GEORGE BEST BELFAST CITY AIRPORT

AIRBORNE AIRCRAFT NOISE CONTOURS

2008

Report to

George Best Belfast City Airport
Sydenham By Pass
Belfast
BT3 9JH

[illegible]01/DC/R01
September 2008

CONTENTS

1.0 INTRODUCTION

Noise contours have been predicted for the 92 day summer period in 2008 using the actual aircraft movements and the Federal Aviation Administration (FAA) prediction methodology, the Integrated Noise Model (INM) Version 7.0a. This methodology has been validated using initial results from the noise monitoring terminals (NMTs) recently installed at George Best Belfast City Airport (BCA) for the most common aircraft operating there.

Noise contours have been produced annually for BCA for several years. Those for 2007 were reported in Bickerdike Allen Partners (BAP's) report Ref: A7794/AH/R01-Rev1 dated October 2007. They were subsequently reproduced following the release of a significantly revised version of the INM software, version 7.0, and reported in BAP's report Ref: A7864/AH/R01 Rev1 dated February 2008. In this report the 2007 contours produced using INM version 7.0 are contained for comparison purposes.

This report sets out the assumptions used in the computation of the contours for 2008. The resulting contours are also included as are population counts for the key noise exposures. The Terms of Reference for this study were prepared by the airport in conjunction with BAP.

2.0 AIRCRAFT OPERATIONS

2.1 General

The aircraft movement data, submitted by BCA in terms of daily ATC logs, has been assessed in relation to aircraft type, departure and arrival route, stage length and runway usage to enable input into the noise computation program, the INM. This section of the report describes how this briefing information has been compiled in a form suitable for analysis purposes and considers the following:

- Traffic Distribution by Aircraft Type
- Flight Tracks
- Dispersion
- Flight Profiles
- Traffic Distribution by Route

2.2 Traffic Distribution by Aircraft Type

The basis for the noise contours are the actual movements in 2008 during the 92 day summer period. This is the usual period taken when producing noise contours in the U.K. and in most cases represents a worst case as airport traffic generally peaks in the summer due to holidays.

The actual movements are a combination of the passenger movements, the freight movements, and the non commercial movements which include any training flights. Detailed information was provided for all aircraft movements during the busy 92 day period in 2008. Although there are a number of early morning movements over the 92 day period, for the purposes of this study all movements are assumed to take place within the "daytime period" of 0700 hours to 2300 hours.

As with all modelling programs every aircraft type is not specifically included in the INM model and substitutions are used. This is particularly the case with the smaller types. For each of the actual aircraft types the recommended INM aircraft type has been substituted, for the majority of the larger aircraft this does not involve a change but for the smaller types, and in particular the general aviation aircraft several aircraft types have been grouped together.

The movements have then been sorted by these INM types, and this highlighted a number of aircraft types where the total number of arrival and departure movements in the 92 day period is very low. These are generally the smaller aircraft forming part of the non commercial movements. For these types the few movements have been combined with more common types which have similar noise certification levels.

Table 2.1 shows the aircraft split over the 92 day summer period and how these have been modelled in INM.

Aircraft Type	INM Designator	Total No. of Movements over 92 Days	% of Total Movements
Boeing 737-800	737800	1658	15.32%
Airbus 319	A319-131	986	9.11%
Airbus A320	A320-232	388	3.58%
Avons Transport Regional ATR42-300	DHC830[1]	28	0.26%
Beech Barron 58P	BEC58P	12	0.11%
Exec Jet	CIT3	39	0.36%
Regional Jet	CL600	8	0.07%
GA Single	CNA172	4	0.04%
Pilatus PC12	CNA441	51	0.47%
Executive Jet	CNA500	22	0.20%
Executive Jet	CNA750	4	0.04%
Douglas DC3	DC3	32	0.30%
Let L-410	DHC6	619	5.72%
Dash 8-400	DHC830[1]	3846	35.54%
Embraer 145	EMB145	319	2.95%
Embraer 195	GV[1]	1379	12.74%
Global Express	F10065	4	0.04%
GA Single, Variable Pitch Prop.	GASEPV	18	0.17%
Gulfstream GIV	GIV	15	0.14%
ATR 72	HS748A[1]	917	8.47%
Executive Jet	LEAR35	99	0.91%
Executive Jet	MU3001	42	0.39%
Piper PA31	PA31	160	1.48%
Saab 340	SF340	152	1.40%
		10822	**100.00%**

Table 2.1 Aircraft Types used in INM 2008

Note 1. For the types highlighted initial validation has found modification are required to the INM standard assumptions as detailed in Section 3.1.2.

The actual non commercial movements from 2008 also include 124 movements by helicopters. Earlier versions of the INM software were not able to model helicopter movements and so they were excluded for the contours produced for 2005, 2006, and 2007. Given the noise output of the helicopter movements and considering they comprise just over 1% of the total movements with a prevalence of larger jet aircraft, their continued omission is not considered significant to the overall contours and is consistent with previous contouring.

Aircraft types and associated movement numbers used to generate the 2007 INM contours are given in Table 2.2.

Aircraft Type	INM Designator	Total No. of Movements over 92 Days	% of Total Movements
Boeing 737-700	737700	290	2.57%
Airbus A321	A32123	68	0.60%
Airbus A320	A32023	1152	10.22%
Airbus 319	A319	307	2.72%
BAe 146-200	BAE146	18	0.16%
BAe 146-300	BAE300	1431	12.70%
Beech Barron 58P	BEC58P	72	0.64%
Regional Jet	CL600	8	0.07%
Executive Jet	CNA500	94	0.83%
Dash 8-400	DHC830[1]	5985	53.11%
Let L-410	DHC6	528	4.69%
Embraer 145	EMB145	796	7.06%
GA Single, Variable Pitch Prop.	GASEPV	10	0.09%
Gulfstream GV	GV	53	0.47%
ATR 72	HS748A	294	2.61%
Executive Jet	LEAR35	78	0.69%
Executive Jet	MU3001	86	0.76%
		11270	**100.00%**

Table 2.2 Aircraft Types used in INM 2007

Note 1: Shorts 330 (INM type SD330) and Dash 8-300 used for Dash 8-400 approaches and departures respectively (see Section 3.0).

Although the overall movement numbers are very similar in 2008 to 2007, they have reduced by around 4%, the mix of aircraft types has changed significantly. In 2007 over half the movements were by the Dash 8-400 whereas in 2008 this type only conducted just over one third of the movements. Conversely the activity by the Airbus and Boeing types has increased. In 2007 these larger aircraft, mainly Airbus A320's, performed around 16% of the movements. In 2008 these types, mainly Boeing 737-800's and Airbus A319's, performed 28% of the movements. Another change is the replacement of the BAe 146 movements in 2007, almost 13% of the total, with a similar number of Embraer 195 movements in 2008.

2.3 Flight Tracks

The standard arrival and departure tracks at George Best Belfast City Airport have been used. The main departure tracks are shown in Figure 1.

2.4 Traffic Distribution by Route

The overall runway usage during the 2008 summer period is given in Table 2.3. For the modelling the actual usage by aircraft type was used.

Runway	Arrivals	Departures
04	20.7%	30.9%
22	79.3%	69.1%

Table 2.3 Actual Runway Usage

For each runway there is a single arrival route but there are three assumed departure routes on runway 04 and just one initial departure route on runway 22. To determine the split of departures between these three routes on runway 04, the aircraft movements have been separated into small propeller, large propeller and jet aircraft. The Air Pilot stipulates that small propeller aircraft should commence their turn when they reach 1500ft, large propeller aircraft when they reach 2000ft, and jet aircraft when they reach 3000ft. On review of the aircraft used at George Best Belfast City Airport, this resulted in three departure routes with the turns occurring at approximately 6 km, 8 km and 11 km from the start of roll.

2.5 Dispersion

Aircraft on departure are allocated a departure route to follow. In practice, this route is not followed precisely by all aircraft allocated to this route. The actual pattern of departing aircraft is dispersed about the route's main track. The degree of dispersion is normally a function of the distance travelled by an aircraft along the route after take-off and also on the form of route. The INM model allows this dispersion about the departure tracks to be taken into account. The effect on the contours is to slightly widen the contours where departure noise dominates.

When considering many departures, it is commonly found that the spread of aircraft approximates to a "normal distribution" pattern, the shape or spread of which will vary with distance along the route. A simplified mathematical model can be adopted to represent a normal distribution of events, based on standard deviations. Airport noise modelling commonly assumes that there are five "dispersed" tracks associated with each departure route.

The allocation of movements adopted in this case to the main and sub tracks is as follows:

- 53.3% departures along the main track;
- 22.2% departures split equally along two inner sub tracks either side of the main track and offset by a distance of 1.355 standard deviations;
- 1.15% departures split equally along two outer sub tracks either side of the main track and offset by a distance of 2.71 standard deviations.

The resultant dispersion scenario for all routes is shown in Table 2.4.

Distance from SOR (km)	Outer Track Displacement (m)
End of Runway	0
3.5	105
4.0	211
4.5	323
5.0	434
5.5	556
6.0	678
6.5	792
7.0	905
7.5	1007
8.0	1109
8.5	1184
9.0	1260
9.5	1324
10.0	1387
10.5	1444
11.0 and above	1500

Table 2.4 Assumed Dispersion (All Routes)

These dispersion assumptions have been adopted for several years at BCA. The new noise and radar track keeping system will allow in future years these to be checked.

2.6 Flight Profiles

For the departure movements the INM model offers a number of standard flight profiles for most aircraft types, and in particular for the larger aircraft types. These relate to different departure weights which are greatly affected by the length of the flight, and consequently the fuel load. In the INM model this is referred to as the stage length and is initially in increments of 500 nautical miles. The INM model assumes all aircraft take off with a full passenger load irrespective of stage length. As the stage length increases the aircraft has to depart with greater fuel and so its flight profile is slightly lower than when a shorter stage length is flown.

The standard option when producing contours using INM is to use destination information for the departures to select the stage length for determining the departure flight profile. For all aircraft operating from the airport stage length 1 is assumed with the exception of the Airbus A320. For this aircraft type following the initial validation exercise, discussed in Section 3.1.2, stage length 2 has been used.

3.0 INM MODEL

3.1 Methodology

3.1.1 General

All contours, footprints and population counts are determined using the Integrated Noise Model (INM) version 7.0a software and a postcode/population database.

The Integrated Noise Model (INM) software evaluates aircraft noise in the vicinity of airports using flight track information, aircraft fleet mix, standard defined aircraft profiles, user-defined aircraft profiles and terrain. INM is used to produce noise exposure contours as well as predict noise levels at specific user-defined sites.

INM allows population points to be defined in a particular study. Each point consists of a Point ID, a latitude, a longitude and a population value for the point. If the population point lies within the threshold of a particular contour then the population value is included in the total count within the contour.

The population data has been derived from census information and has been supplied by CACI Ltd. Strictly for the contours produced for 2007 and before the population data was the CACI Ltd estimate for 2005. For the 2008 contours the population data is their estimate for 2007.

3.1 2 Assumptions

George Best Belfast City Airport data relevant to the INM study is taken from the latest edition of the UK Aeronautical Information Package.

As with all modelling programs not every aircraft type is specifically included in the INM model and substitutions are required. Details regarding aircraft types are given in Section 2.2.

A 3.0° approach angle is used for all aircraft and the ground topography is assumed to be flat. The INM default headwind of 14.8 km/hr and hard ground lateral attenuation is assumed.

For some aircraft types it has been necessary to modify the standard INM assumptions. This was done for the earlier contours, including those for 2007, where the INM predictions did not agree with the FAA certification data for specific aircraft. With the partial installation of the permanent Noise Monitoring Terminals (NMTs) at BCA a significant amount of measured noise data is now available. This has been used in an initial NMT validation exercise to review the INM assumptions for the common aircraft types in 2008 and is detailed in Appendix A.

The initial NMT validation exercise found that modifications were required for three aircraft types, the Avons Transport Regional ATR72, Dash 8-400 and Embraer 195 and these have been incorporated into the 2008 contours. In addition the earlier finding based on FAA certification data for the Avons Transport Regional ATR42-300 has been incorporated into the contours, as there were insufficient measurements of this type to update it.

The result of this validation is that the noise characteristics of these aircraft have been adjusted by modifying the INM aircraft used and/or the actual movement numbers flown during the period. These are detailed in Table 3.1

Initial INM Type	Substitution	Modification to Movement Numbers	
		Departures	Arrivals
Avons Transport Regional ATR42-300	DHC830/SD330	DHC830 x 2.7	SD330 x 1.4
Avons Transport Regional ATR72	DHC6	DHC6	DHC6
Dash 8-400	DHC6/SD330	DHC6	SD330 x 1.3
Embraer 195	A319-131	A319-131 x 1.6	A319-131 x 2.0

Table 3.1 Modifications to INM Assumptions

4.0 RESULTS

4.1 Daytime (16h) Contours

Noise contours have been produced for the 16 hour daytime period, 07:00 hours to 23:00 hours, based on the actual movements for the summer 92 day period in 2008. The 16 hour daytime contours of this type, shown in Figure 2, have been used for many years in the UK to assess noise impact. Contour areas are given in Table 4.1 and are compared with the contour areas for 2007.

Figure 3 shows a comparison between the 63 dB $L_{Aeq,16hr}$ daytime contour based on the 2008 movements and the DoE indicative contour. The 2008 contour is slightly wider than the indicative contour in some locations. However, there are no residential properties at these locations. Figure 4 shows a comparison between the 60 dB $L_{Aeq,16hr}$ daytime contour based on the 2008 movements and the DoE indicative contour. The 2008 contour is again slightly wider than the indicative contour in some locations and contains some additional properties located in Sydenham near the A2.

Figures 5 to 7 show comparisons between the 2008 and 2007 for the 63, 60 and 57 dB $L_{Aeq,16hr}$ contours respectively. Table 4.1 shows the difference in area between the 2008 and 2007 $L_{Aeq,16hr}$ contours.

Contour Level $L_{Aeq,16h}$, dB	Area of Daytime Air Noise Contours (km^2)		Increase in Contour Area
	2007	2008	
54	7.657	9.601	25.4%
57	3.831	5.153	34.5%
60	1.921	2.586	34.6%
63	1.016	1.313	29.2%
66	0.585	0.735	20.4%
69	0.363	0.458	26.2%

Table 4.1 Comparison between 2007 and 2008 Noise Contour Areas

Table 4.1 shows that the 2008 54 dB $L_{Aeq,16hr}$ contour increases by approximately 25% compared with 2007. Figures 5 to 7 show that although the 2008 and 2007 contours are similarly shaped, the 2008 contour is longer and significantly wider toward the south.

There is a small technical difference in the production contours in that the version of the INM software used varies, the 2008 contours being produced using version 7.0a and the 2007 contours version 7.0. The changes from version 7.0 to 7.0a are not related to the calculation algorithms and are largely to correct problems with the earlier version so this is not expected to be the cause of the increase.

The contours also differ in the validation used to check the INM assumptions used, with that for the 2008 contours being largely based on NMT data at BCA and that for the 2007 contours being based on FAA certification data. As described in Appendix A comparison has been made between contours for 2007 produced using both validations and little difference found.

The cause of the change is therefore largely attributed to the change in the aircraft mix.

4.2 Population Counts

Population counts for the 2008 and 2007 $L_{Aeq,16hr}$ daytime contours are given in Table 4.2 and Table 4.3.

Contour Level $L_{Aeq,16h}$, dB	Population	
	2007	2008
54	12084	18859
57	3522	7819
60	28	1442
63	0	0
66	0	0
69	0	0

Table 4.2 Comparison between 2007 and 2008 Population Counts – Cumulative Totals

Year	Population by Contour Band (dB $L_{Aeq,16h}$)						Total
	> 69	66 - 69	63 - 66	60 - 63	57 - 60	54 - 57	
2007	0	0	0	28	3494	8562	12084
2008	0	0	0	1442	6377	12482	18859

Table 4.3 Comparison between 2007 and 2008 Population Counts

The increase in population included within the 2008 contours compared to the 2007 contours is due to the fact that the 2008 contour is longer and significantly wider toward the south. This results in more population in the Sydenham and Ballymacarrett area of the city being included in the 2008 contours than the 2007 contours. As noted earlier the populations for 2008 are determined from updated data from CACI Ltd but this change is not expected to be a significant cause of the increase.

5.0 SUMMARY

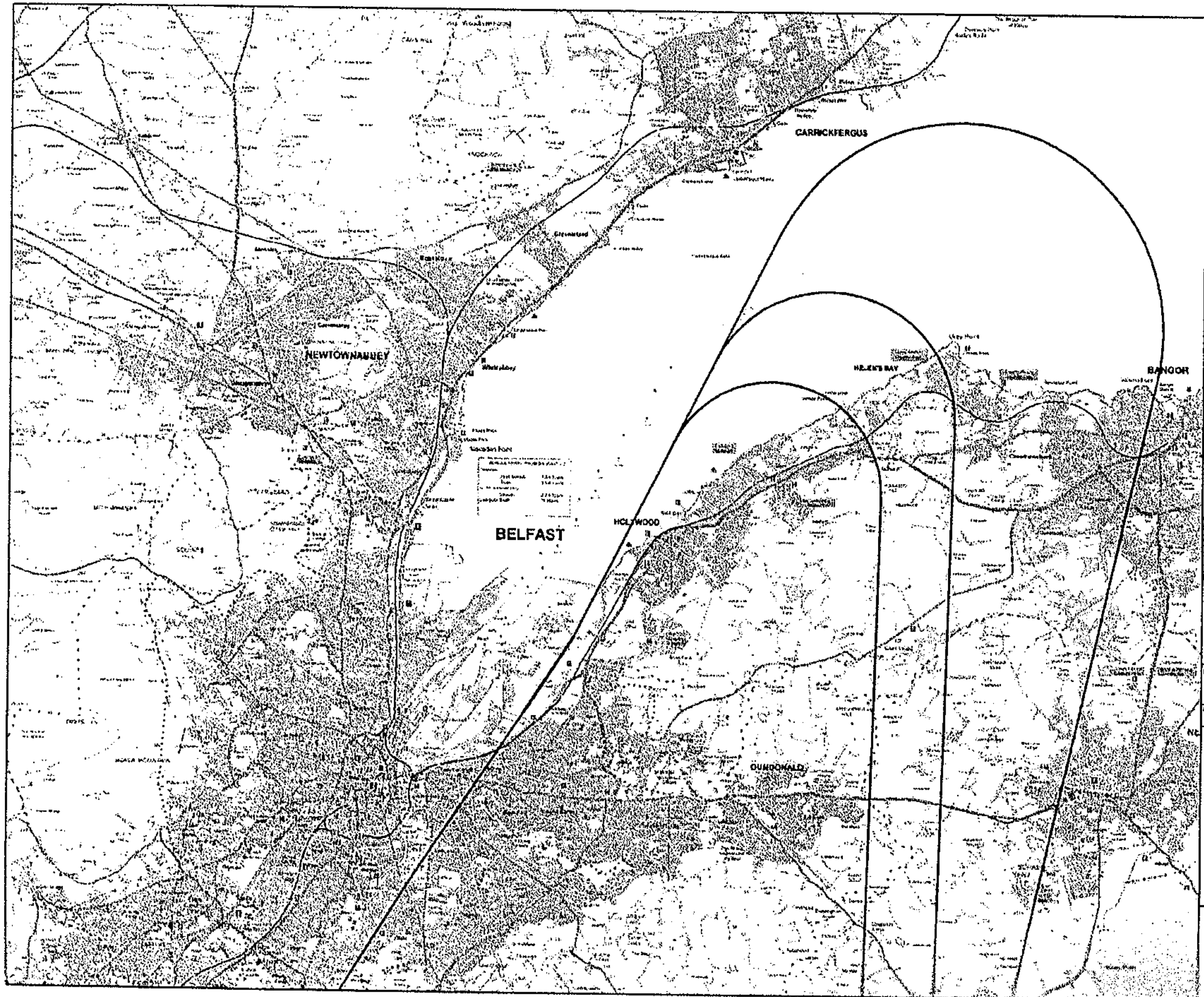
$L_{Aeq,\ 16h}$ noise contours have been produced, and population counts made, based on the actual movements during the 92-day, summer period in 2008.

The 2008 contours do exceed the indicative contours by a small amount but the areas within the increased areas are generally non-residential. The exception is for the 60 dB $L_{Aeq,16h}$ contour where an area of Sydenham near the A2 is included in the 2008 contour but not the indicative contour.

The 2008 $L_{Aeq,16hr}$ contours are larger than the 2007 $L_{Aeq,16hr}$ contours. The 2008 57 dB $L_{Aeq,16hr}$ contour increases by approximately 35% compared with 2007. This is attributed to the significant change in the mix of aircraft types operating at BCA.

The population included within the 2008 contours is greater than that included within the 2007 contours. This is due to 2008 contour being longer and wider toward the south. This results in more population in the Sydenham and Ballymacarrett area of the city being included in the 2008 contours than the 2007 contours.

David Charles	Jeff Charles	Peter Henson
for Bickerdike Allen Partners	Consultant	Partner



— Departure Routes

Drawing Number

Figure 1

Drawing Title

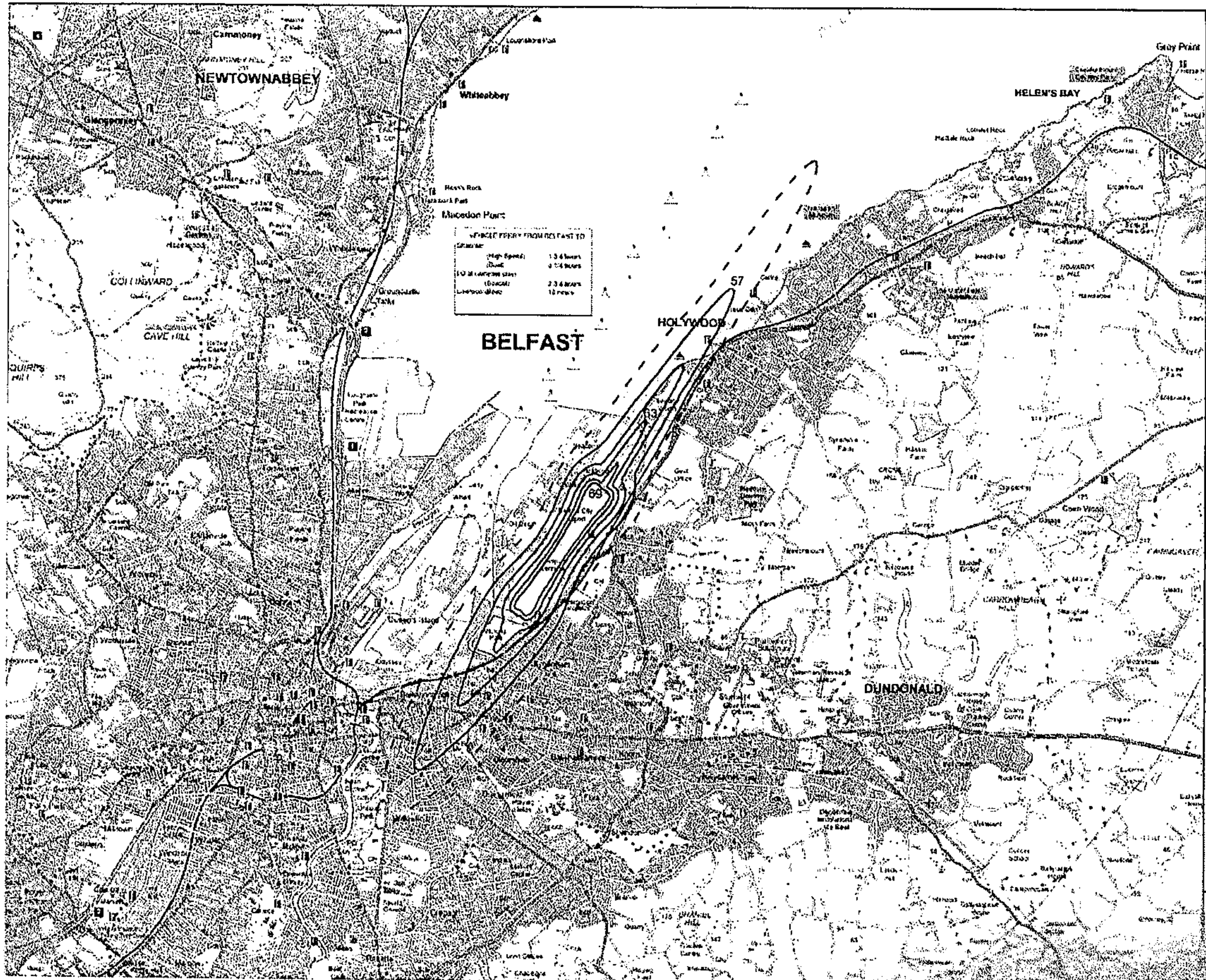
Departure Routes

Scale at A3

1:75000

Date

September 2008



INM v7.0a 2008 Noise Contour

Drawing Number	Figure 2
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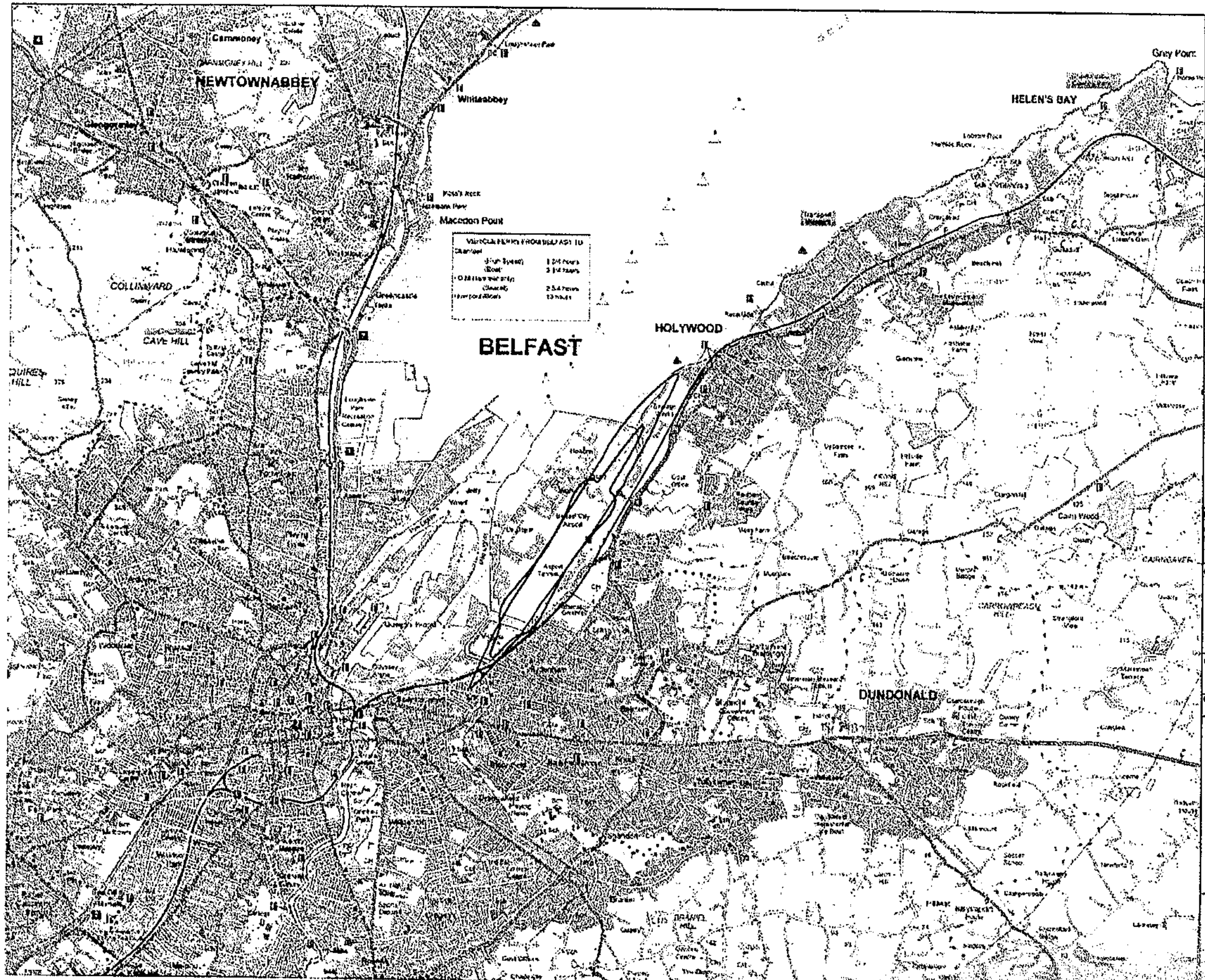
Date	September 2008



Drawing Number

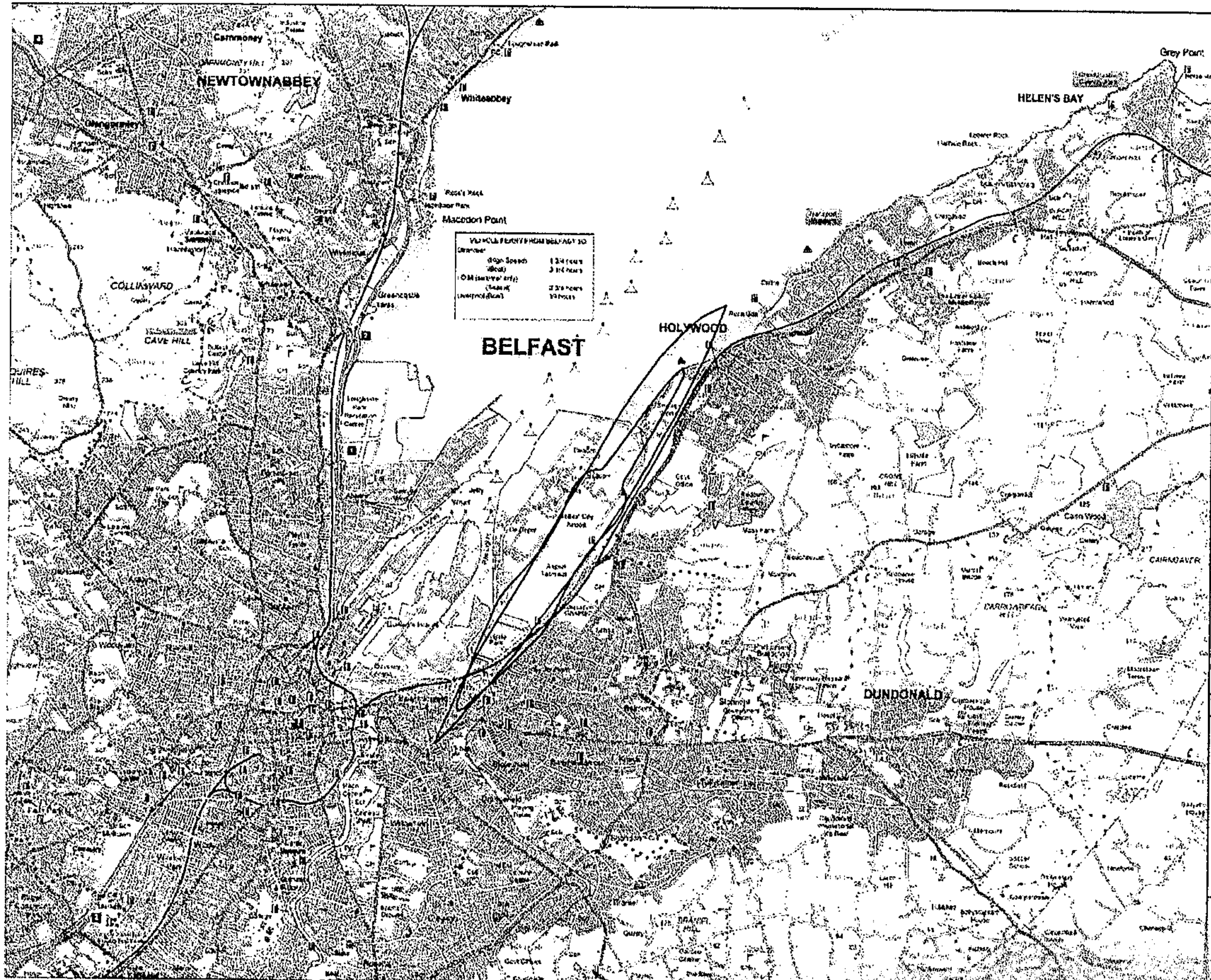
Figure 3

Drawing Title

Comparison of Daytime Noise Contour 2008 with DoE Indicative Noise Contour 63 dB $L_{Aeq,16h}$

1:50000

September 2008



— INM v7.0a 2008 Noise Contour
— DoE Indicative Noise Contour

Drawing Number
Figure 4

Drawing Title
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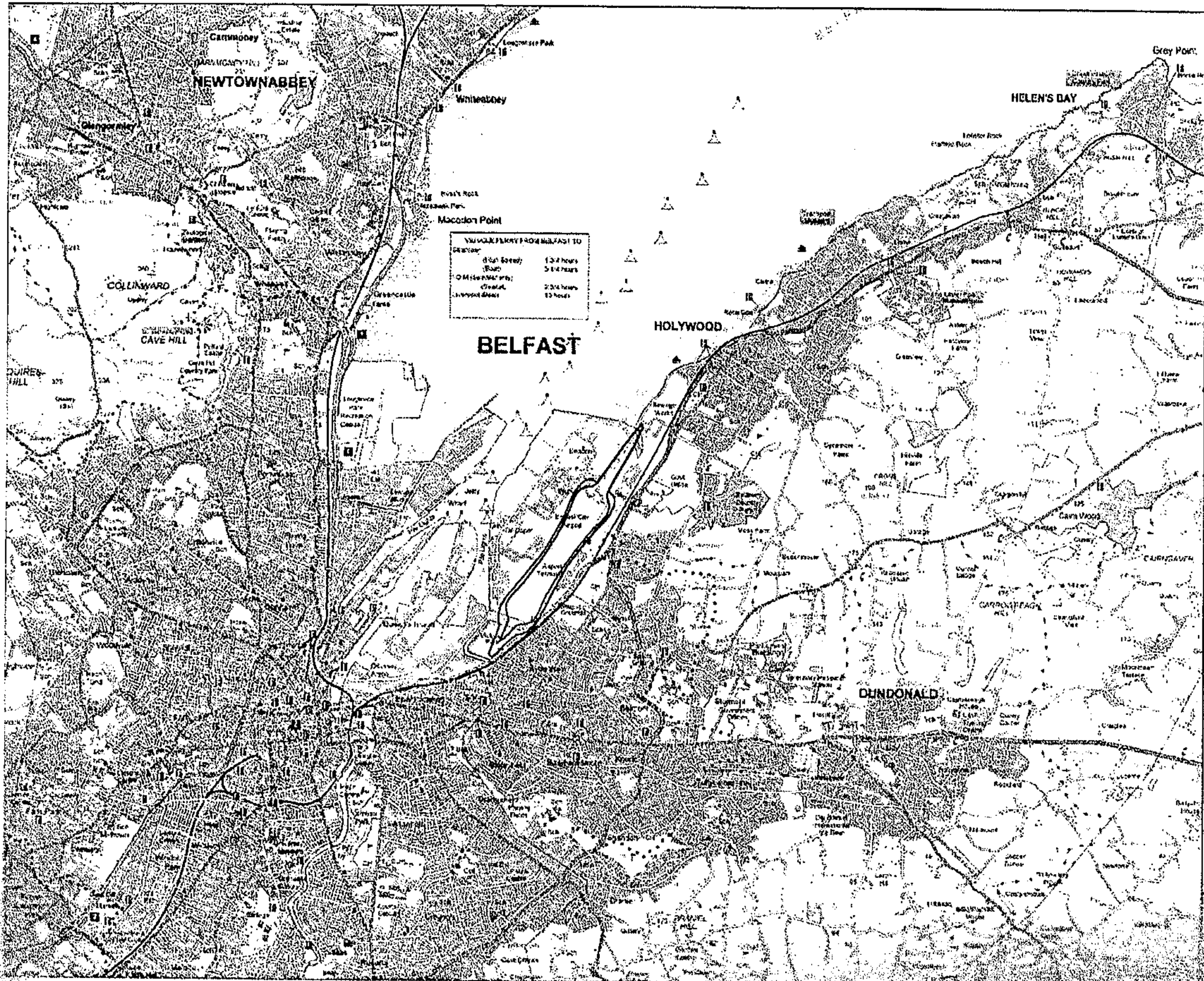
1:50000

September 2008



— INM v7.0a 2008 Noise Contour

— INM v7.0 2007 Noise Contour

Drawing Number

Figure 5

Drawing Title

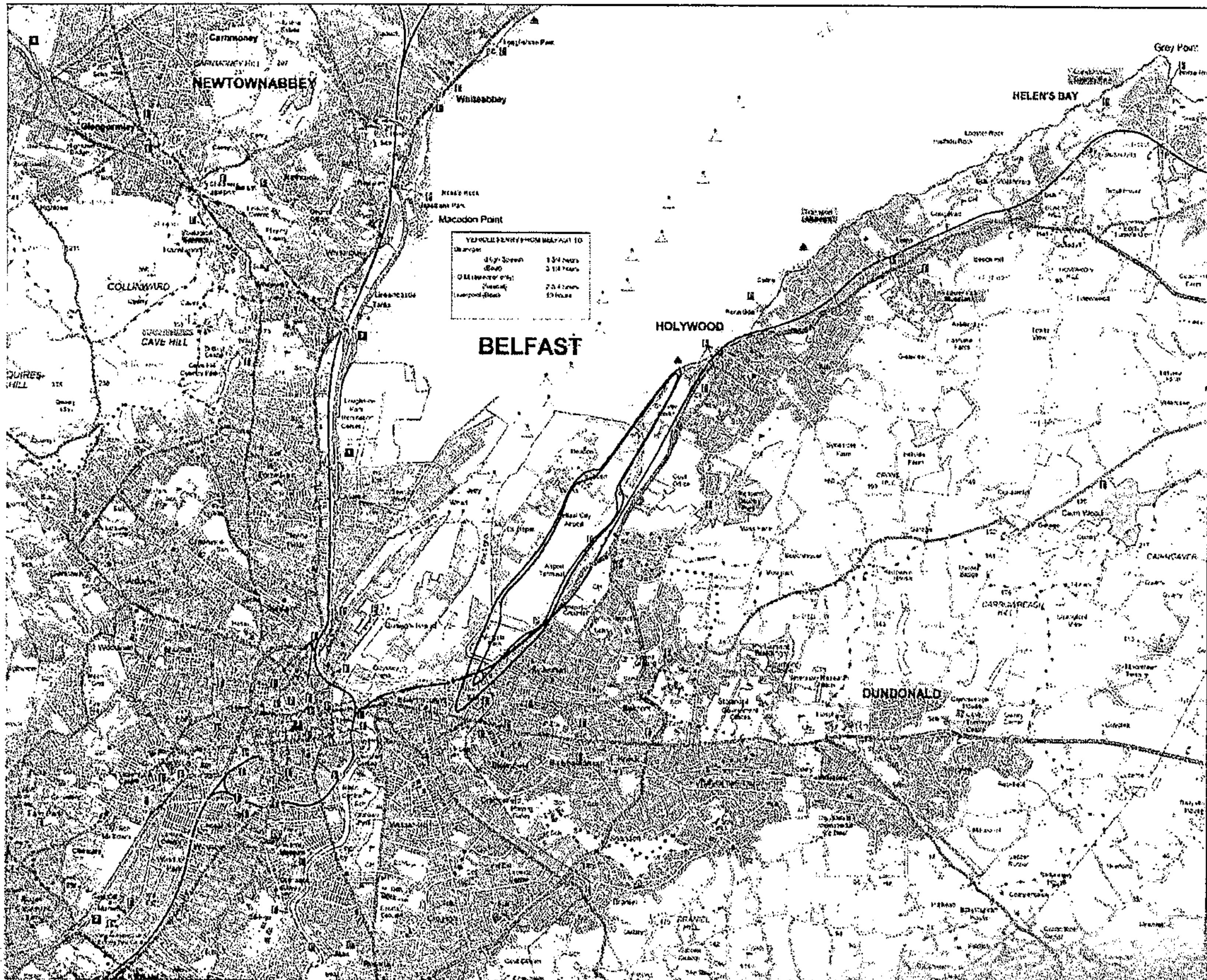
Comparison of Daytime Noise Contour 2008 with Daytime Noise Contour 2007 63 dB $L_{Aeq,16h}$

Scale at A3

1:50000

Date

September 2008



Drawing Number

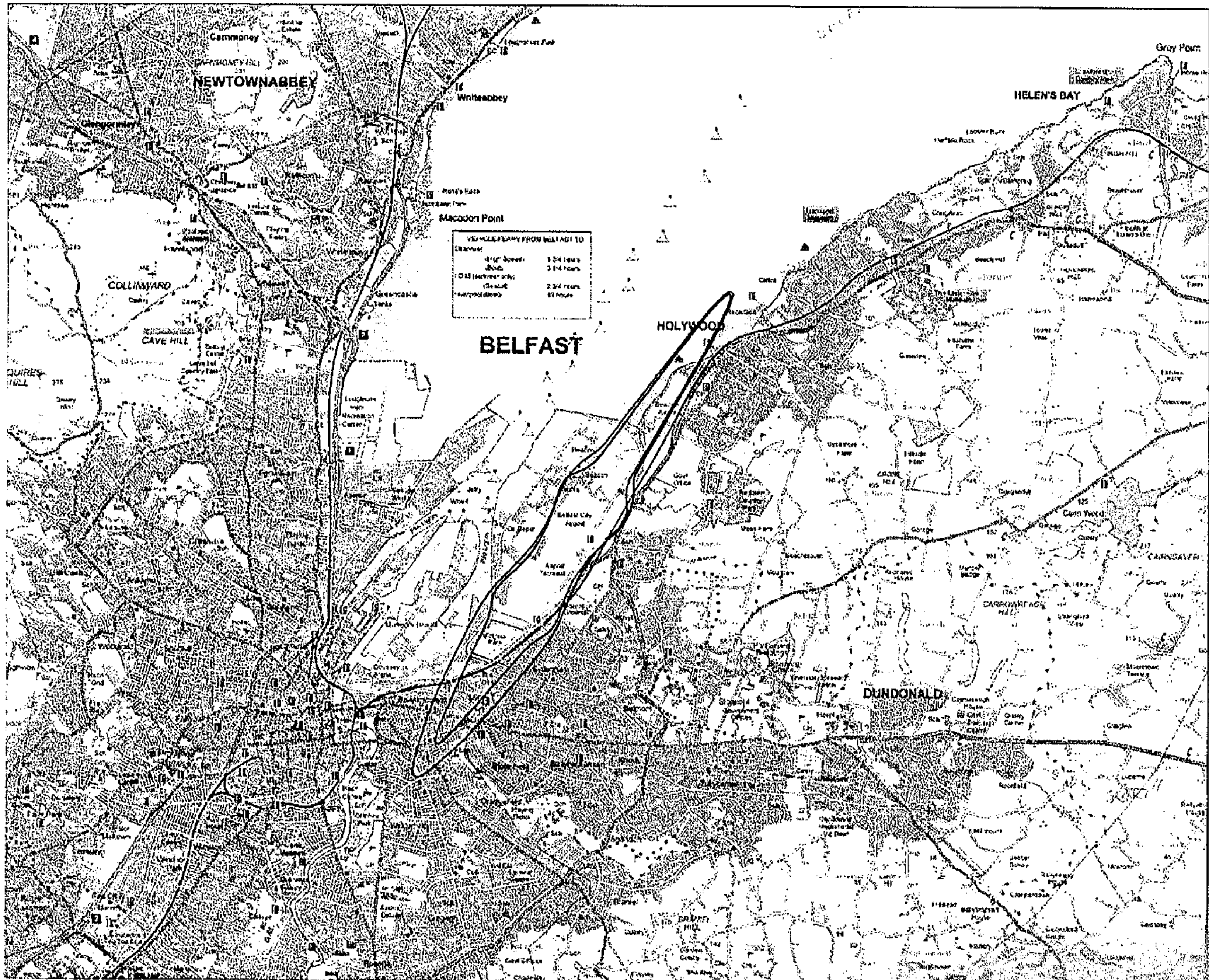
Figure 6

Drawing Title

Comparison of Daytime Noise Contour 2008 with Daytime Noise Contour 2007 60 dB $L_{Aeq,16h}$

1:50000

September 2008



Drawing Number

Figure 7

Drawing Title

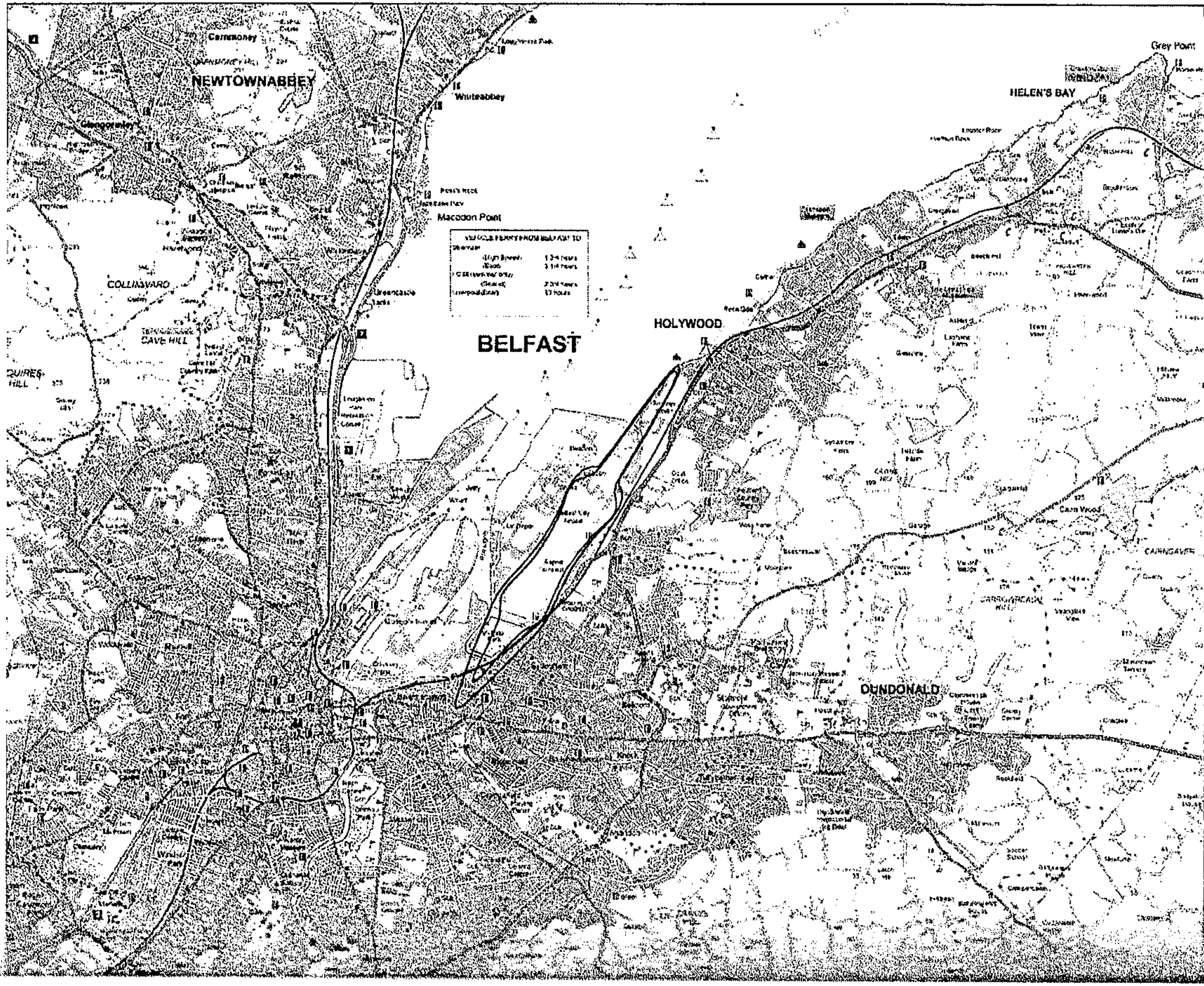
Comparison of Daytime Noise Contour 2008 with Daytime Noise Contour 2007 57 dB $L_{Aeq,16h}$

Scale at A3

1:50000

Date

September 2008



— INM v7.0a 2008 Noise Contour
— INM v7.0 2007 Noise Contour

Drawing Number

Figure 6

Drawing Title

Comparison of Daytime Noise Contour 2008 with Daytime Noise Contour 2007 60 dB $L_{Aeq,16h}$

1:50000

September 2008

Appendix A

BCA Initial NMT Validation – September 2008

A9001
BCA – Initial NMT Validation – September 2008

The permanent noise monitoring system at Belfast City Airport (BCA) is now partially installed. Initial results have been obtained from the Noise Monitoring Terminal (NMT) at Nettlefield Primary School (MP01) for almost all of July and August. Additional results have also been obtained for the period 19th to 27th August from the mobile NMT (MP03) which has been temporarily sited at the location for the second permanent NMT at the Kinnegar Army Camp. Using these measurements of nearly 3,000 individual aircraft the assumptions made in the computer modelling of the airborne aircraft noise have been reviewed.

Summer contours have been prepared for BCA based on the movements during the summer period for a number of years. This has involved the use of the Federal Aviation Administration (FAA) prediction methodology, the Integrated Noise Model (INM). The last such contours were prepared for 2007 and used the current version of the software, Version 7.0. To review the modelling assumptions predictions have been made, using the INM software, of the SEL from individual movements of each common current aircraft type at the two NMT locations. These have then been compared with the average measured level from the monitors.

The results of the initial validation are detailed in the following table, in summary for the largest turbofan aircraft the INM standard predictions agree well with the measured levels.

Aircraft Type	INM Standard Assumptions	Adjustments following Initial Validation	
		Departures	Arrivals
Airbus A319	A319-131	-	-
Airbus A320	A320-232	Stage Length 2	-
Avons Transport Regional 72	HS748A	DHC6	DHC6
Boeing 737-800	737800	-	-
Dash 8-Q400	DHC830	DHC6	SD330 Moves x1.3
Embraer 145	EMB145	-	-
Embraer 195	GV	A319-131 Moves x 1.6	A319-131 Moves x 2

From the table it can be seen that the standard INM assumptions for the Airbus A319, Boeing 737-800 and Embraer 145 do not need adjustment following the initial validation. That is that there was good correlation between the predicted and measured values at the NMTs. For the Airbus A320 a small change is suggested for the departures. This is to increase the Stage Length from 1 to 2 to increase the weight of the aircraft on departure and increase the predicted levels slightly.

For the remaining aircraft types considered the INM software does not include specific data for the aircraft type and instead suggests one with similar noise characteristics. For example for the Avons Transport Regional 72 the software suggest the Hawker Siddeley 748 is used instead however the initial validation finds that the predicted noise levels from the Dash 6 agree much better with those measured than those for the 748, and therefore the Dash 6 has been used as a substitute.

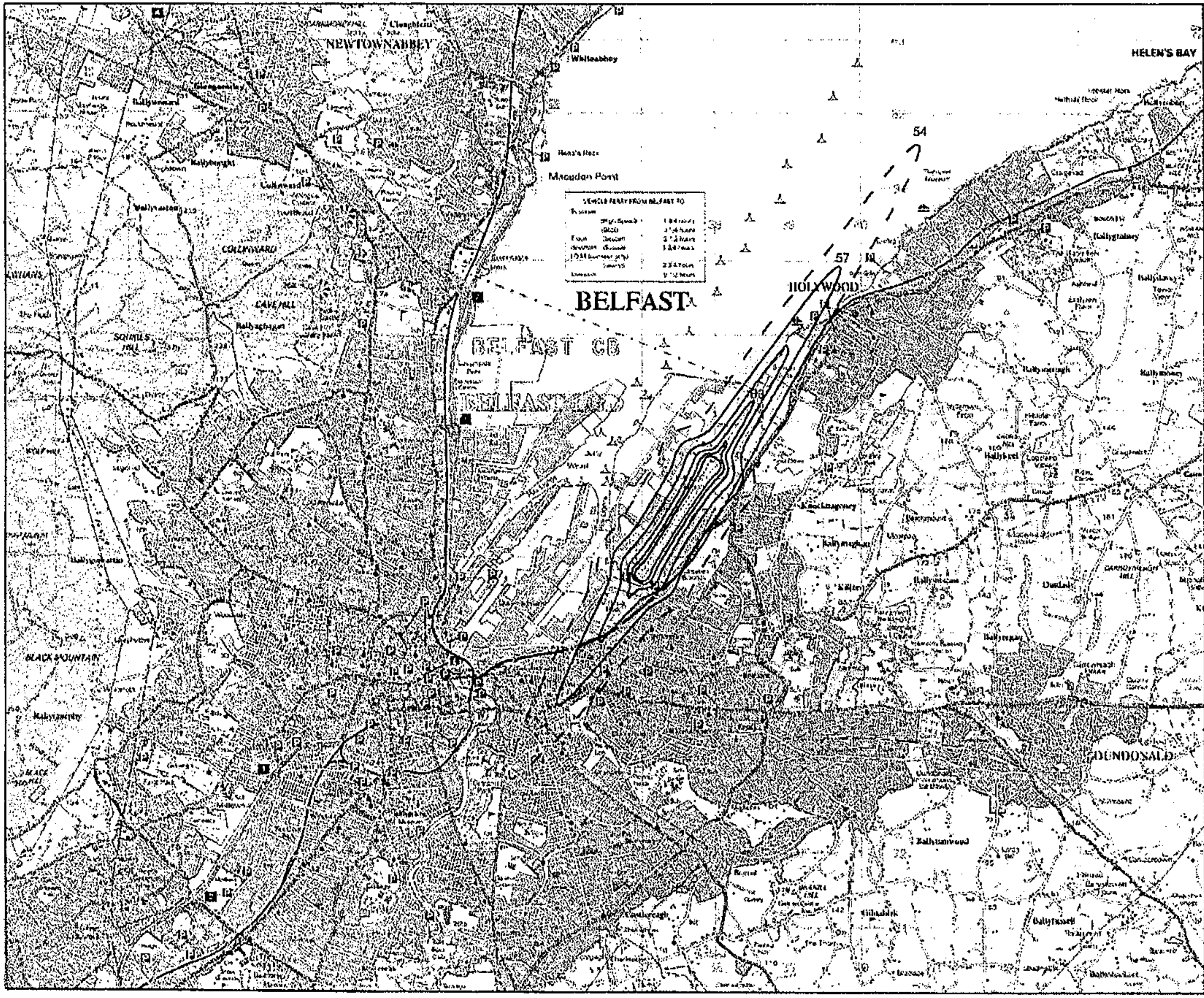
For the Embraer 195 the software suggest the Gulfstream V is used instead however the initial validation finds that the predicted noise levels are too low and those from an Airbus A319 with the movement numbers factored up agree much better with those measured.

For the Dash 8-Q400 the software does not suggest a type but does include the data for the smaller Dash 8-300. Predictions using this data do not however agree well with the measured noise levels and the initial validation finds that using the Dash 6 for departures and the Shorts 330 with movement numbers factored up for arrivals greatly improves the agreement with measured noise levels.

To assess the effect of this initial validation the contours produced for the summer 2007 period have been reproduced taking the findings into account. These contours were reported in February 2008 (Ref:A7864/AH/R02 Rev 01) and already included some modifications to the standard INM assumptions based on FAA certification data which are detailed in the table below.

Initial INM Type	Substitution	Modification to Movement Numbers	
		Departures	Arrivals
A320-232	-	1.3 x actual	1.9 x actual
BAE300	-	0.50 x actual	1.6 x actual
DHC830	DHC830/SD330	2.9 x DHC830	1.3 x SD330

Comparing the earlier validation to that following the initial validation exercise using the NMT initial results it is noted that modifications are suggested in both cases to the Airbus A320 although only for departures when measured levels are considered. Both exercises also suggest changes to the Dash 8 and agree that on arrival the Shorts 330 with revised movements is appropriate. The earlier validation also suggested changes for the British Aerospace 146 but this type is no longer operating from BCA and so no measured noise levels are available.



— INM v7.0 2007 Noise Contour

Drawing Number

Figure A9001 A

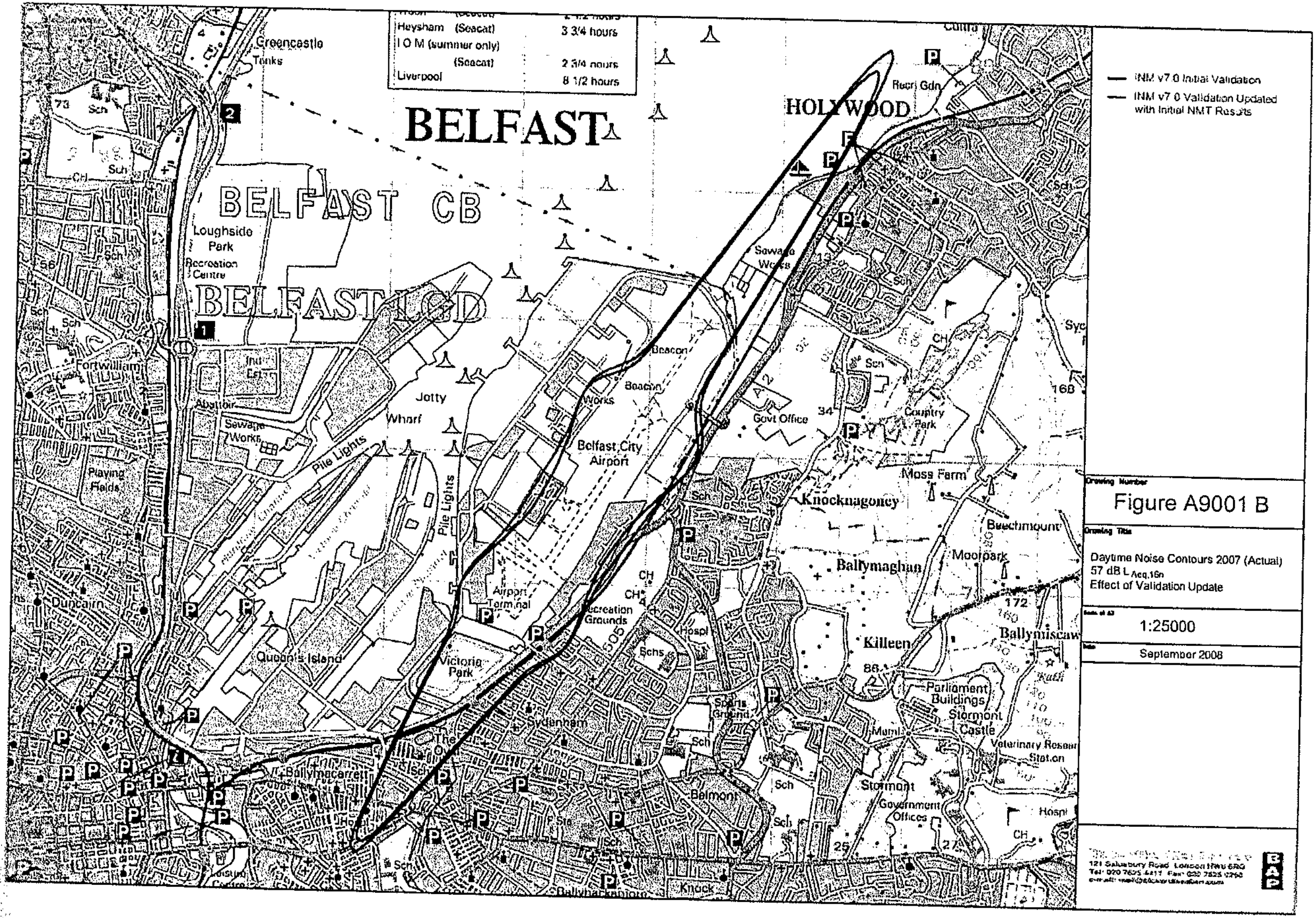
Drawing Title

Daytime Noise Contours 2007 (Actual)
54, 57, 60, 63, 66 & 69 dB $L_{Aeq,16h}$
Validation Updated with Initial NMT Results

1:50000

September 2008

121 Salusbury Road London NW6 6RG
Tel: 020 7625 4411 Fax: 020 7625 0250



Drawing Number

Figure A9001 B

Drawing Title

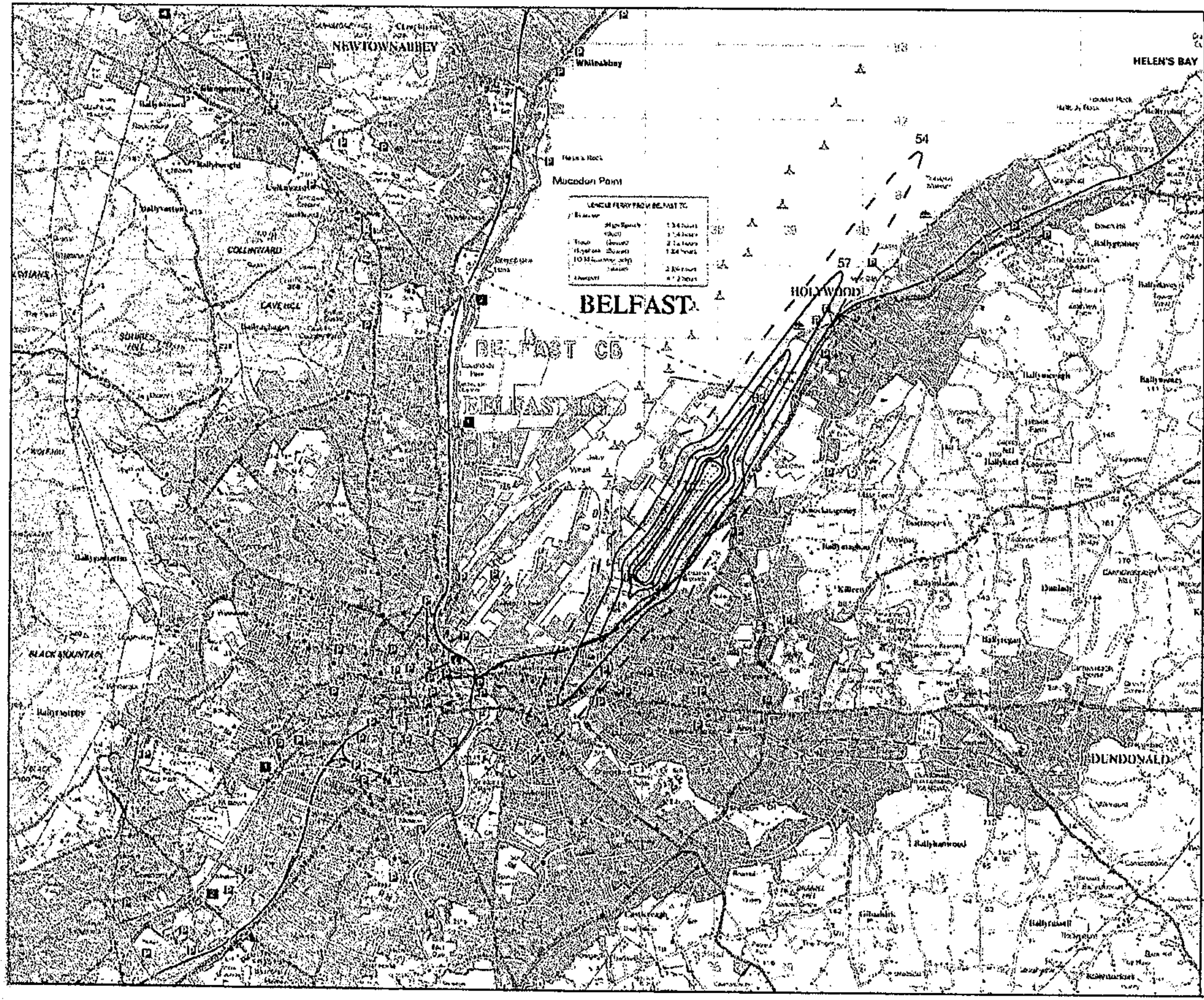
Daytime Noise Contours 2007 (Actual)
57 dB $L_{Aeq,16h}$
Effect of Validation Update

1:25000

September 2008

121 Salusbury Road London NW6 6RG
Tel: 020 7625 4411 Fax: 020 7625 0250

BAP



— INM v7.0 2007 Noise Contour

Drawing Number

Figure A9001 A

Drawing Title

Daytime Noise Contours 2007 (Actual)
54, 57, 60, 63, 66 & 69 dB $L_{Aeq,16h}$
Validation Updated with Initial NMT Results

Scale at A3

1:50000

Date

September 2008

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Tel: 020 7625 4411 Fax: 020 7625 0250
BAP