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Evaluating the impact on noise levels of a ban on private cars in Dublin city centre, Ireland

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Abstract

Dublin's city centre is the primary destination in the Dublin region for shopping, employment and education. Public transport services in the area have experienced significant time delays throughout peak periods of the day due to severe traffic congestion. In an effort to alleviate traffic congestion and increase the efficiency of public transport in the area, a 'bus gate' was introduced to one particularly sensitive area in the city centre. The scheme restricts private vehicles from accessing the area during peak traffic hours. It was hoped that this scheme would result in significant journey time-savings for public transport users and would also result in reduced noise pollution in the city centre from the removal of through traffic. This paper aims to quantify the effect the 'bus gate' has had on noise levels in the area. Noise levels were monitored prior to and after the introduction of the scheme and the extent to which the scheme impacted on the noise levels was thus evaluated. The study also estimates the impact extending the ban would have on noise exposure levels in Dublin city centre.

Keywords: Action Planning, Traffic Management, Environmental Noise, Noise Mapping, Noise Exposure.

1. Introduction

Dublin is the capital city of Ireland and has a population of approximately 1.66 million. The city centre is the primary destination in the Dublin region for shopping, employment and education (Dublin City Council Traffic and Transportation Strategic Policy Committee, 2009). Trips to the city centre are made by a variety of transport modes resulting in high numbers of buses, private vehicles, taxis, commercial vehicles, motorcycles, bicycles and pedestrians throughout the day. These high numbers have led to significant traffic congestion in the city centre area which has led to severe delays in the public transport services that operate through the city centre. In an effort to alleviate traffic congestion and increase the efficiency of public transport in the area, Dublin City Council introduced a 'bus gate', which imposed a ban on private vehicles, in the vicinity of the College Green area in the city centre. College Green is an area of major civic, historic and touristic importance in Dublin city. The scheme operates during the peak morning (07:00 to 10:00) and evening (16:00 to 19:00) hours, during which times only public transport vehicles are allowed to travel on selected streets.

While the primary aim of the bus gate was to improve journey times for public transport it also serves to promote the use of public transport in the city centre and improve the overall environment. A previous study in the test area noted that current extent of noise exposure in Dublin is considerable and the authors noted that traffic management measures have the potential to lead to significant reductions in the level of noise exposure, provided careful consideration is given to the impact of traffic flows on residential populations (Murphy et al, 2009). Murphy and King (2011) later examined the impact of several traffic management measures on noise in a broad citywide context. A separate study, conducted in Cairo, indicates that town planners can use various strategies to change the traffic composition in

order to achieve quieter city environments. This study examined a ban on horns, a ban on horns and trucks and a ban on horns, trucks and noisy buses (Ali and Tamura, 2003). Dublin's 'bus gate' could also demonstrate the potential for traffic management schemes to form the basis for noise action plans which must be produced in accordance with EU Directive 2002/49/EC (European Union, 2002). This directive requires action plans to be developed and these plans must outline how authorities are planning to protect areas where the noise environment is good and reduce the noise in areas where noise levels are considered unacceptable.

The objective of this paper is therefore to quantity the effect the 'bus gate' has had on noise levels in the vicinity of the scheme. This is achieved using both experimental and predictive techniques. The potential impacts a more widespread scheme will have on environmental noise levels in the city centre are also explored.

2. Description of current ban

The 'bus gate' restricts private vehicles from the College Green area in Dublin city centre. Between the hours of 07:00 to 10:00 and 16:00 to 19:00 selected streets in the city centre may only be accessed by public transport vehicles and cyclists. A map of the area is displayed in Figure 1.

Figure 1 – The College Green Bus Gate (Dublin City Council, 2009)

There are 4,400 Dublin Bus movements per day through the 'bus gate', which represents approximately 40% of the total daily Dublin Bus trips. A further 3,100 bus movements operate to, from or through the city centre but do not pass through the 'bus gate' (Dublin City Council Traffic and Transportation Strategic Policy Committee, 2009). In addition to Dublin Bus, Bus Éireann and many private bus services also operate in the area. The primary aim of the scheme is to significantly reduce journey times for cross-city public transport and allow for increased reliability and frequency.

3. Experimental Method

3.1 Measurement Procedure

Two noise monitoring locations were selected for analysis; Site 1 (the junction of College St. and Westmoreland St.) was located at a busy interchange within the ban while Site 2 (Pearse St.) was along a street which approached the entrance to the 'bus gate'. A long term environmental noise monitor, developed by Sonitus Systems, was used to continuously log noise levels (L_{Aeq} and L_{A10}) in five minute intervals. Measurements were taken at each location for 14 days prior to the introduction of the scheme and for a further 28 days after the introduction of the scheme.

3.2 Prediction Procedure

The most widespread method for road traffic noise prediction in Ireland at present is the UK's Calculation of Road Traffic Noise (CRTN) prediction method (UK Department of Transport, 1988). It was used to create strategic noise maps for every major road in Ireland and is also widely used for assessing noise during the preparation of Environmental Impact Statements in Ireland today (King et al., 2011). The hourly and 18-hour L_{10} noise levels may be calculated from

$$L_{10,1h} = 42.2 + 10\log_{10} q \quad (1)$$

$$L_{10,18h} = 29.1 + 10\log_{10} Q \quad (2)$$

where q and Q are the hourly and 18-hour flows of traffic respectively. The above equations must be modified to account for various aspects of the traffic flow; i.e. the mean traffic speed, V, and the percentage of heavy vehicles, p. The following correction takes these variables into account:

$$Correction_{V\&p} = 33\log_{10}(V + 40 + \frac{500}{V}) + 10\log_{10}(1 + \frac{5p}{V}) - 68.8 \quad (3)$$

The gradient of the road, G, is accounted for by equation 4 where G is expressed as a percentage:

$$Correction_{G} = 0.3G \quad (4)$$

An additional correction must also be included for the type of road surface. The corresponding correction is dependent on a number of factors, such as the texture of the road surface or if the surface is impervious or not. When the mean speed is less than 75 km/hr and the road has a given texture depth, TD, the correction for a concrete surface is:

$$Correction_{surface} = 10\log_{10}(90TD + 30) - 20 \quad (5)$$

and for a bitumous surface

$$Correction_{surface} = 10\log_{10}(20TD + 60) - 20 \quad (6)$$

For more information on these equations the reader is referred to the CRTN method. Additionally, as predictions are made in terms of the L_{10} index, results are converted to a L_{eq} based index. This is achieved by incorporating the Irish National Roads Authority's conversion procedure (O'Malley et al, 2009):

$$L_{den} = 0.86 \times L_{A10,18h} + 9.86 \quad (7)$$

4 Traffic Count Results

Traffic counts were conducted at a number of key junctions in the test area in order to assess the impact of the ban. Counts were made over two days, one prior to the introduction of the ban (24th February 2009) and again after the ban was introduced (29th September 2009). These counts were commissioned by Dublin City Council who made the results available for this study.

4.1 Location 1

Figure 2 described the traffic movements at the first noise monitor location while Table 1 presents a summary of the traffic counts corresponding to each movement at this location. The results in Table 1 outline the reduction in traffic levels during the morning ban (07:00 – 10:00) and the evening ban (16:00 – 19:00).

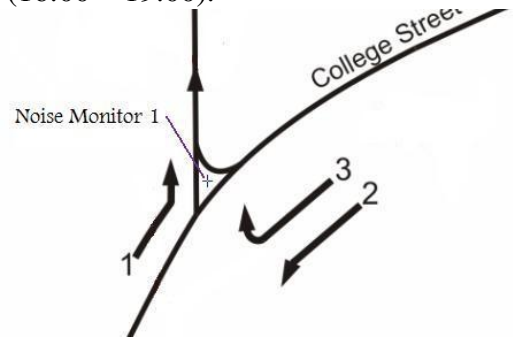

Figure 2 – Traffic Conditions at Location 1 along with noise monitor location

Movement 1	**Morning Period**					**Evening Period**				
	Cars	HGVS	Buses	Other	**Total**	Cars	HGVS	Buses	Other	**Total**
Prior	1655	432	671	1140	**3898**	1464	201	609	1426	**3700**
After	159	51	614	1189	**2013**	390	45	580	1417	**2405**
Reduction	**1496**	**381**	**57**	**-49**	**1885**	**1074**	**156**	**29**	**9**	**1295**
Movement 2										
Prior	1854	401	701	1328	**4284**	1847	161	610	1645	**4263**
After	148	40	708	1695	**2591**	384	37	615	1947	**2983**
Reduction	**1706**	**361**	**-7**	**-367**	**1693**	**1463**	**124**	**-5**	**-302**	**1280**
Movement 3										
Prior	194	78	140	104	**516**	394	52	138	291	**875**
After	382	150	157	169	**858**	851	88	188	286	**1413**
Reduction	**-188**	**-72**	**-17**	**-65**	**-342**	**-457**	**-36**	**-50**	**5**	**-538**

Table 1 – Traffic counts prior to and after the introduction of the 'bus gate' at Location 1

For Movement 1 the following was observed during the morning period; i) a decrease of approximately 90% in the volume of cars; ii) a decrease of approximately 88% in HCVs; iii) a slight decrease (8.5%) in buses and iv) a slight increase in the movement of other modes of transport. Accounting only for cars, buses and HGVs this would correspond to a decrease in

2.7dB(A) for each hour by applying equations 1 and 3, assuming the signposted speed limit (50km/hr) and an average variation per hour. In this way the variation in the basic noise level for each movement may be predicted (Table 2).

	Morning Period [dB(A)]	**Evening Period [dB(A)]**
Movement 1	2.7	1.7
Movement 2	2.2	1.4
Movement 3	-1.6*	-1.9*

Table 2 – Predicted reduction in noise levels at Location 1 *Note: A negative value indicates a predicted increase in noise levels.

The apparent increase in noise levels associated with movement 3 is as a result of increased traffic levels taking this path to avoid the 'bus gate' (see Figure 1, Figure 2).

4.2 Location 2

Figure 3 described the traffic movements at the second noise monitor location while Table 3 presents a summary of the results of the associated traffic counts during the morning and evening periods.

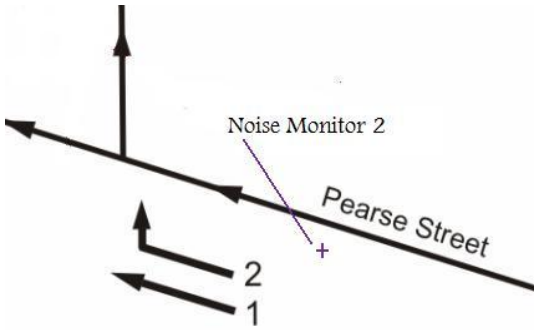

Figure 3 – Traffic Conditions at Location 2 along with noise monitor location

Movement 1	**Morning Period**					**Evening Period**				
	Cars	HGVS	Buses	Other	**Total**	Cars	HGVS	Buses	Other	**Total**
Prior	259	43	153	633	**1088**	127	18	172	790	**1107**
After	462	21	151	491	**1125**	174	23	179	782	**1158**
Reduction	**-203**	**22**	**2**	**142**	**-37**	**-47**	**-5**	**-7**	**8**	**-51**
Movement 2										
Prior	2947	658	119	593	**4317**	5115	651	80	1104	**6950**
After	4019	632	87	781	**5519**	5138	679	53	1157	**7027**
Reduction	**-1072**	**26**	**32**	**-188**	**-1202**	**-23**	**-28**	**27**	**-53**	**-77**

Table 3 – Traffic counts prior to and after the introduction of the 'bus gate' at Location 2

It is evident that the bus gate had almost no impact on traffic profiles at this location i.e. a street approaching the 'bus gate' zone. Table 4 predicts the change in noise levels associated with the slight change in traffic counts as presented in Table 3.

	Morning Period [dB(A)]	Evening Period [dB(A)]
Movement 1	0.1	-0.1
Movement 2	-0.2	-0.1

Table 4 – Predicted reduction in noise levels at Location 2

5. Noise Measurements

Noise measurements were conducted for 14 days prior to the introduction of the ban and a further 28 days after the ban was implemented. All results are integrated over the complete measurement period to yield an overall average 24 hour profile.

5.1 Location 1

Figure 4 presents the variation in noise levels before and after the introduction of the 'bus gate' at Location 1. The morning and evening periods are also identified. The impact of the bus gate is apparent during the hours during which the ban is enforced, with an approximate 2 dB(A) reduction in noise levels observed during these periods.

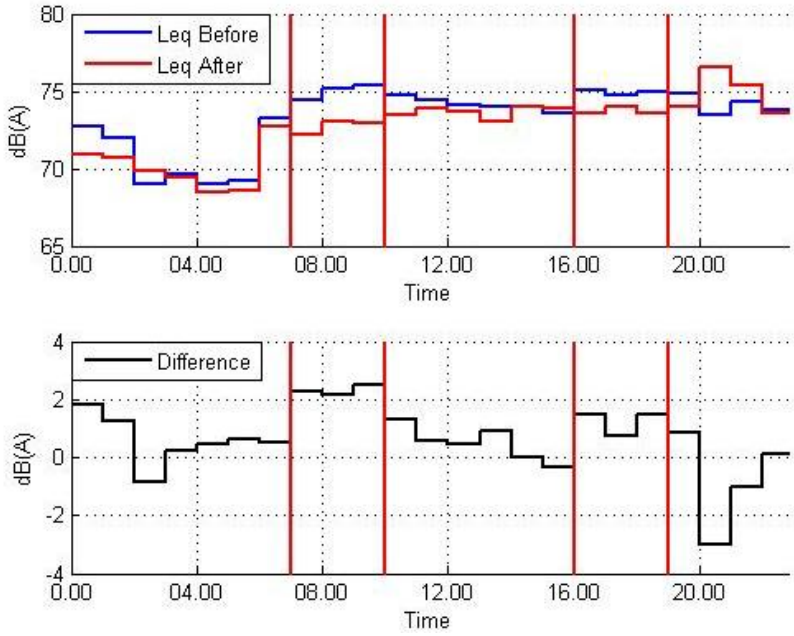

Figure 4 – Average 24-hour noise profile at Location 1 prior to and after the introduction of the ban

Table 5 however reports the variation in noise levels in terms of the periodic noise indicators, L_{day}, $L_{evening}$, L_{night}, and L_{den}, the universal indicator used to assess overall annoyance. It is apparent from this table that, when one considers the overall weighted average 24 hour level, no significant improvement in noise level has been achieved.

	Before	After
L_{day}	74.6	73.5
$L_{evening}$	74.1	75.3
L_{night}	71.2	70.5
L_{den}	**78.5**	**78.2**

Table 5 – Periodic Results prior to and after the introduction of the 'bus gate' at Location 1

5.2 Location 2

The noise monitor at Location 2 was situated adjacent to an approach street and as such traffic counts were not directly impacted by the ban. Predictions made from the traffic counts presented in section 4.1.2 indicate minimal variation of noise levels and this is also observed in the measured results, presented in Figure 5.

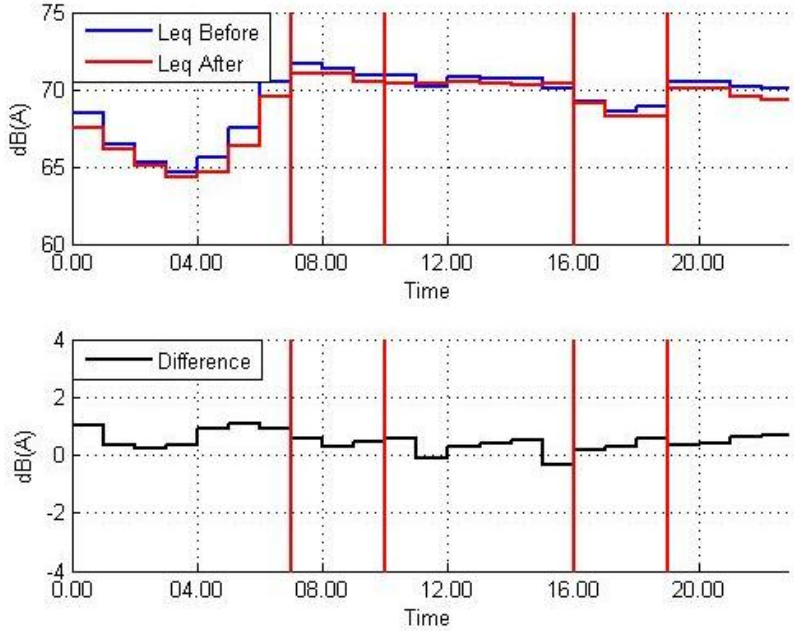

Figure 5 – Average 24-hour noise profile at Location 2 prior to and after the introduction of the ban

Table 6 presents the measured periodic noise levels recorded prior to and after the introduction of the ban. Again minimal variation in the overall noise level is observed.

	Before	**After**
L_{day}	70.4	70.1
$L_{evening}$	70.3	69.8
L_{night}	67.5	66.7
L_{den}	**74.8**	**74.1**

Table 6 – Periodic Results prior to and after the introduction of the 'bus gate' at Location 2

5.3 Observations

From the foregoing analysis it is evident that, in line with simple acoustic theory, a ban on private cars in a city centre region will lead to reduced noise levels. On a practical note, if traffic is diverted onto different streets, it is clear the noise levels on these streets may experience an increased noise level. As such, the increased activity on nearby streets may impact on noise measurements taken in the action zone, i.e. the 'treated' streets, as observed at Location 1. However, from this simple study, it is reasonable to assume that were the ban to

be geographically expanded to encompass more streets, or expanded to include more hours throughout the day, the benefits in terms of noise levels would be increased.

It is also interesting to note that a complete ban on private cars does not automatically imply a significant reduction in noise levels. HGVs and buses are key contributors to the noise level on a street and a reduction in passenger cars will see an increase in the percentage of HGVs in the flow, and therefore, a direct increase in the associated correction (equation 3).

6. Extending the ban

A hypothetical extension of the 'bus gate' was then examined. The investigation focused on a geographically extended ban that encompassed more city centre streets. This new strategy was explored in an effort to investigate the benefits associated with the 'bus gate' and if such a strategy could be incorporated as part of a noise action plan as outlined in EU Directive 2002/49/EC.

6.1 The base condition

Initially the base condition representing the current case was evaluated i.e. a ban on private cars during the peak hours. Calculations were performed using the CRTN calculation method and traffic data obtained from Dublin City Council. It was assumed that traffic travelled at the sign posted speed limit, following suggested guidance contained in the WG-AEN Good Practice Guide for Noise Mapping (Working Group on Assessment of Exposure to Noise, 2006).

Population exposure was estimated by determining the number of residential units for each building in the study area. Once determined, each residential unit was assigned an average household size value equivalent to the census enumerator area (EA) where the building was located. This value was obtained from the 2006 Census of population data. Information on the number of residential units in each building was acquired from the Irish GeoDirectory database for 2007[i]. Given the number of residential units for each building in the study area and the average household size associated with each building location, it was possible to compute estimates of the residential population for each building. Figure 6 displays the noise map for the base condition while the population exposure estimates are contained in Table 7.

[i] The GeoDirectory is a complete database of every building in Ireland which among other things contains information detailing the number of residential units in each building. It is updated on an ongoing basis by the Irish Postal Service and is the most complete building database available in Ireland.

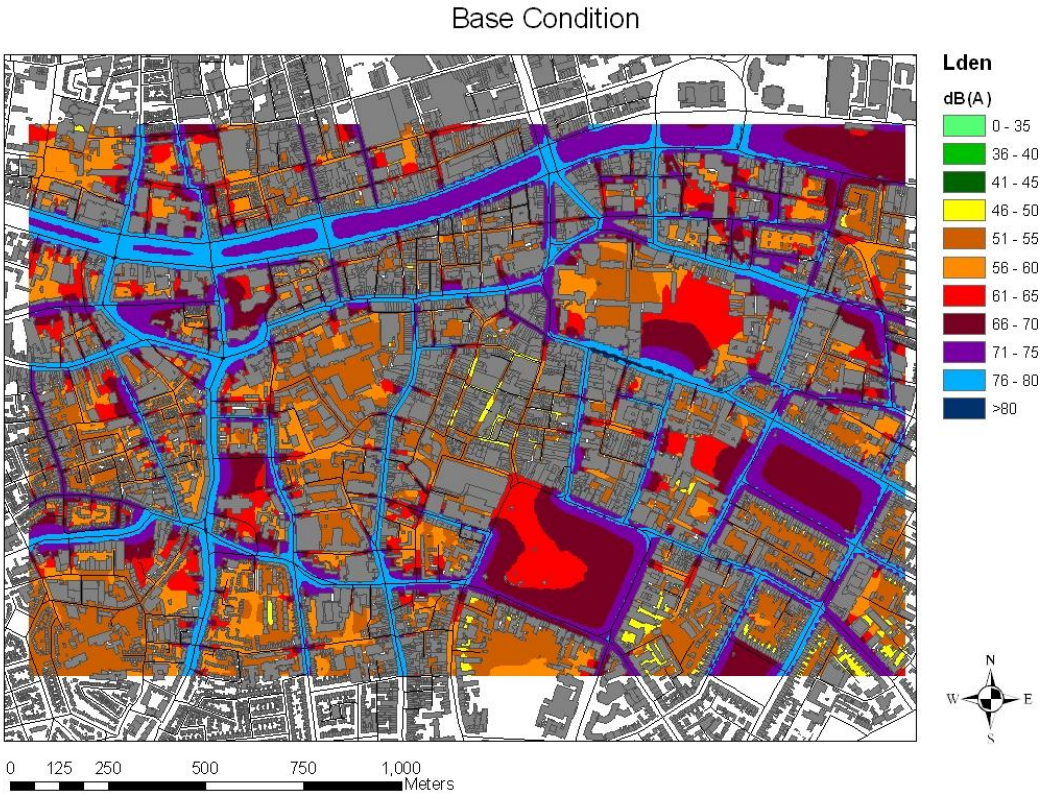

Figure 6: Noise Map for Dublin City Centre – base condition.

L_{den} [dB(A)]	***<55***	***55 - 60***	***60 - 65***	***65 - 70***	***70 - 75***	***>75***
Residents	19827	4413	4780	2300	2992	6926
L_{night} [dB(A)]	***<50***	***50 - 55***	***55 - 60***	***60 - 65***	***65 - 70***	***>70***
Residents	23228	4706	2637	1481	6273	2913

Table 7 – Population Exposure Estimates in terms of L_{den} and L_{night} for the base condition.

6.2 Increasing the area of the 'bus gate'

The effect of extending the area of the ban, encompassing an increased number of city centre streets was then examined. This ban was assumed to be in effect over the full 24 hour period. It is important to note that a traffic management strategy of this extent is likely to significantly impact traffic flows in the rest of the city and as such may result in increased traffic movements, and as such noise levels, in other areas of the city. However, for the purpose of this analysis it was assumed that the road users removed from the city centre streets found alternative means of transport, e.g. they may be using the improved bus service running through the city centre.

In order to apply the ban over a wider area the average variation in traffic volumes are assumed over each street. Traffic counts were performed at a total of 14 different locations within the city centre to assess the impact of the 'bus gate' on traffic levels. Upon an analysis of those streets directly affected by the ban, the following is noted:

- The overall quantity of vehicles, Q, is reduced by an average of 30%

- The percentage of heavy vehicles in the flow increase by 6%.

By applying these adjustments to the new streets, identified in Figure 7, the noise map for the new strategy was recalculated (Figure 8) and revised estimates for population exposure were made (Table 9).

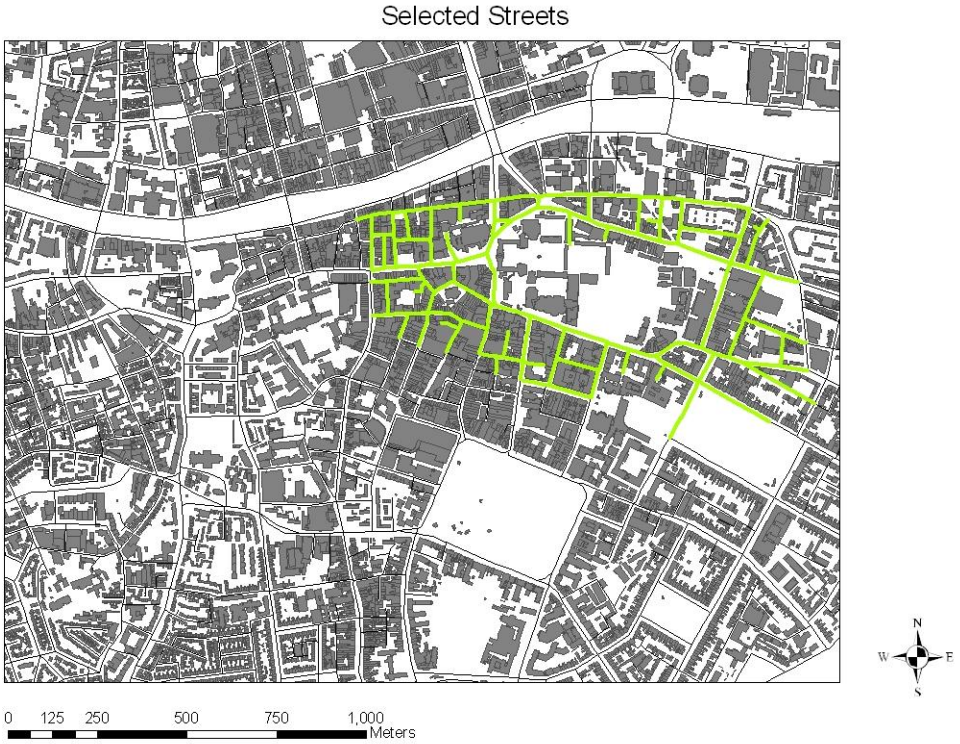

Figure 7: Identifying the streets on with the wider ban is enforced

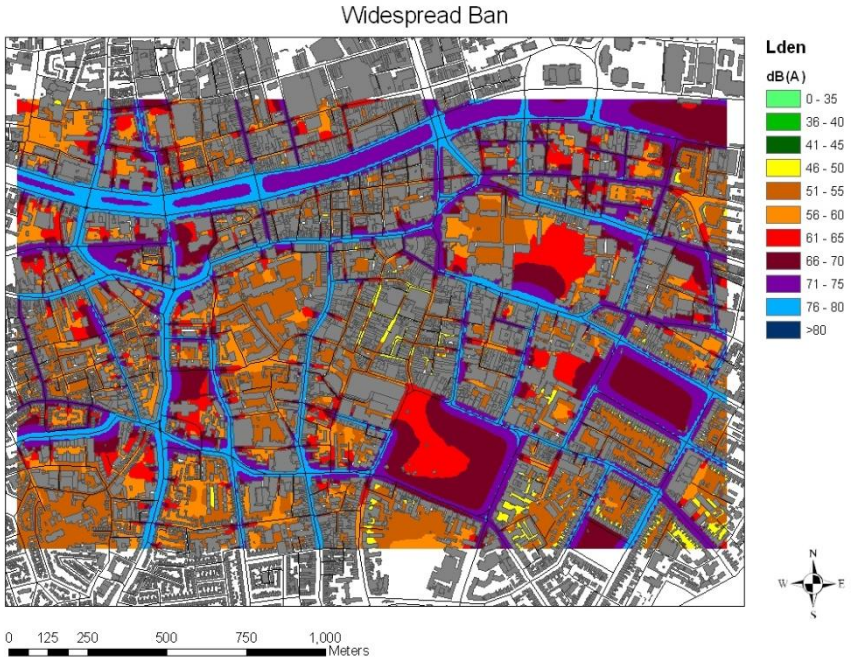

Figure 8: Noise Map for Dublin City Centre with extended ban

L_{den} [dB(A)]	<55	55 - 60	60 - 65	65 - 70	70 - 75	>75
Residents	19852	4460	4732	2316	2971	6908
Percentage Change	+0.1	+1.1	-1.0	+0.7	-0.7	-0.3%
L_{night} [dB(A)]	<50	50 - 55	55 - 60	60 - 65	65 - 70	>70
Residents	23407	4535	2675	1502	6207	2913
Percentage Change	+0.8	-3.9%	+1.5	+1.4	-1.1	0

Table 9 – Population Exposure Estimates in terms of L_{den} and L_{night} showing percentage reduction, relative to the base condition, associated with the extended ban.

Results show that the new ban will have a positive effect on population exposure levels reducing the number of residents exposed to high levels of noise. However it is noted that the percentage change is minimal.

7. Conclusions

Taken over a complete 24-hour period, noise levels in Dublin's city centre have not been significantly reduced due to the implementation of a ban on private cars. However, if one considers noise levels during the enforcement period of the ban, a reduction of about 2 dB(A) is observed that correspond with predictions of between 2 to 3 dB(A). If noise levels are considered over a 24 h in terms of Lden the associated impact on noise levels is, though, minimal.

The effectiveness of the ban would be further increased if the 'bus gate' was restricted to quiet buses. Additionally, a hidden improvement of the 'bus gate' includes a more reliable public transport system not subject to city centre congestion. This benefit may also be experienced outside the area of the ban. If the ban is extended to encompass a wider geographical area and over 24-h the benefits in terms of noise exposure will be increased. However, if the strategy is considered in the context of the full agglomeration, reductions in exposure estimates will be minimal. In terms of annoyance, however, the Lden indicator cannot adequately account for the passage of intermittent loud buses rather than the continuous passage of cars. In order to better describe the improvement in the area an alternative noise indicator is required. For the current case one must consider that the city of Dublin represents an agglomeration with approximately 1.2 million inhabitants and an area of 924 km2. It is thus possible that an action plan covering the agglomeration as a whole, may fail to communicate its benefits at a local level.

8. Acknowledgments

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References

Ali, S.A., Tamura, A., 2003. Road traffic noise levels, restrictions and annoyance in Greater Cairo, Egypt", Applied Acoustics, 64(8), 815-823.

Dublin City Council Traffic & Transportation Strategic Policy Committee, 2009, College Green Bus Priority Scheme (Public Transport Gate), Quality Bus Network Project Office.

Dublin City Council Information Leaflet, 2009. College Green Bus Corridor, available online at http://www.dublincity.ie/Press/dccPressPacks/Documents/InfoLeafletFinal_090713.pdf

European Union, 2002. Directive 2002/49/EC relating to the Assessment and Management of Environmental Noise. Official Journal of the European Communities 2002 No. L 189

King E.A., Murphy, E., Rice, H.J., 2011. Implementation of the EU environmental noise directive: Lessons from the first phase of strategic noise mapping and action planning in Ireland, Journal of Environmental Management, 92(3), 756-764

Murphy, E., King, E.A., Rice, H.J., 2008. Estimating human exposure to transport noise in central Dublin, Ireland, Environment International, doi:10.1016/j.envint.2008.07.026

Murphy E. and King E.A., 2011. Scenario analysis and noise action planning: Modelling the impact of mitigation measures on population exposure, Applied Acoustics 72(8), 487-494

O'Malley, V., King E.A., Kenny L. and C. Dilworth, 2009. Assessing methodologies for calculating road traffic noise levels in Ireland – converting CRTN indicators to the EU indicators (L_{den}, L_{night}), *Applied Acoustics* 70 (2), 284–296

Working Group on Assessment of Exposure to Noise (WGAEN), 2006. Good Practice Guide for Strategic Noise Mapping and the Prediction of Associated Data on Noise Exposure. European Commission Working Group.