

STATE HIGHWAY NOISE MAPPING – AUCKLAND MOTORWAYS CASE STUDY

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ABSTRACT

The NZ Transport Agency initiated a strategic noise mapping exercise in 2009. The aim was to generate noise maps covering the 220 km motorway network in Auckland, which could then be used to inform and identify priority areas for noise mitigation.

The 2009 exercise was repeated and refined in 2012 to address a number of short-comings, in particular, the limited geographical coverage of the maps due to incomplete input data, as well as output inconsistencies associated with the mapping methodology. Careful project scoping, supplier selection and project management enabled the efficiency of the 2012 mapping process to be enhanced and streamlined. Ultimately a comprehensive and consistent set of noise maps have been generated for the Auckland motorway network for a base year of 2006 as well as for 2011.

This paper explores the lessons learnt from the noise mapping exercise. It discusses the benefits of optimising the use of specialists in geographical information systems (GIS), acoustics, transport policy and asset management. The paper also discusses how the information provided by the maps is now being used to shape the Transport Agency's response to road-traffic noise issues in Auckland.

INTRODUCTION

Road-traffic is a widespread source of environmental noise, which can adversely affect community health and well-being. The World Health Organisation¹ identified a range of health effects associated with exposure to elevated levels of noise, such as from road-traffic, including:

- noise-induced hearing impairment
- interference with speech communication
- disturbance of rest/sleep
- physiological, mental health and performance effects.

Noise levels from roads can be calculated in neighbouring areas using acoustics software, which takes account of numerous factors including topography, road geometry and traffic volumes. The resulting noise levels can be displayed as 'noise contours' around the road to create a 'noise map', as shown in Figure 1. Noise maps can be used to indicate populations that may be subject to adverse health effects.

In 2002 the European Noise Directive² required member states to develop action plans over the following years to reduce environmental noise where required. The action plans were to be informed by strategic noise mapping, including for major roads with over six million vehicles per year (approximately 16,400 vehicles per day), and for cities with more than 250,000 people. Consequently, there has been significant development of strategic noise maps in Europe and expertise formed around the use, manipulation and management of geospatial data required for acoustics calculations.

In New Zealand the Transport Agency is a government agency responsible for: planning the land transport networks, investing in land transport, managing the state highway network and providing access to and use of the land transport system. The *Land Transport Management Act*³ requires the Transport Agency to 'exhibit a sense of social and environmental responsibility'. This is reflected in the Agency's *Environmental and social responsibility policy*⁴ and *State highway environmental plan*⁵ (Environmental Plan). An objective set in the Environmental Plan is:

N1 Reduce exposure to high traffic noise levels from the existing state highway network

In response to this policy direction, in a similar manner to the work done in Europe, the Transport Agency has conducted strategic noise mapping for the 220 km long motorway network in Auckland, which is the country's largest city. The intention is to use outputs from this mapping work to identify priority areas for noise mitigation and to understand trends in exposure to road-traffic noise.

An initial noise mapping exercise commenced in 2009 which was then repeated and refined in 2012 to address a number of short-comings, in particular, the limited geographical coverage of the maps due to incomplete input data, as well as output inconsistencies associated with the mapping methodology.

2009 NOISE MAPPING

The first set of strategic noise maps for the Auckland motorway network were commissioned in 2009 by the Auckland Motorway Alliance (AMA). The AMA is a consortium of the Transport Agency, Fulton Hogan, Beca, Opus and Resolve Group, appointed in 2008 to manage and maintain the Auckland motorway network. The maps were generated in 2009 to help identify locations adjacent to the motorway network where residents might be exposed to high levels of road-traffic noise.

In 2009 the Transport Agency (then Transit NZ) was operating a Noise Improvement Programme (NIP)^a in accordance with criteria stipulated in the Environmental Plan. One of the key criteria was that funding for noise improvement works would only be made available where existing road traffic noise levels exceeded 65 dB $L_{Aeq(24h)}$. The 2009 noise maps were intended to provide a first-cut at identifying noise sensitive locations next to the motorway network where this level might be exceeded. Prior to the maps being generated potential areas for noise mitigation were identified using site measurements. By using a traffic noise model to produce a set of noise maps it was then possible to adopt a more strategic and efficient approach to noise improvement works. Not only did the maps provide a greater spatial coverage, but they could also be used to test the benefits of treating any given area.

The 2009 noise mapping allowed all parties to learn and develop a common understanding of the challenges and benefits of producing road-traffic noise maps for the Auckland motorway network. Some of the key lessons learnt from that phase of work were:

- **Inconsistent availability of input data.** Issues included: a) some data such as building footprints were not available for all parts of Auckland; b) while data such as traffic flows were readily available other data such as traffic speed had to be inferred using proxy measures; and c) not all data sets were available for the same modelling year.
- **Inefficient collating, cleaning and managing of input data.** Issues included: a) data coming from numerous sources with some readily and publically available, but not others; and b) the need for the acoustics specialists to spend considerable time processing ('cleaning') input data before it could be used in the model, instead of being solely focused on generating robust and quality-assured model outputs.
- **Unclear end-user requirements.** The AMA had a clear end-use in mind for the maps that were generated, but there was not sufficient recognition of additional and subsequent use of the maps by the Transport Agency. For example, how the outputs could inform operational

^a Funding for the NIP was stopped in 2010. The Transport Agency's current approach to managing state highway road-traffic noise is detailed in Technical Memorandum NV3 (acoustics.nzta.govt.nz/transport-agency-publications). A business case is required to be developed to justify and confirm funding for any noise improvement initiatives.

policy development, trend monitoring, and mapping exercises in other areas of New Zealand.

As a result of the 2009 study the Transport Agency produced a draft *Guide to state highway noise mapping*⁶ to provide information about some of these issues.

2012 NOISE MAPPING

Scoping and planning

In 2012 the Transport Agency reviewed the AMA noise mapping work and commissioned a new noise mapping study for the Auckland motorway network. When making this decision the Agency carefully considered the lessons learnt from the earlier work to ensure the end product would represent good value-for-money and would result in information that could be used for multiple purposes and by multiple end-users.

The noise maps commissioned in 2012 incorporated models for two different years: 2006 and 2011. The reason for using 2011 was that it was the most recent year that aligned with census data in New Zealand, and for which complete annual traffic data was available. The earlier year of 2006 was selected so that improvements resulting from noise mitigation implemented by the AMA and as part of asset improvement projects between 2006 and 2011 could be examined.

A key change in approach between the modelling in 2009 and 2012 was that the Transport Agency, as the client commissioning the work, took a clear leadership role in scoping and managing the 2012 project. The earlier work had been undertaken at arm's length through the AMA. While this change in management approach was in response to the lesson learnt about unclear end-user requirements, it also enabled a number of other objectives to be addressed. In particular:

- The need to review the purpose and use of strategic road-traffic noise models, in terms of the Agency's approach to: environmental and social responsibility; transport and land use planning; asset and risk management; as well as performance and outcome monitoring.
- A desire to enhance client and industry capability as well as facilitating a more collaborative approach to noise mapping.
- A desire to 'future-proof' the modelling and mapping work to provide a more efficient approach to noise management, research and development, model maintenance and on-going support.

In addition to the revised role of the Agency a number of different approaches were adopted for the 2012 mapping exercise that improved on the 2009 work. A key aspect was to use geographical information systems (GIS) specialists for all data preparation, rather than this being conducted by the acoustics specialists. The Agency also took an active role in sourcing and collating data sets. At the outset, the required data structures were agreed for both inputs and outputs, so that as well as satisfying immediate needs, the information could be updated and used again in future.

Supplier selection

The Agency engaged the same consultants, Beca and Marshall Day Acoustics (MDA), that had undertaken the earlier noise mapping for the AMA. This ensured continuity of approach, and built on existing relationships between all parties. It also took advantage of Beca's GIS track record and their role within the AMA, as well as MDA's significant experience of modelling road-traffic noise in New Zealand.

As the majority of the work in the project was related to GIS, Beca was appointed to lead the work with MDA as sub-consultants providing specialist acoustics modelling services. From the outset, a collaborative approach to the project was adopted. Sufficient time was taken to agree the scope of the work and to agree the various roles and responsibilities of all parties involved.

Project management

A project steering group was created to address two of the key lessons learnt from the 2009 mapping exercise (inconsistent availability and inefficient provision of model input data), as well as to check that the work stayed within scope and on track to deliver the agreed outputs on time. This group was led by the Transport Agency Environment and Urban Design team with significant input and direction from the Agency's internal GIS team. The steering group met with the consultants undertaking the work on a number of occasions during the project.

Time and effort was spent during the early stages of the project, shaping, fostering and reinforcing a collaborative culture amongst the parties. As the project evolved this enabled all to focus on identifying opportunities to share relevant information and knowledge in a timely manner, as well as helping to streamline and undertake the work in a more efficient manner than had been the case in 2009.

The steering group obtained input from key stakeholders and likely end-users of the noise maps. This included the AMA as well as the Transport Agency transport planning and land-use planning teams in Auckland. In addition, input was sought from Transport Agency National Office staff developing operational policy relating to public health (road-traffic noise) as well as those undertaking research and monitoring in this subject. Input from end-users was important in determining appropriate outputs from the mapping to ensure the project delivered value for multiple parties. An iterative approach, enabled by the collaboration underpinning the project, was adopted to confirm the detail and format of outputs. This detail included the format, collation, processing and archiving of model input and output data, and the delivery and format of map outputs. Crucially, time was spent on ensuring that the attributes of GIS data files and maps matched the input requirement of the noise model.

Methodology

By adopting a collaborative and team-based approach when undertaking the 2012 mapping work, it was possible to create an environment where each party readily understood and valued the role and input of each other party. Input from all parties was targeted to ensure each added timely and maximum value to the project.

The GIS specialists (both at the Transport Agency and Beca) focussed on all aspects of data management including; sourcing data, data collation, data processing, data warehousing, input data provision as well as mapping and spatial analysis of acoustics model output data. By contrast the acoustics modelling team focussed on quality assurance activities as well as preparing and running the model. This included ensuring that input and output data was fit-for-purpose in terms of the scope and objectives of the project.

In addition to the above role for this project, the Transport Agency GIS team also used the project to develop and enhance relationships with key data providers such as the Auckland Council. For example, building footprint and terrain (LiDAR) data was obtained from the Council at minimal cost for the whole of the study area by making use of an organisation-to-organisation data sharing agreement. Obtaining such data from the Council had proved challenging during the earlier 2009 study, partly because the Transport Agency was not directly involved, but also because the work preceded the creation of the unitary Auckland Council (in 2009 there were eight councils in Auckland holding the necessary GIS data. As a consequence it was not possible to produce consistent noise maps for the whole of the Auckland motorway network in 2009.)

The project proved beneficial for all parties involved in terms of 'learning by doing'. As mentioned, each organisation had previous experience and a good track record undertaking noise modelling and mapping work. The 2012 project built on this base knowledge and increased the capability and capacity to undertake strategic road-traffic noise mapping at both the Transport Agency and at the consultancies.

As stated previously, the project objectives included a requirement for the mapping method to be future-proofed so a similar approach could be replicated elsewhere in New Zealand, or repeated for Auckland in future with reduced effort. To facilitate use of the approach in other areas, the method was clearly documented and used to inform an updated draft of the *Guide to*

state highway noise mapping⁶. The draft guide also helped to reduce the effort required to repeat the maps in Auckland. The fact noise maps were required for both 2006 and 2011 (i.e. the exercise was repeated using different input data) created an incentive for Beca and MDA to undertake this project as efficiently as possible with clearly structured data. Thanks to the structured work involved in preparing the first maps, the second set was produced in a fraction of the time.

As well as resulting in a set of maps, the scope of the work included for all intermediate input and output data to be provided to facilitate any subsequent, modification, analysis and research. This will allow for more detailed modelling and scenario testing, such as benefit and impact assessment of noise mitigation measures.

Outputs

Figure 1 below is an example of the noise mapping outputs from the 2012 project. Noise level information is presented as contours in 5 dB bands from 55 dB $L_{Aeq(24h)}$ to greater than 70 dB $L_{Aeq(24h)}$. In addition, noise levels are shown for individual noise sensitive buildings – or ‘PPFs’ (Protected Premises and Facilities) – in accordance with the three noise criteria categories in NZS 6806:2010⁷ (Category A – less than 64 dB, Category B – 64 to 67 dB and Category C – greater than 67 dB).

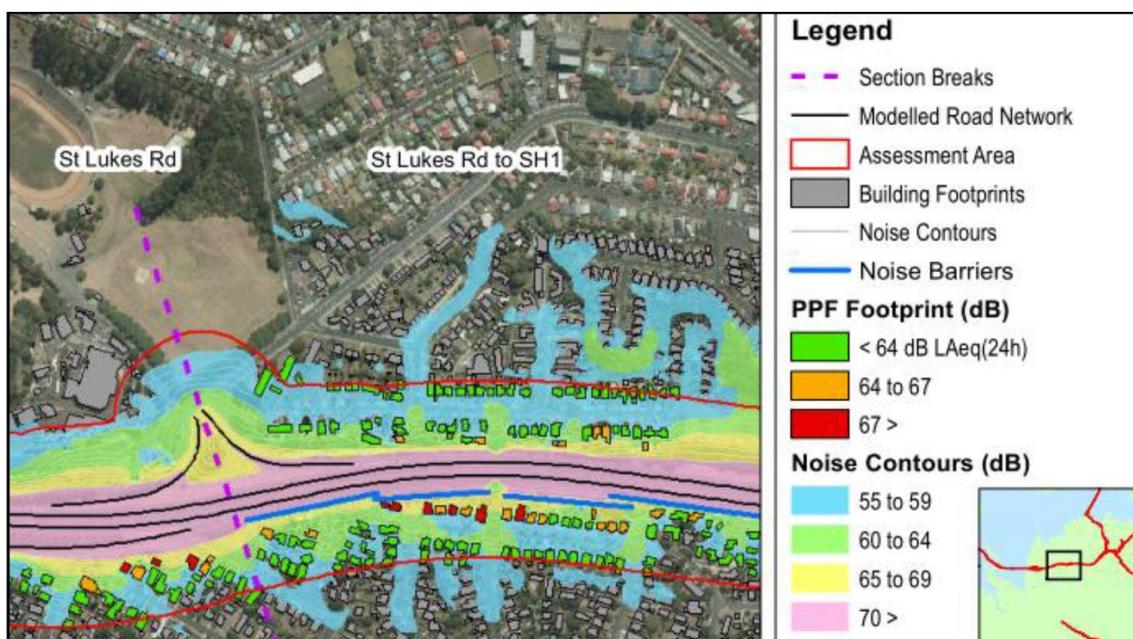


Figure 1: Example of noise mapping output

Noise levels are shown as $L_{Aeq(24h)}$ values as this is the parameter used to assess road-traffic noise effects on people in New Zealand. As well as noise levels, other key attributes shown on the maps include: state highway centre lines, noise barriers and the extent of the assessment area used to determine individual noise levels. The assessment area was set at 100 metres from the edge of the nearest carriageway in urban areas, and 200 metres in rural areas, in accordance with NZS 6806:2010.

In addition to maps like Figure 1 covering the entire Auckland motorway network, a series of complementary data tables were produced summarising the GIS analysis. Data was generated for each motorway section to show both the number of PPFs within the assessment area and the estimated residential population exposed to noise levels in each of the 5 dB bands.

The stimulus for generating data, which was to understand population exposure to road-traffic noise levels, was the Transport Monitoring Indicator Framework (TMIF)⁸ produced by the Ministry of Transport. The TMIF (now referred to as ‘Transport Indicators’) includes the following indicator:

PH010 - Road traffic noise measurements that are in excess of the following noise levels: 55, 60, 65, 70 and 75 dB(A) $L_{eq,24hrs}$.

At this time the Ministry of Transport does not report against this indicator. The Transport Agency collates and provides a comprehensive range of 'Transport Data'⁹ covering a wide range of topics, but not currently including road-traffic noise. The Auckland motorway noise maps will help to address this shortcoming and improve on the limited number of transport-related public health datasets generally.

As indicated above, noise maps were generated for both 2006 and 2011 scenarios. The purpose of generating maps for these two years was to enable investigation of changes in road-traffic noise levels over this time period. While the maps facilitate a variety of analyses, as discussed below, there was a specific desire to understand the impact of noise mitigation implemented as part of asset improvement projects on the Auckland motorway network between these dates. There were several major projects during this time, including parts of two of the seven 'Roads of National Significance (RoNS)' specified in the *Government Policy Statement of Land Transport Funding*¹⁰: Victoria Park Tunnel and the Western Ring Route. The noise maps will support a review of the social and environmental impact of these RoNS projects.

As well as being able to assess the impact of noise mitigation implemented as part of asset improvement projects, the two sets of noise maps and associated data allow the Transport Agency to better understand the impact of several other parameters on community noise levels including:

- the NIP measures implemented by the AMA between 2009 and 2011
- changes in traffic characteristics (flow, speed, fleet)
- land use changes
- population changes
- changes in asset management practices (e.g. alteration to road surfaces).

The maps and data could also be used to support Transport Agency research, and for initiatives by other parties such as Auckland Council, Auckland Transport, Universities and Crown Research Institutes to investigate the impacts of road-traffic noise. For example the information could be used to look into the nature and extent of human health and amenity effects or to support economic analyses of road-traffic noise.

An interim finding from limited and unpublished research undertaken to date using the maps and data suggests the combined benefits of the NIP implemented by the AMA and mitigation implemented to address adverse noise effects associated with asset improvement projects, including RoNS projects, has been counter-balanced by a growth in traffic between 2006 and 2011. Consequently it appears that road-traffic noise exposure at the population level has remained constant between these two dates.

Beyond the research focussed activities discussed above, the mapping outputs have been, and are to be, used to support a range of operational needs of the Transport Agency including:

- **Assisting complaint management.** The Agency (including the AMA) received over 250 documented complaints about road-traffic noise between 2006 and 2011. While some complaints relate to temporary issues such as noise caused by road construction and maintenance activities, many complaints are associated with road-traffic noise and frequently include requests for the installation of noise barriers. The maps now provide factual information that the Agency and the AMA can use to respond to such requests. Instead of responding in an inconsistent manner the noise mapping data can be used to provide an informed customer-focussed response.
- **Supporting the development of business cases.** Since funding is no longer available for the NIP outlined in the Environmental Plan, a business case must be developed to justify investment in any measures to reduce road-traffic noise effects. The maps and associated data sets have already been used to provide the evidence for a business case that seeks to improve the noise environment around the Auckland motorway network by installing noise barriers. The data showed that over 5,000 people living within 100 metres of the motorway network are exposed to road-traffic noise levels above 65 dB $L_{Aeq(24h)}$. This specific business

case is subject to standard Transport Agency investment decision making processes and is yet to be approved.

- **Identifying ‘hot spots’.** For the business case discussed above, a number of potential sites for noise mitigation have been identified using information from the noise mapping and based on the scoring system shown in Table 1. The criteria are broadly based on those in the Environmental Plan that were previously used to assess submissions for NIP funding. The scoring system has resulted in the identification of 10 candidate sites, which may alter as further more detailed analysis is conducted.

Table 1: Scoring system to identify areas for noise mitigation

Measure	Maximum score
Number of houses exposed to noise level	10
Clustering of houses per length	5
High level engineering judgement of practicability	5
Planned or recent work (since 2011) that includes noise mitigation	5
Pre-existing noise mitigation	5

- **Informing transport planning.** The noise maps have been used to inform transport planning studies for motorway corridor improvements. In particular the maps have been used to reduce the time and effort required to investigate potential noise effects associated with a number of improvement projects, such as increasing the number of traffic lanes in a certain location. This has enabled informed discussions to occur earlier than would otherwise be the case, reducing costs associated with project re-design to take into account noise mitigation requirements.
- **Informing land use planning.** The maps have been used to inform the Transport Agency’s submission on the *Proposed Auckland Unitary Plan*¹¹ that has been developed by the Auckland Council. In particular the noise maps provide evidence that illustrates the Agency’s position on the ‘High Transport Noise Overlay’ included in the plan. There are associated rules in the plan requiring new noise sensitive activities establishing near existing motorways to be appropriately designed and constructed so that occupants are adequately protected from road-traffic noise.

CONCLUSIONS

There are various reasons for generating noise maps for state highways, and there are many potential uses for the resulting data. Through careful planning and management of the production of the 2012 Auckland motorway noise maps, the data and information generated has, and will continue to have value for multiple purposes and end-users.

The keys to the success of the 2012 study were ensuring clarity around the scope of the project, identifying the key focus areas of each party, and promoting frequent communication and collaboration between the experts involved.

To date, the noise maps discussed in this paper have only been produced for the Auckland motorway network. In line with experience in Europe, it is likely that further noise mapping in New Zealand would only be appropriate for the major cities of Wellington and possibly Christchurch. However, much of the information could be used to inform research and operational needs beyond the immediate focus of Auckland, motorways and the Transport Agency. To increase the value derived from the outputs it is incumbent on the Transport Agency to actively engage with other potentially interested parties and to continue to foster the spirit of collaboration that was used to develop the noise maps in the first place.

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