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STATE-WIDE ROAD NOISE MAPPING OF QUEENSLAND, AUSTRALIA

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Abstract

The Queensland Department of Main Roads (Main Roads) has recently undertaken a State-wide road traffic noise mapping project which relied upon GIS information. The purpose of the mapping was primarily for purposes of planning Main Roads road traffic noise management program. The mapping used the relatively simple algorithms of the United Kingdom, Calculation of Road Traffic Noise model (CoRTN). CoRTN is known to provide satisfactory results for assessment purposes close to roads but is not computationally intensive. The results of the information obtained from the mapping provided an indication of the level of road traffic noise exposure for the population of Queensland. GIS data, such as the Digital Cadastral Database (DCDB), the State controlled Road Network with CoRTN attributes, planning scheme data (urban, commercial, and rural) were loaded into the SoundPLAN software using its GIS interface module. Road traffic noise calculations were performed for each local government area in Queensland, and then grouped into each of Main Roads Districts. The various results of the project are discussed and finally future improvements for the state-wide mapping project are made.

1.0 INTRODUCTION

Queensland is the north-eastern state of Australia and covers an area of approximately 1,724,000 km^2. Within Queensland, Main Roads administers approximately 36,000 km of roads, ranging in hierarchy from motorways to single carriageway unbound granular roads (rural gravel roads). Main Roads has divided the state into 14 districts of various sizes. A district is formed by a group of Local Government Areas (LGA's). Figure 1 shows the extent of the Queensland state controlled road network and also the boundaries of Main Roads districts (note: there is no district number 14).

State-wide mapping in Queensland has not been previously conducted. The purpose of conducting the mapping was to:

- Predict the extent of road traffic noise (from the State controlled road network, that is, excluding roads under the jurisdiction of local governments);
- Assist in determining which areas have priority for road traffic noise management intervention;
- Assist in determining the overall costs and benefits of managing road traffic noise across the state;
- Assist in developing road traffic noise management plans for each district; and

- Use the predicted road traffic noise levels as background information for the assessment of proposed private developments.

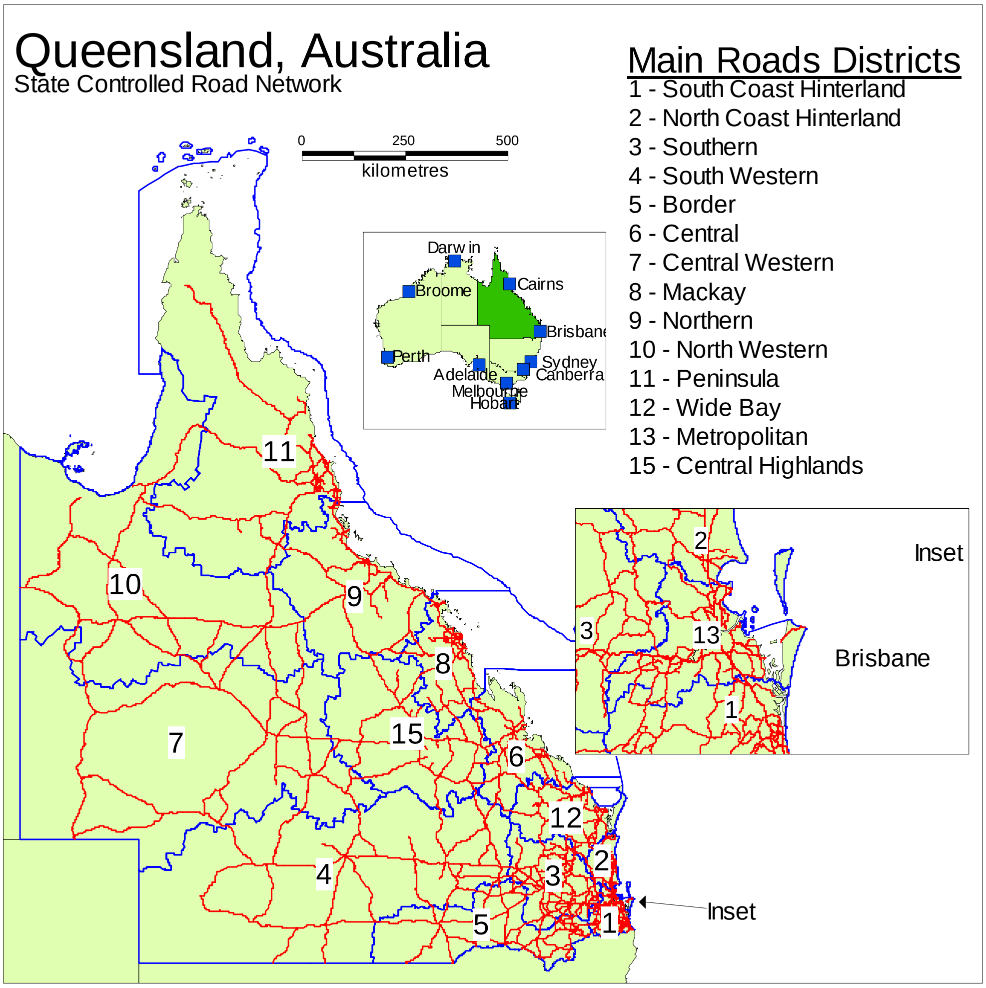

Figure 1: Queensland State Controlled Road Network and Main Roads Districts

This paper describes the methodology used to conduct the noise mapping. Each element of data used and the process used in manipulating this data is discussed and the method of calculation is presented. This is followed by a discussion of the results and conclusions. Further recommendations to improve the mapping are provided.

2.0 METHODOLOGY

2.1 Overview

For the calculation of road traffic noise, the United Kingdom CoRTN [1] methodology has been used consistently in Queensland for many years. This methodology was adopted for this noise mapping due to its simplicity and the relative ease in which the required input data is available. It is considered acceptable to use this CoRTN method for large scale mapping as the predicted levels are to be used for predominantly planning purposes.

The road traffic noise calculations were conducted using the SoundPLAN [2] software. The optional GIS interface module within SoundPLAN was required to interface with the GIS software used, MapInfo [3]. All of the data for this mapping was sourced and compiled in MapInfo, then translated to an ESRI Shape File format for input into SoundPLAN.

The coordinate system used for this mapping was the Map Grid of Australia (MGA). MGA coordinate systems are divided into longitudinal zones due to the curvature of the earth. Queensland is approximately 1,500 km wide and spans around 12 degrees of longitude thus crossing three MGA Zones (MGA54, MGA55, and MGA56). The east coast of Queensland falls mostly within the MGA56 zone. The central and western regions of Queensland use MGA55 and MGA54 coordinate systems respectively.

2.2 Source Database

The road traffic source database was obtained from Main Roads Asset Management and GIS branches. A single database was provided for the entire state, in Latitude/Longitude coordinates and with fields that allow appropriate sub-selections to be performed e.g. district. Each sub-selection district road database was converted to the relevant MGA coordinate system. The data contained the AADT, % commercial vehicles, sign posted speed and pavement surface type. A pavement surface type correction factor was added to the source database. It is a typical practice in Queensland to assume 18 hour traffic flow is 94% of the AADT. For this study, it was decided not to convert the AADT to an 18 hour traffic flow, as the resulting error would be an over prediction of only 0.3 dB(A) . Considering the overall scale of the calculations, this was considered to be an acceptable assumption.

2.3 Receivers

The basis for all receiver data is the Digital Cadastral Database (DCDB), which is a GIS database for all parcels within Queensland. Each parcel is defined by a Lot Number and Plan Number (Lot/Plan). The parcels database is divided into a sub-selection for each LGA.

The DCDB does not identify the land use category of a parcel. A separate database of categorised land use region objects with consistent terminology across the state was used to update the DCDB data. Table 1 presents the land use categories used.

Table 1: Land Use Categories

Land Use Category	Land Use Code Number*
Not Available	1
Commercial	2
Conservation	3
Industrial Heavy/Other	4
Industrial Light/Medium	5
Rural[#]	6
Rural Residential[#]	7
Special Facilities	8
Special Purposes	9
Sport & Recreation/Open Space	10
Un-zoned	11
Urban[#]	12

*Code number used for land use in SoundPLAN

[#] Assumed as containing residential dwellings

The combined DCDB and land use categorised parcels were then converted from region objects to point objects, located at the centroid of the original region object. The database of DCDB point objects was then translated for import into SoundPLAN as receiver objects. In SoundPLAN, the name of each receiver object was defined as the Lot/Plan number.

2.4 Terrain and Shielding Structures

Due to limited resources and lack of available data, this mapping assumed all LGA's to have flat terrain which was soft i.e. 100% absorptive. A flat terrain assumption is likely to ensure that most results are generally over predictions due to the absence of any shielding attenuation provided by terrain. However in some sites, under predictions would occur when actual average propagation heights are significantly high or there is a higher percentage of hard terrain surface between the source and receiver. Another error introduced by a flat terrain assumption is that any gradient corrections for the source are zero.

Existing noise barrier data is not currently available in a spatial GIS based database. Therefore, no existing noise barriers were included in the calculations. This assumption ensures that most parcels currently protected by existing noise barriers will have over-predicted noise levels. The same applies for buildings.

2.5 Calculations

There are 158 LGA's in Queensland. Of this a total of 130 LGA's were modelled. Those that were not modelled were primarily in the Cape York Peninsula where there are no state controlled roads.

In SoundPLAN, a single point receiver type calculation was conducted for each modelled LGA. The calculations were set to a search radius of 5,000 m, 10 degree search angles and no reflections and each parcel receiver was 5.0 m above the terrain.

2.6 Criteria

The results were extracted from SoundPLAN as a text file which was imported into a spreadsheet for statistical analysis. All of the results were free field, that is, no account was made for façade reflection. Main Roads criteria for state controlled road projects is a level of 68 dB(A) $L_{A10\,(18\,hour)}$ façade corrected. For this mapping, the corresponding free field level was set to 65 dB(A) $L_{A10\,(18\,hour)}$.

3.0 RESULTS

The percentage of each land use within a district was analysed first (Table 2) where it is observed that the majority of land use categories in each district are Rural, Rural Residential or Urban. The percentage of "non-residential" land uses within an LGA was minor, and therefore it was considered acceptable to analyse all parcels combined without introducing unacceptable inaccuracies in the results.

Table 2: Percentage of each land use category per district number

Land Use Code Number	District 1	District 2	District 3	District 4	District 5	District 6	District 7	District 8	District 9	District 10	District 11	District 12	District 13	District 15
1	0.3	0.9	0.5	3.8	0.9	1.7	5.4	1.8	1.0	6.9	3.5	0.7	0.5	1.9
2	1.9	2.5	2.4	2.4	3.9	2.8	0.0	2.1	0.6	2.5	2.9	2.1	1.0	2.3
3	0.4	0.3	0.1	0.0	0.2	0.0	0.0	0.0	0.3	0.0	1.5	0.1	0.6	3.7
4	1.2	0.7	0.7	0.4	0.9	0.7	0.0	0.0	1.2	1.4	0.2	0.1	1.5	1.3
5	1.4	1.3	1.4	0.4	0.7	1.5	0.0	1.7	0.2	1.0	2.0	1.4	1.3	1.0
6*	11.0	15.1	36.7	60.3	57.8	28.4	54.6	28.3	17.2	33.8	19.9	33.8	3.4	28.2
7*	11.5	10.5	8.0	0.1	1.5	1.6	0.0	4.4	40.5	0.6	7.3	6.9	2.6	2.5
8	1.1	2.6	0.9	0.0	0.1	1.8	0.3	3.4	0.7	0.2	0.6	1.1	3.1	1.3
9	0.8	1.1	1.5	3.4	2.9	2.5	0.8	1.9	1.4	1.6	2.9	2.7	3.2	7.4
10	2.2	1.1	1.1	0.5	0.2	0.9	0.0	2.3	0.6	1.4	1.3	0.5	1.6	0.8
11	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.1	0.1	0.1	1.2	0.0	0.0	6.5
12*	68.2	63.8	46.8	28.7	31.0	54.9	38.8	54.0	36.3	50.6	56.6	50.6	81.0	43.1

* Rural (6), Rural Residential (7) and Urban (12) land use categories

Histograms of the number of parcels within sound pressure level bands from 45 to 100 dB(A) $L_{A10\,(18\,hour)}$ were calculated, and then these were combined to create histograms for each district. From this data, the number of parcels exceeding a level of 65 dB(A) $L_{A10(18\,hour)}$ was established. The combined district histograms are presented in Figure 2. This figure shows that District 13 has the widest spread of data and the highest number of parcels. The district with the second largest spread and number of parcels is District 1.

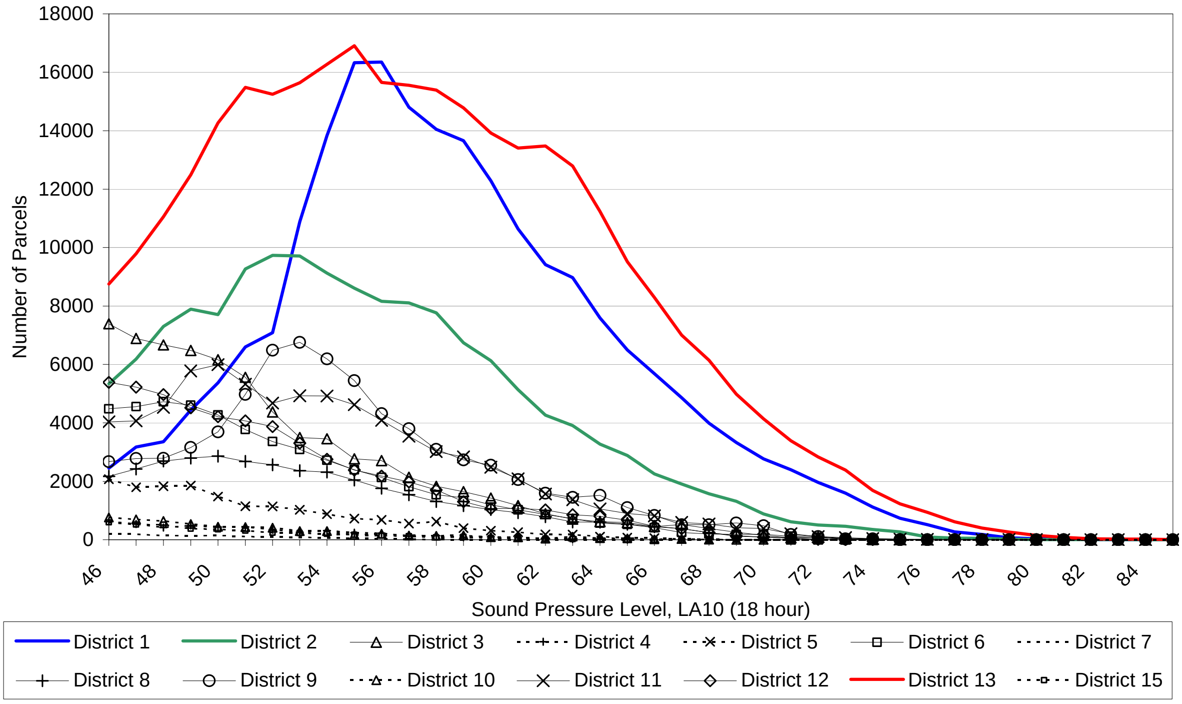

Figure 2: Histogram of the results from each district

The percentage of each district exceeding 65 dB(A) $L_{A10\,(18\,hour)}$ was calculated and is shown in Figure 3. It was found that Districts 1 and 13 (both in southeast Queensland) have around 12% of their parcels greater than 65 dB(A) $L_{A10\,(18\,hour)}$, Districts 2, 3, 6, 8, 9, 11 and 12 (all on the east coast of Queensland) were between 1% and 5%, and the remaining Districts 4, 5, 7, 10 and 15 (all in western Queensland) were between 0.0% and 0.2%.

Next, the relative contribution from each district to Queensland of parcels exceeding 65 dB(A) $L_{A10\,(18\,hour)}$ was calculated and is shown in Figure 3. It is observed that District 13 contributed to nearly 46% of all parcels in Queensland exceeding 65 dB(A) $L_{A10\,(18\,hour)}$. The second highest contributor is District 1 with 30%. Combined, the southeast corner of Queensland contributes nearly 76% of all parcels in Queensland which exceed 65 dB(A) $L_{A10\,(18\,hour)}$. The remaining parcels are predominantly located on the remaining eastern coast of Queensland.

Finally, the highest predicted and mean predicted $L_{A10\,(18\,hour)}$ in each district was determined with the results presented in Table 3. Except for District 7, all Districts have at least one parcel greater than 65 dB(A) $L_{A10\,(18\,hour)}$. There is at least one LGA in District 13 having a mean value of greater than 65 dB(A) $L_{A10\,(18\,hour)}$.

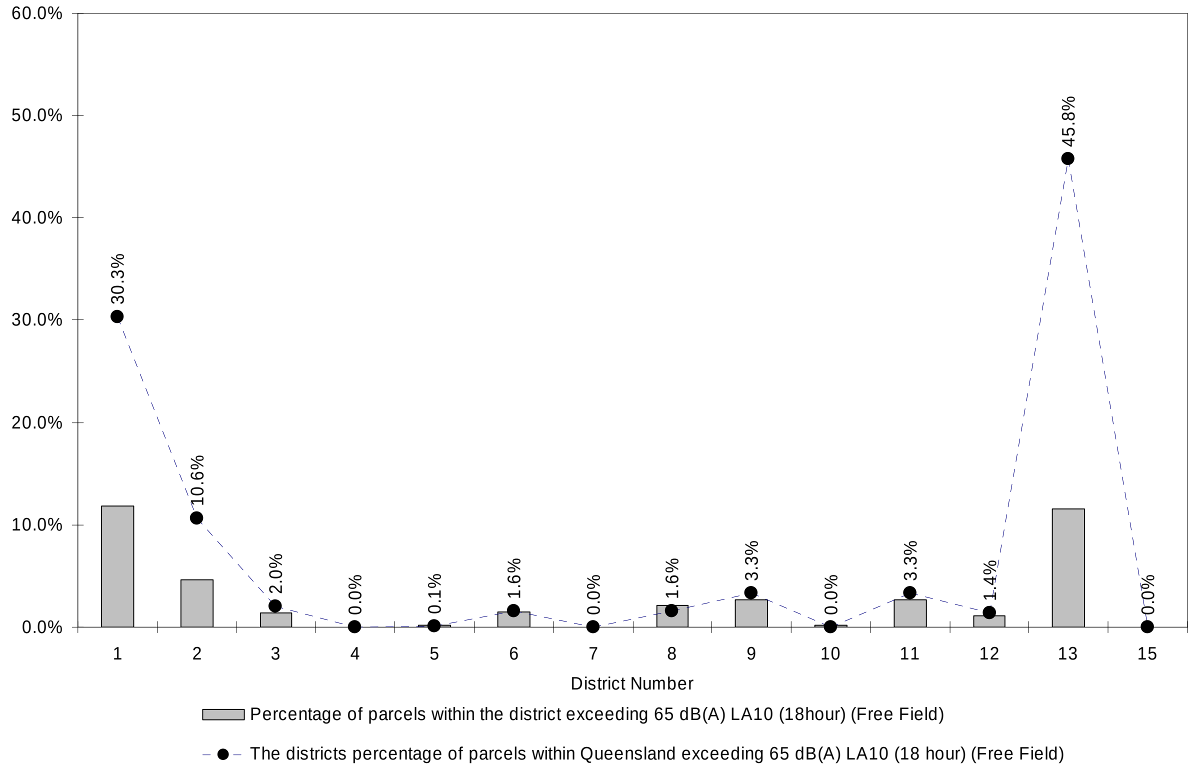

Figure 3: Percentage of each district exceeding 65 dB(A) $L_{A10(18\ hour)}$ and the proportion of each district compared to the Queensland total

Table 3: Summary statistics for each district

District	No. Parcels in District	No. Parcels >65 dB(A)	Highest Predicted $L_{A10\ (18\ hour)}$	Mean $L_{A10\ (18\ hour)}$ for whole district	Highest LGA Mean $L_{A10\ (18\ hour)}$	Minimum LGA Mean $L_{A10\ (18\ hour)}$
1	249427	29556	86.4	45.3	57.9	38.0
2	225929	10387	87.0	43.0	54.3	30.1
3	143644	1941	79.1	36.0	50.2	22.4
4	29381	1	65.1	24.7	45.6	15.8
5	49164	81	69.5	33.2	48.9	20.9
6	103945	1520	75.9	35.7	51.4	10.7
7	14273	0	58.5	23.0	33.8	14.1
8	69997	1516	76.1	36.6	46.3	28.5
9	120554	3246	75.1	34.0	50.9	0.0
10	22003	43	67.9	17.3	44.6	0.0
11	119957	3234	82.1	32.7	51.6	0.9
12	123872	1365	76.5	33.2	51.5	24.2
13	387076	44646	89.3	51.5	61.9	37.7
15	25218	5	67.8	22.8	35.7	12.9

4.0 CONCLUSIONS

This noise mapping has commenced an important step for road traffic noise mapping in Queensland for state controlled roads. The results obtained provide a state wide holistic view. There is nothing which is particularly surprising about the results as they are reasonably expected, but this mapping has confirmed expectations by a systematic system of GIS data processing and reliable road traffic noise calculations. The methodology developed sets up a system and procedure where ongoing improvement can be implemented. By using GIS software for data manipulation and processing, and dedicated road noise calculation software such as SoundPLAN, then the ability for detailed calculations with increasing data availability for example, terrain and barriers, is possible for large areas of Queensland.

4.1 Further Improvements

There are many possibilities for improving the detail and quality of the noise mapping conducted thus far.

The implementation of road traffic noise attenuation measures such as noise barriers primarily depends on whether a sensitive receiver is subjected to road traffic noise from an access controlled road or a non-access controlled road. The next step to further improvement in the mapping is to construct a sub-selection of the roads database of those roads that are access controlled only. Then the calculations can be performed with this sub-selection only. In this way, the noise level contribution from only access controlled roads can be established.

Ultimately it is intended to develop a state wide priority index for road traffic noise management. To do this further data is necessary which is not currently available. It is intended to develop a GIS database of all existing noise barriers within districts so as to improve the accuracy of the calculations. Also it is intended to incorporate population densities into the DCDB database. Where available, three dimensional terrain is to be included in the SoundPLAN model, however it is expected that as a minimum the terrain contour interval needs to be no larger than 1.0 m and be recent enough to represent the existing road network. It is also intended that noise contours be calculated in SoundPLAN and presented in GIS format.

More detailed and accurate land use categories are expected to be available with the release of GIS data from the Australian 2006 population census. Use of this data is expected to significantly enhance any further results obtained from state wide road traffic noise mapping.

REFERENCES

[1] Department of Transport Welsh Office, *Calculation of Road Traffic Noise.* London: Her Majesty's Stationery Office, 1988.

[2] Braunstein + Berndt GmbH, "SoundPLAN 6.4," 2007.

[3] MapInfo Corporation, "MapInfo Professional Version 8.0," 2005.