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Benefits of developing a detailed noise model for a large industrial site

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ABSTRACT

The development of detailed noise models for large industrial sites is becoming increasingly common in New Zealand. However, there appears to be a dearth of information on the benefits of developing such a model. Based on a number of recent project experiences, we have found that the key benefits of developing a detailed noise model for a large industrial site include:

- Ability to identify and prioritise cost-effective noise control opportunities for an existing site;
- Accurate assessment of how future expansions may affect total site noise emissions;
- Inform the development of noise budgets for contract purposes and compliance with relevant environmental noise standards; and
- More effective communication with project team, site operators and general public through the use of model outputs such as noise contour maps.

The aim of this paper is to consolidate recent project experiences that have involved detailed noise models and provide information on the benefits these models can offer for large industrial sites.

Keywords: Industrial, Noise Model I-INCE Classification of Subjects Number(s): 76.1.4

1. INTRODUCTION

This paper sets out the key benefits of developing detailed noise models for large industrial sites, based on a number of our recent project experiences. While examples used in this paper are dairy factories, the concepts and principles apply equally to other types of large industrial sites.

Background on the issues that resulted in our development of detailed noise models is discussed.

A brief overview of our detailed noise modelling process is also provided.

2. BACKGROUND

Our experience in developing detailed noise models arises from addressing noise issues for a number of historically non-compliant dairy factories.

Common questions we have had to address include:

- How can existing site noise emissions be cost-effectively reduced to achieve compliance?
- How would total site noise emissions be affected by a proposed site expansion?
- What noise control would be required to allow site expansion whilst achieving compliance?

We have found the use of detailed noise models to be extremely helpful in answering these questions.

The use of detailed noise models was initially born out of the necessity to account for the complex cumulative effects of noise emissions from large dairy factories, particularly taking into account reflections and screening by buildings or terrain. The use of these models was also pursued to improve the accuracy of noise predictions in light of both increasing public sensitivity and scrutiny of noise emissions and enforcement from local territorial authorities.

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3. DEVELOPING A DETAILED NOISE MODEL

Our process for developing detailed noise models for large industrial sites typically involves the following:

a) Undertake detailed noise surveys of the particular site of interest, including the surrounding area;
b) Process and analyse measurement data for input into a suitable noise modelling program;
c) Calibrate the noise model based on close-up and distant noise measurement results; and
d) Prepare model output, such as noise contours and difference maps, as required.

Each of these aspects are outlined below.

3.1 Detailed Noise Surveys

In order to collect adequate data for a detailed noise model, a large number of noise measurements are required within and around the site of interest. An on-site noise survey involves measuring all significant sources of noise, along with relevant dimensions, reflective surfaces and spatial arrangements so that individual sound power levels can be determined. It is important to consider the way in which the various noise sources will be modelled when undertaking these measurements. For example, whether the noise source is likely to be modelled as a point source, line source or area source will affect how the measurements are performed.

Off-site measurements, including subjective impressions of the dominant noise sources (where possible), are used to calibrate the model. These measurements are performed in general accordance with NZS 6801:2008 (1) with particular attention to meteorological conditions and minimising any contamination from extraneous noise sources.

Although a detailed noise survey involves a significant initial investment in time and resources, the project benefits offset this by reducing the need for return visits to distant and sometimes relatively inaccessible sites, and enabling prompt evaluation of various noise control and expansion scenarios. For example, if only boundary noise measurements are undertaken to estimate the approximate noise 'footprint' of a site (by reducing the site to 1-4 equivalent point sources), then a follow up visit would be necessary to determine the effect of relocating or removing a significant noise source. A follow up visit is likely to adversely impact on project timelines due to potential delays associated with suitable weather and plant operating conditions required to conduct the noise survey. In contrast, having collected noise data for all significant noise sources during an initial detailed noise survey, the effect of removing or relocating a noise source on site can be swiftly investigated as a desktop exercise.

3.2 Processing and Analysis of Measurement Data

Following completion of the detailed noise surveys, the on-site measurement results are used to calculate the sound power levels of the various sources. The sound power levels are then built into a three-dimensional noise model using an appropriate noise prediction computer program by way of point sources, line sources and area sources including buildings. An example of such a model is shown in Figure 1.

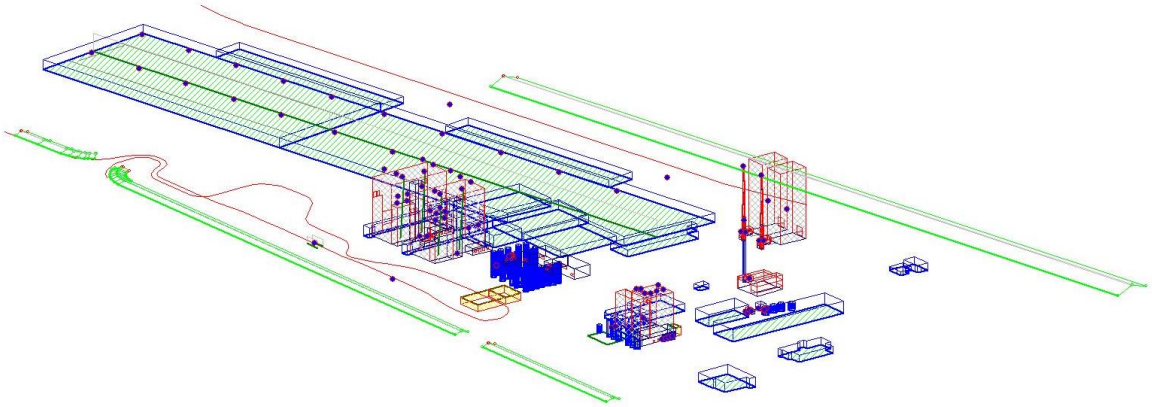

Figure 1 – A detailed three-dimensional noise model for Fonterra's Studholme dairy factory expansion

It is important to carefully consider the way in which noise sources are modelled. Key factors to consider include source directivity, proximity to buildings, and distance from critical noise sensitive receivers.

In some cases clusters of noise sources can be combined into a single source in the model to reduce calculation run times. Sensitivity analysis is often required to determine the validity of combining groups of noise sources.

Consideration of the noise assessment standard is also essential when entering source data into the model. In New Zealand noise levels are typically assessed in accordance with NZS 6802:2008 (2). This standard includes allowance for averaging and adjustment for special audible characteristics (e.g. tonality) which should be taken into account when adding sources into the model.

3.3 Calibration of Model

Once the initial sound power level inputs have been entered into the model, the model is calibrated to match the noise survey results. Both close-up and distant noise measurements are used to calibrate the model. However, preference is usually given to distant measurements, as the accuracy of the model at distant locations is often more important than the accuracy of predicted noise levels within the site itself.

Consideration of the noise calculation method is important when calibrating the model. For example, if calculations are performed in accordance with ISO 9613-2:1996 (3), a calculation standard that is based on light downwind propagation, the meteorological conditions present during the measurements must be accounted for. That is, measured noise levels at distant locations upwind of a site should be lower than those predicted by the model under ISO 9613-2:1996.

Noise sources and model parameters are adjusted accordingly until a suitable degree of calibration is achieved. Where discrepancies are significant, it is important to undertake a thorough investigation of the initial data collection, calculation of sound power and directivity, and the modelling process. Simply lumping a large calibration adjustment as ‘meteorological effect’ without solid justification is likely to prove detrimental in later stages of the project.

3.4 Preparation of Noise Contours

Once the noise model calibration process is complete and the predicted noise levels have been finalised, the results are usually presented in the form of noise contours. An example of a noise contour map is provided in Figure 2. Noise difference maps can also be prepared when necessary to illustrate how changes between various scenarios can affect site noise emissions.

Only essential information should be provided on the noise contour maps so that noise levels can be easily interpreted. It can be tempting to include many noise contours on model outputs. However, in our experience this can be confusing and may result in an overload of information for the recipient. Using too fine an increment in contour also implies a degree of precision that in practice may not exist. For models of large industrial sites we typically prepare a small number of noise contours at 5 dB increments around the level of noise of key interest, e.g. the night-time noise limit.

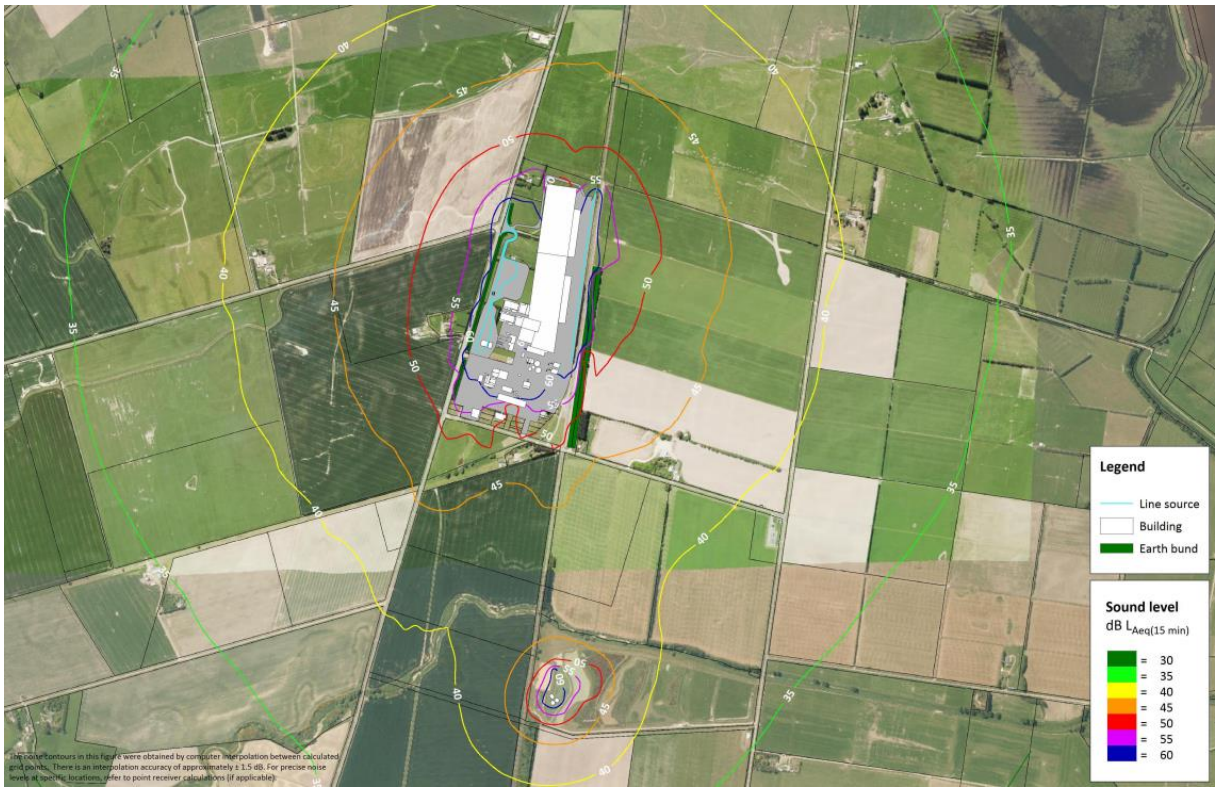

Figure 2 – A noise contour map for Fonterra's Studholme dairy factory expansion

4. PROJECT EXAMPLES

Having developed twelve detailed noise models for large dairy factories over the last five years, the types of projects can be broadly separated into the following three categories:

a) Existing sites requiring noise control;
b) Existing sites undergoing expansion; and
c) New greenfield sites.

Examples of these types of project are briefly discussed below.

4.1 Existing Site Requiring Noise Control: Fonterra Pahiatua

Fonterra Co-operative Group Limited (Fonterra) sought to expand a fairly small existing dairy factory located near Pahiatua, in the Tararua District of New Zealand, by adding a new 15 tonne/hour whole milk powder dryer and associated boiler and drystore. The expansion also involved the construction of a new wastewater treatment plant nearby. The whole milk powder production capability of the site was intended to triple as a result of the expansion.

The key challenge for this project was that the existing dairy factory already exceeded its noise limits. An assessment was therefore required to determine the extent of noise control required for both the existing sources and the new sources proposed under the expansion.

To perform this assessment we undertook a comprehensive noise survey of the site and used the data obtained to develop a detailed noise model. This model was used to inform noise control recommendations to ensure that cumulative noise from the existing site and the proposed expansion would comply with the relevant environmental noise standards. The model was also particularly useful for informing noise budgets for supplier contract specifications.

4.2 Existing Site Undergoing Expansion: Fonterra Studholme

Fonterra proposed to significantly expand their Studholme dairy factory, located near Waimate, South Canterbury, New Zealand. The existing relatively small scale site consisted of a single 5.5 tonne/hour whole milk powder dryer, two 15 MW coal fired boilers and associated dry store operations.

The proposed two-stage expansion involved the construction of two additional whole milk powder dryers, each capable of producing around 30 tonnes of product per hour. Two new 50-65 MW coal and

wood biomass fired boilers, large drystore facilities with a total building area of approximately 70,000 m^2, rail loadout, and an upgraded wastewater treatment plant were also proposed.

Our work on this project included assessing the site's existing noise emissions by conducting detailed noise surveys, and developing a noise model of the existing site and the proposed multi-stage expansion. The noise model was used to predict cumulative noise emissions from the proposal, and inform noise control recommendations and the development of a noise control boundary for planning purposes.

4.3 New Greenfield Site: Fonterra Darfield

The Fonterra Darfield dairy factory was established on a greenfield site in West Canterbury, New Zealand in 2012 (4). The large multi-stage site includes two whole milk powder dryers, one of which was the world's largest whole milk powder dryer at the time of construction, capable of producing 30 tonnes of product per hour. The development also includes two 30-45 MW coal fired boilers (5), rail loadout area, drystore facilities, and wastewater treatment plant.

This site was acoustically challenging due to the relatively quiet rural area of the greenfield site. We were involved throughout the development of this site from early feasibility assessments through to consenting, design and commissioning of the two current stages of development. We also provided advice for future expansion plans. Detailed noise models were used to inform our advice throughout the various stages of this project.

5. KEY BENEFITS OF DEVELOPING A DETAILED NOISE MODEL

Based on our experiences with the projects outlined above, and others, we have found that the development of detailed noise models can offer the following key benefits.

5.1 Identification and Prioritisation of Noise Control Opportunities

A detailed noise model enables us to determine the dominant sources of noise at any particular location around the site of interest. This is especially useful to identify and prioritise which noise sources should be treated in order to most effectively reduce overall noise emissions.

This approach has been successfully utilised at Fonterra's Pahiatua site. Our detailed noise model of the existing site indicated a number of key noise sources that would require treatment in order to achieve acceptable noise levels at nearby dwellings. Key noise sources included dryer exhausts and process air intakes.

By treating the key noise sources, noise levels at nearby dwellings were reduced so that the site expansion could occur whilst not only complying with the site's environmental noise limits, but actually slightly reducing overall community noise exposure.

The spectral output from the detailed noise model also confirmed the source of tonality audible at particular dwellings nearby, enabling the design of appropriate noise control treatment to address this issue.

The benefit of identifying and prioritising noise control was also apparent for the work we undertook at Fonterra's Studholme site, albeit in a different manner. For this particular site, our detailed noise model showed that treatment of existing noise sources would have a minimal effect on total site noise emissions once the proposed expansion had been completed. On this basis the decision was made not to treat the existing plant, which resulted in significant cost savings to the client. For this project, the focus of the detailed noise model was on identifying noise control opportunities for the proposed expansion scenario. The noise control opportunities identified included changes to layout and placement of key noise sources, the construction of earth bunds, and attenuation of specific noise sources such as dryer air discharges.

5.2 Assessment of Impacts of Future Site Expansions

Having undertaken a number of detailed noise surveys for various dairy factories, we have developed a useful database of typical dairy processing related noise sources. In addition to using manufacturers' noise data (where available) this allows us to undertake preliminary modelling of the noise impacts of future site expansion scenarios very quickly.

One of our first major assessments of future site development was for Fonterra's Darfield dairy factory. This greenfield site was initially modelled based on our detailed noise survey of a dairy processing plant recently constructed at another Fonterra site. This data was used to develop a detailed noise model for stage 1 of the Darfield development. Once stage 1 had been completed, a detailed

commissioning noise survey was conducted and the results used to update the model and assess the impacts of future stages of development.

Following Darfield, we undertook a similar exercise for Fonterra's existing dairy factory in Pahiatua. By developing detailed models of both the existing site and the proposed expansion, we were able to assess the cumulative noise impacts arising from the expansion and provide advice for noise control opportunities to ensure that the activity complied with relevant environmental noise limits. For this particular site, the proposed expansion plans changed significantly midway through the project. Because we had developed a detailed noise model, we were able to rapidly assess the impact of these changes and determine any necessary noise control modifications for both the existing and proposed plant and equipment.

Another relevant example is Fonterra's Studholme site. A proposal was put forward to significantly expand this relatively small dairy site by building additional plant and equipment that would increase the processing capacity of the site tenfold. Based on detailed noise surveys of the existing site, and our database of previous detailed measurements, we were able to build a noise model to investigate the noise impacts of various expansion scenarios. Similarly to Pahiatua, this model was particularly useful for assessing different expansion options and determining noise control requirements, particularly for the new plant and equipment proposed.

5.3 Inform Noise Budgets

Noise budgets are particularly useful for the planning and management of noise emissions from future site developments. They are often used for contractual purposes to provide certainty around the levels of noise that particular items or areas of plant must achieve. Noise budgets are also useful for equipment suppliers and manufacturers by indicating the level of attenuation required.

Based on previous project experiences, we have found detailed noise models to be a valuable tool to assist in the preparation of noise budgets for large industrial sites. Noise source data can be exported from such models and used as a noise budget relatively quickly and easily. A key advantage of basing a noise budget on a detailed noise model is that any changes to noise budgets can be updated in the model to determine the effect on total site noise emissions, and on noise budgets for other equipment.

The detailed noise model produced for the Fonterra Darfield project was particularly useful for setting noise budgets. Initially, 'high-level' noise budgets were set for general areas of plant and equipment to determine whether total noise emissions could achieve the relevant noise limits. Later on in the project, more detailed noise budgets were prepared for contractual purposes and used to inform equipment manufacturers and suppliers of maximum allowable noise levels.

These noise budgets were then used as assessment criteria during commissioning measurements after each stage of expansion.

This noise budget approach, based on a detailed noise model, was also successfully adopted for the Fonterra Pahiatua project.

5.4 Communication Tool

Another key benefit of developing detailed noise models is the use of model outputs, such as noise contours, as a communication tool. Noise can be somewhat of a 'mystery' to laypeople and we have found noise contours to be a useful way to communicate what the total noise produced by a site 'looks' like.

Noise contours can be used to compare various scenarios, and visualise the effect that changes to a site may have on noise emissions. The results are useful to communicate with a range of people including members of the project team, site operators, regulators and the general public. We typically provide noise contour maps with consent applications to show the anticipated noise footprint of a proposed activity. In our experience, noise contours are more effective at illustrating the noise impact of an application than decibel levels laid out in a table, for example.

Noise difference maps, another type of model output, can also be used to show differences between scenarios. An example of a noise difference map is provided in Figure 3, which shows the effect of relocating a heavy vehicle access point on Fonterra's Pahiatua site. The yellow, orange, red and blue areas indicate where noise levels will increase as a result of the relocation and the shades of green show the regions where noise levels will reduce.

Figure 3 – A noise difference map showing for relocating a heavy vehicle access point at Fonterra Pahiatua

When preparing model outputs, it is important to highlight relevant model assumptions and conditions, e.g. the presence of a light wind blowing from noise source to receiver, or the assumed treatment of particular noise sources.

6. SUMMARY

Based on recent project experiences, we have found that developing detailed noise models for large industrial sites offers the following key benefits:

- Ability to identify and prioritise cost-effective noise control opportunities for an existing site;
- Accurate assessment of how future expansions may affect total site noise emissions;
- Inform the development of noise budgets for contract purposes and compliance with relevant environmental noise standards; and
- More effective communication with project team, site operators and general public through the use of model outputs such as noise contour maps.

As the use of detailed noise models for large industrial sites increases, further benefits are likely to become apparent. Based on our experiences thus far, the response from clients and other involved parties to outcomes resulting from the use of detailed noise models has been very positive.

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