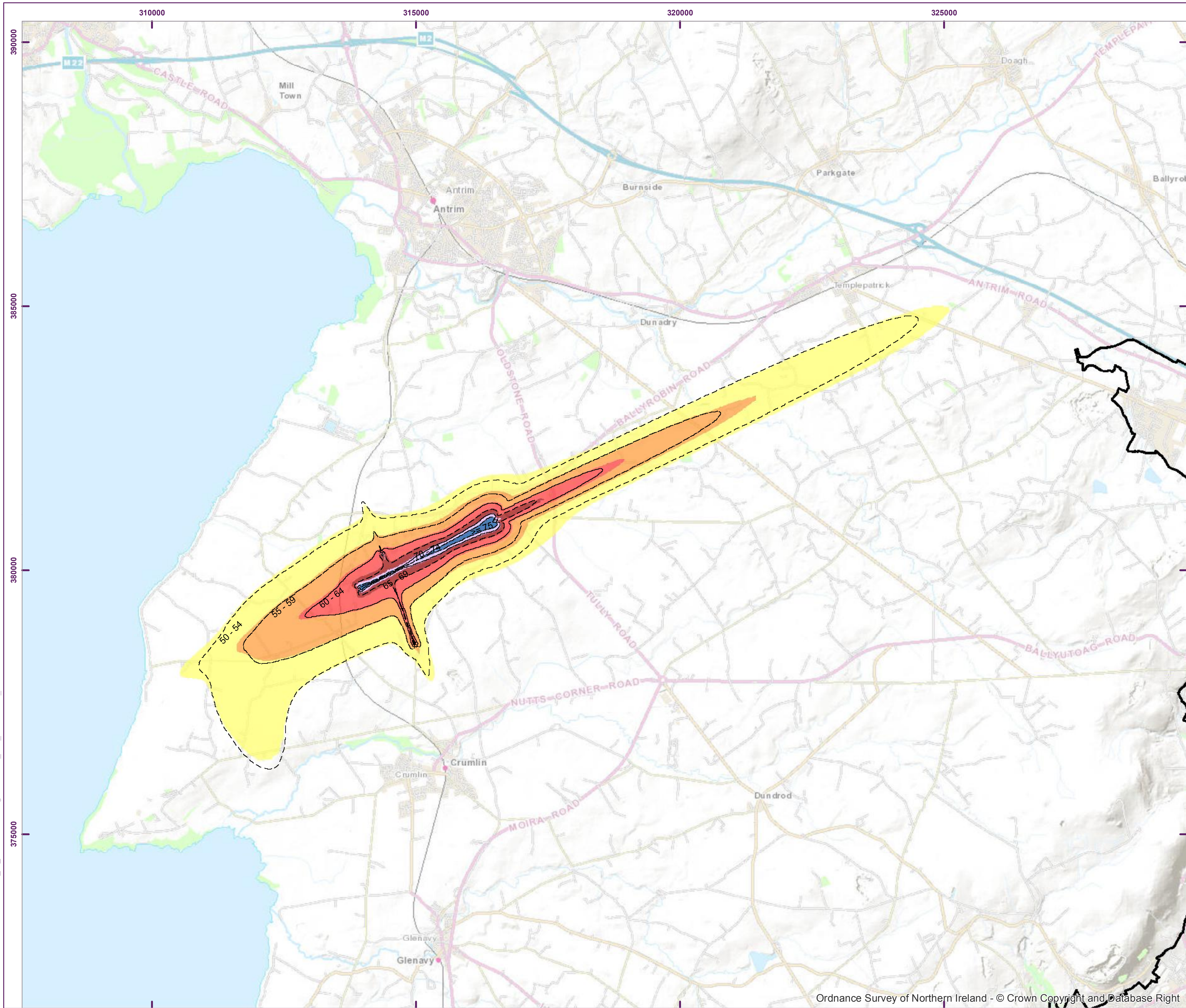

Key

Belfast International Airport Noise Map

$L_{aeq,16h}$ - Commercial Flights

END Round Three - 2017

The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

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0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

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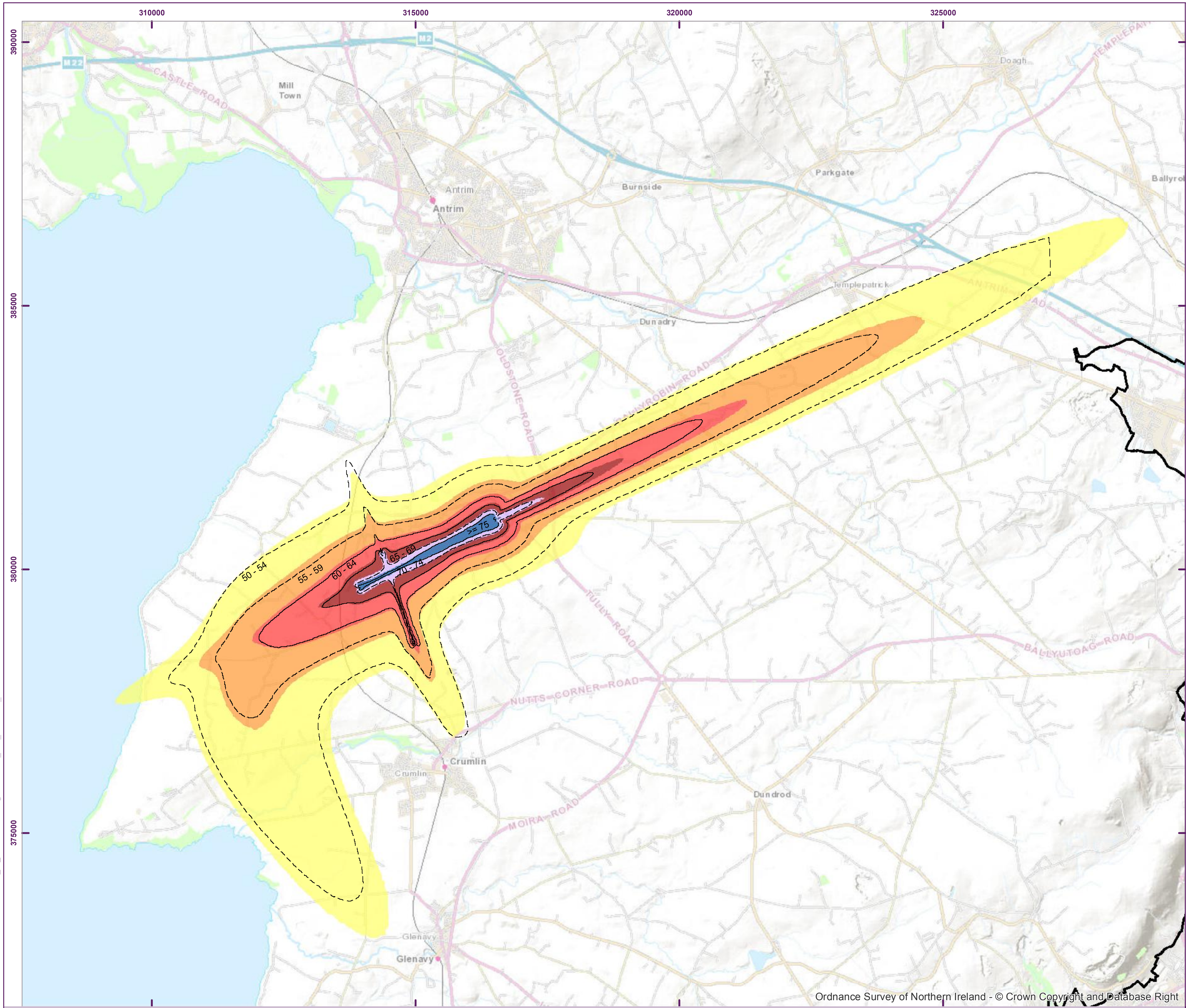

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Key

Belfast International Airport Noise Map

L_{den} - All Flights

END Round Three - 2017 The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

N

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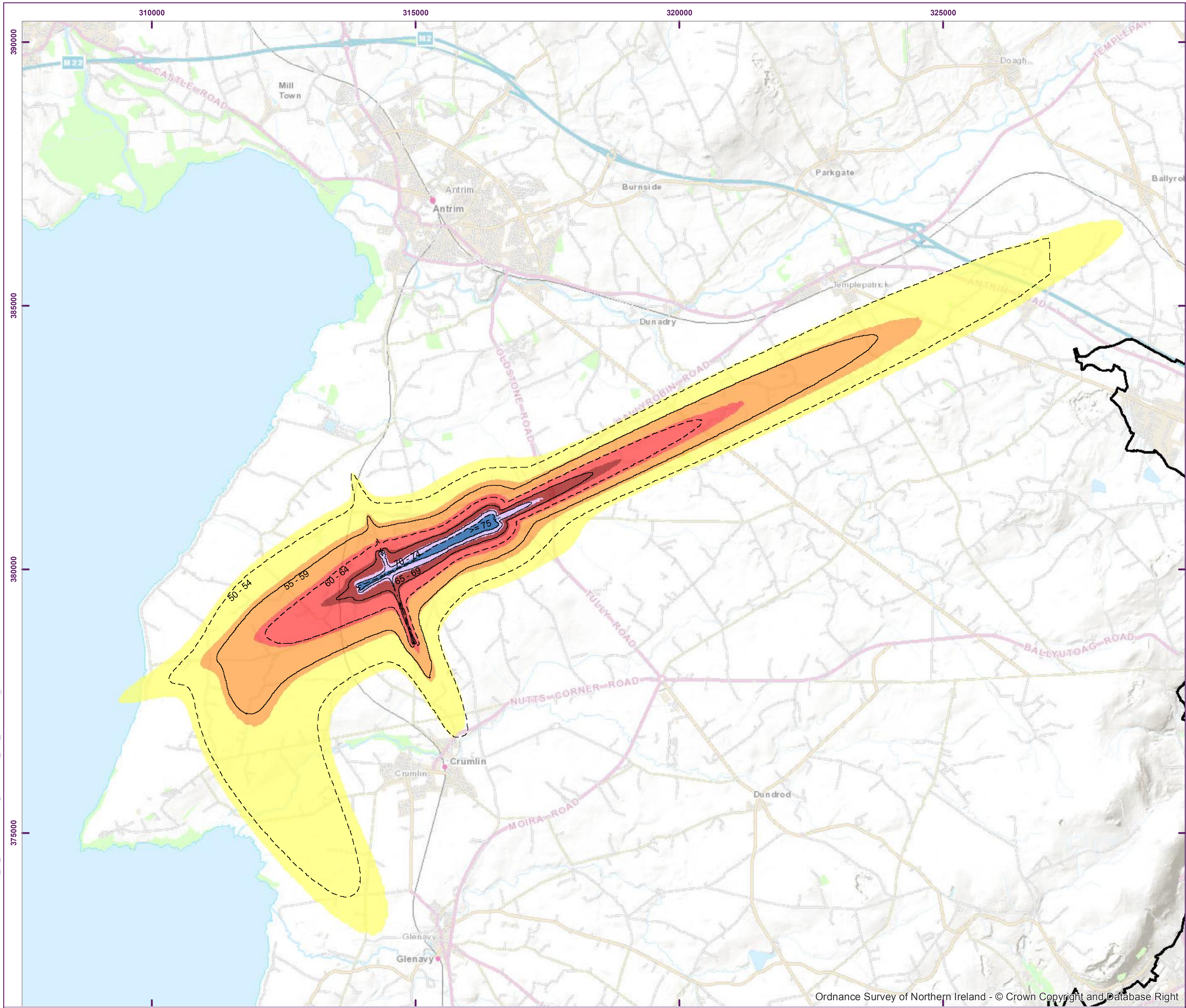

Key

Belfast International Airport Noise Map

L_{den} - Commercial Flights

END Round Three - 2017

The Environmental Noise Regulations (Northern Ireland) 2006

Key

Noise Level (dB)

- 50 - 54
- 55 - 59
- 60 - 64
- 65 - 69
- 70 - 74
- > = 75
- Belfast Agglomeration
- Round 2 Contours (dB)

0 0.5 1 1.5 2 2.5 km

Scale at A3: 1:70,000

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Appendix C
INM and IATA type lookup table

Aircraft Type	INM type	INM Database	Notes
146-1	BAE146	CORE	
A109	A109	HELI	
A139	SA330J	HELI	
A206	B206B3	HELI	
A300	A300-622R	CORE	
A300-6	A300-622R	CORE	
A300B4	A300B4-203	CORE	
A319	A319-131	CORE	
A320	A320-211	CORE	
A320-1	A320-211	CORE	
A321	A321-232	CORE	
A330	A330-301	CORE	
A330-2	A330-301	CORE	
A340-3	A340-211	CORE	
AN26	AN26	SUB	
AS355	SA330J	HELI	
AS55	HELI	HELI	
ASTR	GULF1	SUB	
AT72	ATR72	SUB	
ATP	BAEATP	SUB	
ATR42	ATR42	SUB	
B200GT	BEC200	SUB	

B206	B206B3	HELI	
B300	BEC300	SUB	
B300F4	BEC300	SUB	
B350	BEC300	SUB	
B462	BAE146	CORE	
B727-1	727100	CORE	
B733	737300	CORE	
B737	737800	CORE	Ryanair
B737-2	737QN	CORE	
B737-3	737300	CORE	
B737-4	737400	CORE	
B737-5	737500	CORE	
B737-7	737700	CORE	
B737-8	737800	CORE	
B73F	737400	CORE	
B747	747400	CORE	
B757	757RR	CORE	
B757-2	757RR	CORE	
B7672	767300	CORE	
B767-2	767300	CORE	
B7673	767300	CORE	
B767-3	767300	CORE	
B787-8	7878R	CORE	
BAE146	BAE146	CORE	
BE20	BEC200	SUB	
BE200	BEC200	SUB	

BE300	BEC300	SUB
BE40	BEC400	SUB
BE90	BEC90	SUB
BN2	BN2A	SUB
BN2T	BN2A	SUB
C130	C130AD	MILI
C152	CNA152	SUB
C17	C17	MILI
C172	CNA172	CORE
C177	CNA177	SUB
C182	CNA182	CORE
C208	CNA208	CORE
C21	LEAR35	CORE
C25A	CNA525C	CORE
C25C	CNA525C	CORE
C30J	C130AD	MILI
C310	CNA310	SUB
C402	CNA402	SUB
C406	CNA404	SUB
C425	CNA425	SUB
C510	CNA510	CORE
C525	CNA525C	CORE
C550	CNA500	CORE
C560	CNA560E	CORE
C560XL	CNA560E	CORE
C56X	CNA560XL	CORE

C650	CNA650	SUB	
C680	CNA680	CORE	
C750	CNA750	CORE	
CH47	CH47D	HELI	
CJ2	CNA525C	CORE	
CL300	CL600	CORE	
CL60	CL600	CORE	
CL604	CL600	CORE	
CL605	CL600	CORE	
CL65	CL600	CORE	
CL850	CL601	CORE	
D328	DO328	CORE	
DA42	DA42	SUB	
DA90	FAL900	SUB	
DASH8	DHC830	CORE	
DH8	DHC830	CORE	Flybe
DH8A	DHC830	CORE	
DH8D	DHC4	SUB	
DHC6	DHC6	CORE	
DHC8	DHC830	CORE	Flybe
E121	EMB120	CORE	
E145	EMB145	CORE	
E170	EMB170	CORE	
E175	EMB170	CORE	
E505	CNA560E	CORE	
E50P	CNA560E	CORE	

E55P	CNA560E	CORE
E600	EMB14L	CORE
EC120	EC130	HELI
EC135	EC130	HELI
EC145	B429	HELI
EMB120	EMB120	CORE
EMB135	EMB135	SUB
EMB145	EMB145	CORE
EMB170	EMB170	CORE
EMB190	EMB190	CORE
EMB500	CNA560E	CORE
EMB505	CNA560E	CORE
F100	F10062	CORE
F2000	FAL20A	SUB
F2TH	FAL20A	SUB
F406	CNA404	SUB
F900	FAL900	SUB
FA20	FAL20	CORE
FA7X	FAL900	SUB
G115	GROB15	SUB
G150	GII	CORE
G200	GII	CORE
G280	GII	CORE
G4	GIV	CORE
G450	GIV	CORE
G5	GV	CORE

G550	GV	CORE
G650	GV	CORE
GAZ	HELI	HELI
G-IV	GIV	CORE
GL5T	GV	CORE
GLEX	CL600	CORE
GLF4	GIV	CORE
GLF5	GV	CORE
GLF6	GV	CORE
GLOBAL	GV	CORE
H800XP	HS125	SUB
HA4T	BEC400	SUB
HAWK	HAWK	MILI
HS125	HS125	SUB
IL76	IL76	SUB
JS31	BAEJ31	SUB
KC135	KC-135	MILI
LJ45	LEAR45	SUB
LJ75	CNA550	SUB
LR 60	LEAR60	SUB
LR35	LEAR35	CORE
LR45	LEAR45	SUB
M23	SAMER2	SUB
M3	SAMER3	SUB
MD82	MD82	CORE
METRO2	SAMER2	SUB

P180	P180	SUB
P68	DHC6	CORE
PA22	PA22CO	SUB
PA23	PA23AP	SUB
PA28	PA28	CORE
PA31	PA31	CORE
PA31T	PA31	CORE
PA32	PA32C6	SUB
PA42	PA42	CORE
PA46	PA46	SUB
PC12	PC12	SUB
PN68	DHC6	CORE
PRM1	LEAR35	CORE
PUMA	HELI	HELI
R1	CL600	CORE
R44	HELI	HELI
RJ85	BAE146	CORE
RRJ-95	EMB175	CORE
S20	SAAB20	SUB
S2000	SAAB20	SUB
S340	SF340	CORE
S76	S76	HELI
S92	S76	HELI
SA226	SA226	SUB
SF34	SF340	CORE
SIRA	GASEPV	CORE

SK61	HELI	HELI
SR22	SR22	SUB
SW4	SAMER4	SUB
TB20	STBM7	SUB
TBM7	STBM7	SUB
TBM8	STBM7	SUB
TBM9	STBM7	SUB
TOR	TORNAD	MILI
TORN	TORNAD	MILI
TU204	TU204	SUB