APPENDIX I

Acoustic Assessment
Project: ROYDON QUARRY

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Report No.: Rp 001 R03 20170506

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EXECUTIVE SUMMARY

Marshall Day Acoustics has been engaged by Fulton Hogan to assess the potential noise and vibration effects associated with their proposed Roydon Quarry in the Selwyn District. The quarry will require aggregate extraction down to a depth of around 10 metres below existing ground level, in addition to a full range of processing equipment. Some after-hours operation is proposed, albeit with a more limited scope. Details of the site configuration we have assessed are provided in this report and described more comprehensively in the consent application’s Assessment of Environmental Effects report.

The area around the application site is generally rural, with a mix of dwellings, businesses and agricultural land. The residential area of Templeton is situated around 700 metres east of the site. State Highway 1 and the main south railway line pass the site to the south and both are sources of noise that influence the existing ambient environment. Although Christchurch International Airport lies further afield, the area around the quarry is within the air noise contours in the Christchurch District Plan.

We have undertaken a comprehensive monitoring programme of existing ambient noise levels within the area. The findings of this study were broadly that:

- Noise-sensitive receivers away from State Highway 1 (e.g. north of the site) typically experience external daytime noise levels around 50 dB L_{Aeq} and night-time levels between 35 and 45 dB L_{Aeq}; and
- Receivers near State Highway 1 are subject to over 65 dB L_{Aeq} during the day and 55 dB L_{Aeq} at night.

To consider the potential noise effects of the activity, we have compared the noise emissions with the ambient noise levels above and with appropriate local and international guidance on noise assessment criteria. We have developed project-specific noise limits that apply at the site boundary in order to result in acceptable noise effects at adjacent residences, which are:

- 55 dB L_{Aeq} for the daytime operating period (0600 to 1800 hrs);
- 50 dB L_{Aeq} for the evening period (1800 to 2200 hrs); and
- 45 dB L_{Aeq} and 70 dB L_{Lmax} at night (2200 to 0600 hrs).

Operational noise levels (i.e. from the quarry during its main lifespan) have been assessed against these criteria. We have calculated the levels of noise received at multiple nearby noise-sensitive receivers and also produced computer-generated noise contour plots that demonstrate the propagation of noise at greater distances. The results are summarised in the following table for “average” receiver locations around the site.

<table>
<thead>
<tr>
<th>Receiving Environment</th>
<th>Early Stage Development</th>
<th>Mid Stage Development</th>
<th>Late-Stage Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>North (Maddisons Road)</td>
<td>44 dB L_{Aeq}</td>
<td>44 dB L_{Aeq}</td>
<td>46 dB L_{Aeq}</td>
</tr>
<tr>
<td>South (Main South Road)</td>
<td>47 dB L_{Aeq}</td>
<td>48 dB L_{Aeq}</td>
<td>49 dB L_{Aeq}</td>
</tr>
</tbody>
</table>

This demonstrates that the project’s daytime assessment criteria are easily achieved. We have also considered noise produced during the evening and night, as well as that from temporary daytime activities, all of which also achieve our recommended criteria. Similarly, site preparation ‘construction’ noise will achieve the appropriate guidance given in the national construction noise assessment standard, NZS 6803.

We have also assessed the sites noise emissions against the applicable Selwyn District Plan noise limits. The proposed project specific noise limits are generally more stringent that permitted by the District Plan.

Another key focus of our report has been noise produced outside of the application site, even though this is not strictly a ‘compliance’ issue. The influence of additional heavy vehicle traffic on public roads has been explored in detail in this report. In terms of the wider road network, the additional quarry traffic will not result in any overall noise level increase. Locally, existing traffic is sufficiently high to ensure that there will be no perceptible noise level increases during the day, and only a minimal increase at night in a few cases.

We have also discussed vibration, both from within the site and from heavy road traffic, and find that, while this may be perceptible at times, the effects on receivers are acceptable for this environment.
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1.0 INTRODUCTION

Marshall Day Acoustics has been engaged by Fulton Hogan to assess the potential noise and vibration effects associated with their proposed new quarry located between Maddisons, Jones, Dawsons and Curraghs Roads, near Templeton. The proposed quarry is to be known as the ‘Roydon Quarry’. The site extent is shown in Figure 1.

We have undertaken a detailed investigation of all aspects of the proposal pertaining to the generation of noise and vibration. Our assessment has been based on: reviewing standards and guidance (local, national and international); surveys and observations around the application site; and the results of our computer modelling and calculations.

The primary focus of this report – the calculation and assessment of operational noise (i.e. that generated within the quarry site) – is covered from Section 4.0 to Section 7.0. Also considered in this report, but discussed separately, are:

- Noise from site establishment activities (i.e. construction of the quarry);
- Noise from additional traffic, including trucks, on the public road network; and
- Vibration effects on sensitive receivers in the locality of the application site.

A glossary of acoustical terminology used in this report is provided for reference in Appendix A.

Figure 1: Aerial view of the proposed quarry site and locality
2.0 PROPOSED ACTIVITY DESCRIPTION

The proposed quarry site is located within the Selwyn District and comprises most of the block bounded by Dawsons Road to the east, Maddisons Road to the north, Currags Road to the west, and Jones Road to the south.

The road reserves abut the site to the west, east and south, whereas the northern site boundary is shared with private agricultural land and a dwelling at 319 Maddisons Road. Dawsons Road forms the boundary between Selwyn District and Christchurch City.

Fulton Hogan propose to establish a quarry for long-term use and will excavate the site to a depth of around 10 metres below existing ground level. In addition to aggregate extraction, the operation will also involve the conveying, processing (crushing and screening) and stockpiling of aggregates; importation of aggregate materials; site establishment works; haulage operations, clean-filling and rehabilitation; and other ancillary site operations.

We understand that blasting will not be required at this site and have therefore not included this in our assessment. We understand quarrying activity will generally be staged follow the layout shown in Figure 2 below.

Figure 2: Indicative site layout and staging plan
2.1 Site Establishment

The land will require a range of preparatory works to be completed prior to the commencement of the main quarrying activity. In particular:

- Topsoil and overburden material will be removed from the initial extraction area (shown in Figure 2) by an excavator and trucks, in combination with a loader;
- Stripped material will be used to establish earth bunds around the perimeter of the site (owing to the large size of the site, some material may need to be imported to complete the bunds);
- Bunds of at least 3 metres in height will be developed around the site boundary at the outset of works. The setback required to create the bunds and allow associated plantings will result in the edge of the extraction area being set back by around 20 metres from the site boundary;
- A heavy vehicle site access will be constructed near the midway point along the Jones Road site boundary, with a light vehicle access further to the west along Jones Road; and
- Ancillary features such as workshop and office buildings will begin to be erected as required.

Once the initial extraction area has been prepared for quarrying the main operation – the extraction of saleable aggregates – will commence.

2.2 Main Operations

The proposed quarry will primarily operate from 0600 to 1800 hrs, Monday to Saturday. Beyond these hours, some activities will continue but at a reduced scale or frequency. We understand the following hours in Table 1 are proposed.

Table 1: Proposed operating hours

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Frequency/Duration</th>
<th>Range of Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>0600 - 1800 hrs, Monday to Saturday</td>
<td>All days</td>
<td>Full range of activities.</td>
</tr>
<tr>
<td>1800 - 2200 hrs, Monday to Saturday</td>
<td>150 days per year</td>
<td>Full processing, extraction and loadout activities. No cleanfill or mobile processing.</td>
</tr>
<tr>
<td>2200 - 0600 hrs, Monday to Saturday</td>
<td>150 days per year</td>
<td>Load out of trucks and truck movements. Ancillary activities such as operation of weighbridge and offices. Light maintenance.</td>
</tr>
<tr>
<td>Sundays</td>
<td>15 days per year</td>
<td>Load out of trucks and truck movements.</td>
</tr>
<tr>
<td>All other times</td>
<td></td>
<td>No activity (other than dust suppression, office activities, site security and light maintenance if required).</td>
</tr>
</tbody>
</table>

2.2.1 Extraction

Extraction of the aggregate resource will involve the use of standard quarry machinery, such as excavators, loaders, dump trucks, road truck and trailer units and other machinery as required for the efficient extraction of the resource.

Electric conveyors will be used wherever possible to transport material around the site, which will minimise the number of truck movements necessary on internal haul roads. Road trucks will mostly be loaded from the final stockpiling area adjacent to the processing plant.

Once the pit has been formed, extraction will always occur from the bottom of the pit. This is significant from a noise generation perspective as it means that noise sources are always screened from receivers by the edge of the pit. In addition, mobile machinery tends to work right against the
face of the pit, which maximises the acoustic screening from the pit face. An example of this is shown in Figure 3.

**Figure 3: Example of loader activity at edge of pit**

We understand that there will be a 100 metre setback for extraction from any dwelling adjacent to the site boundary (except where the owners/occupants have provided their consent).

### 2.2.2 Processing

Once the resource has been extracted it will transported (via conveyor or dump truck) to fixed or mobile processing plant located within the quarry floor, where it will be fed through the processing plant to produce a range of aggregate products.

We understand that, typical of any large gravel quarry, the fixed processing plant will comprise:

- Multiple crusher types to produce different products (e.g. jaw, cone, vertical shaft, etc.);
- Multiple tiers of screens for separation of different material sizes; and
- An electrical conveyor system feeding the plant and connecting all of the crushing and screening elements.

The fixed plant will, at times, be complemented by mobile field processing equipment that will be brought to and from the site as demand dictates. This mobile plant will typically comprise a crusher and screening unit.

Fixed processing plant will be situated in the middle of the site, with all crushers and screens at least 500 metres away from the site boundary. Any mobile processing plant will remain at least 250 metres from the site boundary at all times and will only operate during the core daytime period.

### 2.2.3 After-Hours Activities

As described previously in Table 1, some activities will occur outside of the main daily operating hours for the quarry (i.e. from 0600 to 1800 hrs). The following noise-generating activities may occur at times:

- Operation of extraction and processing plant (until 2200 hrs only);
- Haulage/truck load-out (lower rate of movements than during the day);
- Equipment maintenance; and
- General office activities.
We understand that these activities will only occur on some days throughout the year. As such, there will be some variation in terms of when different activities occur and overlap.

It is therefore important to note that, while our assessment tends towards the consideration of worst-case scenarios, this will not be an everyday occurrence and, moreover, after-hours periods on some days will not have any quarry activities at all.

Based on our experience with similar quarries, the highest noise associated with equipment maintenance is likely to be if any cranes are required to service the processing plant (e.g. replacing screen media or crusher parts). However, this occurs very infrequently. Noise from this activity is mainly governed by the crane’s engine, which is similar in character to the engine noise from nighttime haulage and loading activities discussed later in this report (see Section 7.4).

### 2.2.4 Heavy Traffic Distribution

The project’s Integrated Traffic Assessment (ITA) – prepared by Stantec – advises that the following number of heavy vehicle movements in Table 2 are anticipated.

**Table 2: Number of heavy vehicle movements**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Portion of Maximum Day</th>
<th>Heavy Vehicle Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Day (“Peak”)</td>
<td>100%</td>
<td>1,500</td>
</tr>
<tr>
<td>Median Day (“Typical”)</td>
<td>70%</td>
<td>1,053</td>
</tr>
</tbody>
</table>

We understand that the maximum number of movements sought represents the absolute highest needs of the proposed quarry and that typical daily movements are likely to be much lower.

Heavy vehicles will access the site via a dedicated accessway from Jones Road, located around the middle of the site. Figure 4 shows the distribution of traffic on local roads, based on the distribution maps provided by Stantec (see Appendix B). This shows that the majority of movements (94%) will be via Jones Road east of the site access and then, for 87% of all vehicles, SH1 east of Dawsons Road.

**Figure 4: Heavy vehicle distribution on surrounding road network**
We understand that the distribution of traffic, in terms of the proportions shown in Figure 4, will remain consistent for both the maximum and median day scenarios.

In terms of hourly distribution over a given day, we understand that a typical daytime hour will have around 10% to 12% of daily traffic (12% being the peak hour, typically around noon). There will be fewer movements during peak network periods (<10% per hour) and around 2% prior to the morning peak, between 0600 and 0700 hrs, which will have 37 movements in the peak day scenario.

We further understand that the level of night-time heavy vehicle activity is not known at this stage, however, we have allowed up to 40 heavy vehicle movements per hour during the evening and night-time periods. Although this is likely to be reasonably conservative, we consider it a worst-case scenario to include in our assessment.

2.2.5 Light Vehicle Movements

In addition to the heavy traffic discussed above, there will be up to around 150 light vehicle movements per day. These will utilise a dedicated access way into the site, formed along the existing Roydon Stud access. Around 10% of these will occur in the peak hour and remaining movements will be spread over the day, resulting in approximately 10 to 15 movements per hour.

The proposed numbers of light vehicle movements are very low compared to the associated heavy traffic and existing traffic patterns on local roads. We have therefore not discussed light traffic in further detail in this report, although the associated noise has been included in our calculations.

2.3 Rehabilitation

The active working area of the quarry (i.e. working extraction faces; stockpiles; processing areas; and haul roads) will be limited to between 20 and 40 ha at any time. Once extraction is complete within an area, it will be clean-filled prior to re-spreading and contouring of stored overburden materials and then grassing and ultimately returning these areas to pasture.

We note that heavy vehicle movements required for the clean-filling operation are incorporated into the total number of movements discussed above in Section 2.2.4. Infill material would be unloaded at a “tip head” and then spread across the clean-fill area.

2.4 Summary of Assumptions

In order to quantify noise levels and effects, it is necessary to make a number of assumptions on some of the key factors discussed. Table 3 below summarises the information that has been used in our assessment, based on our understanding as described in the previous sections of this report.

Table 3: Summary of proposed activity details

<table>
<thead>
<tr>
<th>Activity/Component</th>
<th>Details</th>
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</table>
| Operating hours:   | Daytime period (0600 to 1800 hrs) – full operation of site  
|                    | Evening period* (1800 to 2200 hrs) – extraction, processing and load out |
|                    | Night-time period* (2200 to 0600) – truck load out, light maintenance |
| Maximum excavation depth: | 10 metres below existing ground (dependant on ground water levels) |
| Use of crushing/processing plant: | Fixed plant centrally located – around 500 metres from boundaries  
| | Mobile plant used as required – at least 250 metres from any boundary |
| Heavy vehicle movements: | Day – Maximum rate of 1,500 vehicle movements per day  
| | Typically around 115 per hour; peak up to 184 per hour  
| | Eve. & Night – Average up to 40 per hour between 2200 and 0600 hrs |
| Perimeter earth bunds: | 3 metre high perimeter bunds, pit set back 20 metres from boundary |

* Activities outside of core daytime hours will not occur every day. This report considers a worst-case combination.
3.0 EXISTING ENVIRONMENT

The application site lies just within the Selwyn District and is bordered by Christchurch City across Dawsons Road to the east.

As shown in Figure 5, the proposed quarry site and surrounding land are all within the Rural (Inner Plains) Zone under the Selwyn District Plan. Adjacent land within Christchurch City is zoned Rural Urban Fringe (RuUF), with the Templeton residential zone boundary further to the east. At its closest, the Templeton residential zone is just over 700 metres from the application site boundary. The Devine Acres Existing Development Area (EDA), as described in the Selwyn District Plan, is around 450 metres from the application site boundary to the south-east.

Figure 5: District boundary and planning zones

There are a number of rural dwellings located in the area surrounding the site, including along Dawsons, Maddisons, Jones and Curraghs Roads. The closest dwelling (319 Maddisons Road) is set back around 19 metres from the northern boundary of the application site, while all others are at least 100 metres from the closest quarrying activity.

Other land uses in the surrounding rural area include farms, Samadhi Buddhist Vihara (a Buddhist temple), a chicken farm, Weedons New Zealand Motor Caravan Association (NZCMA) Park and two agricultural machinery retailers. Specific addresses covered in our assessment are discussed in Section 6.0.

Common sources of noise from existing activities within the area include:

- Traffic on local roads
- Traffic on Main South Road (SH1)
- Train movements on the Main South Line
- Aircraft movements overhead
- Agricultural machinery
- “Natural” sounds: animals and wind-induced vegetation movement
- Ruapuna Motorsport Park
Regarding aircraft noise, we note that the application site is around 10 km from Christchurch International Airport (CIAL). Much of the area shown in Figure 5, including the residential zone at Templeton and the Devine Acres EDA, fall within the airport noise contours as shown in the Christchurch and Selwyn District Plans. The extent of these noise contours is shown in Appendix C.

The airport noise contours control the development of noise sensitive activities such as dwellings. Inclusion within these noise contours generally means that buildings must achieve a minimum level of sound insulation performance to adequately reduce the transmission of aircraft noise from the outside to the inside of the building.

3.1 Ambient Noise Levels

In order to quantify the existing levels of noise in the environment, we have undertaken a programme of noise measurements within the area. This included both long-term unattended monitoring and shorter, attended measurements and observations. The composition of this measurement programme and the results gathered are described below.

Note that, in this report, we use the term “ambient” to describe the residual sound level, as defined in New Zealand Standard NZS 6802:2008 “Acoustics - Environmental Noise”. This is the level of noise present from existing sources in the absence of any proposed quarrying noise.

3.1.1 Methodology

The primary aims of the noise surveys were to determine how the ambient noise level varies over time, with differing weather conditions, and depending on distance from these roads. Our initial subjective impression was that road traffic noise from SH1, and to a lesser extent Maddisons Road, typically governs the background sound level in the area. Noise-sensitive receivers along Maddisons Road are over 1.5 km from SH1, hence variation in noise levels was particularly of interest.

From our observations, Dawsons and Curraghs Roads carry a relatively low level of traffic throughout the day and therefore passing vehicles are not sufficiently continuous to influence the underlying ambient noise level. As such traffic on these roads has been omitted from our measurements as far as possible. (Correlation of the measured noise data with traffic volume information and road usage patterns is discussed further in Section 3.2.2.)

Measurement positions were selected as shown in Figure 6 overleaf. The long-term noise monitoring location was selected as it is:

- A similar distance from SH1 as noise-sensitive receivers along Maddisons Road; and
- Representative of noise-sensitive receivers that are set back approximately 250 metres from Maddisons Road.

Noise levels were continuously recorded at the long-term location for three weeks. Concurrent short-term attended noise surveys were also conducted within this period, at positions 1 to 4 shown in Figure 6. These positions were selected to represent groups of receivers as follows:

- Position 1 – Receivers over 1.5 km from SH1, and not directly on Maddisons Road;
- Position 2 – Receivers closer to passing traffic on Maddisons Road, which influences their local noise level;
- Position 3 – Representative of the Weedons NZCMA Park separation distance to SH1/Maddisons Road; and
- Position 4 – Receivers along or near Main South Road (SH1).

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1 The background sound level is the component of residual (ambient) sound that is subjectively perceived as continuously present. It is typically measured using the $L_{90}$ parameter.
Measurements were undertaken at each of these positions at various times (day, night and early morning) and under different weather conditions (northerly and southerly winds) for comparison with the long-term noise data.

Measurements at all locations were undertaken in general accordance with New Zealand Standard NZS 6801:2008 “Acoustics – Measurement of environmental sound”. Further details of the survey and measurement instrumentation are provided in Appendix D.

3.1.2 Long-term Measurement Data

Unattended noise monitoring was conducted between 27 February and 21 March 2018. The measured data is presented in detail in Appendix E and summarised in Table 4 overleaf.

As discussed later in this report, different day and night-time periods are described in various guidance. For simplicity we have presented the summary below based on a daytime period of 0700 to 2200 hrs.

Our analysis suggests that the start and end definition of the time periods does not appreciably affect the results. This is demonstrated by the Daytime Core, Evening and Early Morning periods shown in Table 4, which broadly align with the proposed operating hours. The noise levels for these periods do not differ significantly from the 15-hour daytime period from 0700 to 2200 hrs. These additional periods have been analysed to consider the potential for additional noise sensitivity during “shoulder hours”, outside of the core daytime period.
Table 4: Summary of measured long-term noise data

<table>
<thead>
<tr>
<th>Period</th>
<th>Time, hrs</th>
<th>( L_{Aeq} ) (Average*)</th>
<th>( L_{A10} )</th>
<th>( L_{A90} )</th>
<th>( L_{Amax} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime</td>
<td>0700 to 2200</td>
<td>51 (37 - 63)</td>
<td>50 (37 - 62)</td>
<td>43 (24 - 54)</td>
<td>66 (47 - 94)</td>
</tr>
<tr>
<td>Night-time</td>
<td>2200 to 0700</td>
<td>46 (24 - 64)</td>
<td>43 (26 - 59)</td>
<td>33 (20 - 51)</td>
<td>57 (34 - 88)</td>
</tr>
<tr>
<td>Daytime Core</td>
<td>0600 to 1800</td>
<td>52 (40 - 64)</td>
<td>51 (42 - 62)</td>
<td>44 (31 - 54)</td>
<td>65 (48 - 94)</td>
</tr>
<tr>
<td>Evening</td>
<td>1800 to 2200</td>
<td>50 (37 - 58)</td>
<td>49 (37 - 60)</td>
<td>40 (24 - 46)</td>
<td>65 (47 - 87)</td>
</tr>
<tr>
<td>Early Morning</td>
<td>0600 to 0730</td>
<td>51 (40 - 64)</td>
<td>51 (42 - 59)</td>
<td>43 (31 - 53)</td>
<td>62 (51 - 88)</td>
</tr>
</tbody>
</table>

*Average shown is the mean value, other than for \( L_{Aeq} \) for which the logarithmic average is given

We have also analysed the diurnal variation in noise level, which is depicted graphically in Figure 7 for a “typical” daytime period. This analysis includes weekend days and therefore may be a slightly conservative representation of a typical day with the proposed quarry operational. Daily background noise level (\( L_{90} \)) profiles are also provided in Appendix E2.

Figure 7: Typical daily profile, based on statistical analysis of all recorded data*

*Analysis considers all days, including weekdays and weekends

The average (\( L_{Aeq} \)) and maximum (\( L_{Amax} \)) parameters measured at the long-term monitor appeared to be significantly affected by aircraft movements overhead. These transient events result in the “spikey” profiles for these parameters that are clearly shown in the time history graph in Appendix E1. In contrast, the background (\( L_{90} \)) noise level shown in red in Figure 7 above is a better representation of the underlying continuous noise level over the course of a typical 24 hour period.

3.1.3 Short-term Measurement Data

The long-term measurements have been supplemented by a programme of short-duration attended surveys, as described in Section 3.1.1. These surveys were used to establish any variation in noise level at particular receiver locations, compared with the long-term monitoring position.
The measured levels are summarised in Table 5 below. For each position, our aim was to measure under both northerly and southerly wind conditions during each time period.

Table 5: Summary of short-term attended survey results

<table>
<thead>
<tr>
<th>Position (Figure 6)</th>
<th>Approximate Location</th>
<th>Measured Noise Level*, dB</th>
<th>Daytime</th>
<th>Night-time</th>
<th>Early Morning</th>
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</tr>
<tr>
<td>1</td>
<td>209 Curraghs Road</td>
<td>A 44 43</td>
<td>B 35 29</td>
<td>E 48 44</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C 46 41</td>
<td>D 36 31</td>
<td>D 43 35</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>300 Maddisons Road</td>
<td>A 68 39</td>
<td>B 52 29</td>
<td>E 67 42</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C 66 40</td>
<td>D 59 30</td>
<td>D 64 38</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>141 Curraghs Road</td>
<td>A 43 41</td>
<td>B 33 27</td>
<td>E 51 46</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C 42 41</td>
<td>D 39 35</td>
<td>D 50 38</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4 Dawsons Road</td>
<td>A 62 58</td>
<td>B 54 34</td>
<td>E 65 62</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C 64 58</td>
<td>D 54 36</td>
<td>D 62 51</td>
<td></td>
</tr>
</tbody>
</table>

* All measurement durations are 15 minutes
† Survey reference identifier—see survey details table in Appendix D

To ensure that the measured noise levels were representative of typical conditions at each location of interest, the following protocols were used:

- Position 1 – Local Curraghs Road traffic noise excluded from measurements; Maddisons included;
- Position 2 – All passing Maddisons Road traffic included;
- Position 3 – Curraghs Road traffic excluded; all other traffic included (i.e. Maddisons, Jones, SH1);
- Position 4 – Dawsons Road traffic excluded; all other traffic on SH1 and Jones Road included; and
- All positions –
  - Aircraft movement excluded from daytime and night-time surveys (as movements are sporadic) but included in early morning surveys (due to sustained high level of aircraft activity during this period).
  - Train noise excluded at all times, as there are a relatively low number over the course of a day (understood to be around one per hour, based on Stantec’s ITA).

Maximum (L_{max}) noise levels are not shown in Table 5. From our observations these levels are generally controlled by aircraft movements overhead, other than for positions close to roads, at which point passing road traffic governs the L_{max} level.

For positions 1 and 3, which are not governed by immediately passing traffic, typical L_{max} levels from aircraft movements are between around 55 and 65 dB L_{Amax}. At positions close to roads, passing road traffic is on average 85 dB L_{Amax} at position 2 (site boundary of 300 Maddisons Road) and 76 dB L_{Amax} at position 4 (representative of the northern façade of the dwelling at 4 Dawsons Road).

3.2 Noise-Related Environmental Factors

The primary sources that govern existing noise levels in the area are road and air traffic. In general, these sources can both vary based on the time of day and prevailing weather conditions, among other factors.
Ultimately, the level of potential noise effects from the proposed quarry will also be dependent on these factors to some extent. For example, any given location will receive more quarrying noise under down-wind conditions. However, we have also considered whether wind direction may also influence the relative degree of traffic noise as receivers become up- or down-wind of local roads and as runway usage at CIAL varies.

3.2.1 Meteorological Conditions

We have reviewed a history of recorded weather observations during our noise monitoring period. These observations have been used to determine suitable periods to use for our analysis. A summary of weather data obtained from an online source is provided below in Figure 8. Further information is provided in Appendix E.

**Figure 8: History of weather conditions during noise monitoring period**

![Weather Data Chart]

We have also compared this information with wind data provided by Golder Associates, which we understand is representative of long-term conditions at the site. This is shown in Figure 9 overleaf.

Both data sets indicate that the predominant wind direction is from the north-east, while occasional conditions exist with south-westerly and north-westerly winds.

In terms of noise emissions, this means that receivers in the Maddisons Road and Templeton areas will mostly be cross-wind from road traffic noise on SH1, down-wind from road traffic noise on West Coast Road (SH73) and in Christchurch, and subject to aircraft movements aligned with the main north-south runway at CIAL.
3.2.2 Road Traffic Patterns

Stantec have provided us with data on measured existing traffic volumes on local roads around the application site. We understand that this information is derived from recent traffic counts undertaken as part of this project on Maddisons, Dawsons and Jones Roads. We have supplemented this information with hourly volume counts on SH1 obtained from NZTA\(^2\). Future development of the road network is discussed in the following section (Section 3.3).

The average number of traffic movements on each of the above roads during weekdays is shown in Figure 10. The hourly distribution of both heavy and light vehicles is shown in more detail in Appendix F.

\(^2\) NZTA Site Ref: 01500355 (Templeton/Rolleston - Btwn Robinsons and Berketts Rd)
We make the following observations on this data:

- Dawsons Road carries a consistent but low volume of traffic throughout the day (we understand this is the same for Curraghs Road to the west);
- Maddisons and Jones Roads are significantly busier in peak periods than during the rest of the day or night;
- SH1 carries a far greater volume of traffic than any local road and traffic begins building each day from around 0400 hrs; and
- Maddisons and Jones Roads also get progressively busier from around 0400 hrs each day, and at 0600 hrs exceed the typical midday traffic volume.

Combining the information above with the typical daily ambient noise levels presented in Figure 7 allows for a comparison between the ambient noise level and traffic movements, as shown in Figure 11.

From this comparison, there is a clear correlation between the measured background ($L_{90}$) noise levels and road traffic volumes on Maddisons Road (which are similar in profile to those on Jones Road) and SH1. SH1 traffic appears to be of particular influence during the afternoon and late at night, when there are relatively low volumes of traffic on Maddisons Road.

Correlation between the traffic data and the measured average ($L_{eq}$) noise level is less clear, which again supports the view that this parameter is influenced by aircraft movements or sporadic local activity.

Figure 10: Hourly weekday traffic distribution
3.3 Future Noise Environment

The Christchurch Southern Motorway – Stage 2 (CSM2) and Main South Road Four Laning project is currently being constructed and is scheduled for completion in 2020. This project will result in a reduction in Main South Road traffic travelling past Templeton. Traffic will leave or join Main South Road via a new intersection to the south of the application site, travelling along CSM2, and eventually connecting to Stage 1 of the Southern Motorway at Halswell Junction Road.

This section discusses the potential change in ambient noise levels at the noise sensitive locations that may come about once CSM2 is in operation.

A visual comparison of the existing and proposed Main South Road layout is provided in Figure 12.
Marshall Day Acoustics prepared the *Assessment of Operational Noise Effects*\(^3\) report (CSM2 report) for the CSM2 project, which was submitted to the Environmental Protection Agency as part of the regulatory consenting process. This report provided predicted traffic noise levels along the entire CSM2 alignment.

The traffic noise contours provided in Appendix D-5 of the CSM2 report are closest to the application site. However, noise contours were only presented for locations within 200 metres of the highway. Of the ambient noise measurement positions discussed in Table 5, only measurement Position 4 (4 Dawsons Road) is close enough to the highway to be included in the CSM2 report contours. The predicted CSM2 traffic noise level here is approximately 56 dB \(L_{Aeq}(24\text{hr})\), which we note does not contain any noise contribution from traffic on Jones Road.

From information given in Stantec’s ITA, Jones Road carries approximately 3,800 vehicles per day (9% heavy vehicles) which translates to a traffic noise level of 56 dB \(L_{Aeq}(24\text{hr})\) at Position 4. Combining both the CSM2 and Jones Road noise levels gives a total level of 59 dB \(L_{Aeq}(24\text{hr})\) at Position 4.

In order to perform a comparison of Year 2020 ambient noise levels with the measured noise levels presented in Table 5, we have calculated the day, night and early morning traffic noise levels based on the diurnal traffic distribution. The results are summarised in Table 6.

**Table 6: Estimated change in ambient noise levels at Position 4 with the operation of CSM2.**

<table>
<thead>
<tr>
<th></th>
<th>24 hour</th>
<th>Daytime</th>
<th>Night-time</th>
<th>Early Morning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(dB\ L_{Aeq}\ (24\text{hr}))</td>
<td>(dB\ L_{Aeq})</td>
<td>(dB\ L_{Aeq})</td>
<td>(dB\ L_{Aeq})</td>
</tr>
<tr>
<td>2016 measured noise levels</td>
<td>–</td>
<td>A</td>
<td>B</td>
<td>E</td>
</tr>
<tr>
<td>2020 predicted noise levels</td>
<td>59</td>
<td>–</td>
<td>61</td>
<td>53</td>
</tr>
</tbody>
</table>

\(^{†}\) Survey reference identifier—see survey details table in Appendix D

Comparison of the 2016 measured and 2020 predicted noise levels at Position 4 indicates that the ambient noise environment will not significantly change. As traffic noise is the dominant noise source across all measurement positions, it is reasonable to infer that the operation of CSM2 will not

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significantly change the ambient noise environment at all noise sensitive locations adjacent to the application site.

### 3.4 Variation in Ambient Noise Levels

Our observations at both the long-term and short-term monitoring positions are that existing ambient noise environment is governed primarily by road traffic and aircraft activity. Our analysis indicates that:

- The ambient noise level at any given time is most dependant on the intensity of road and air traffic; and
- Wind direction is not especially critical to the noise levels experienced in the area.

These points are demonstrated in Figure 13 below, which plots the mean $L_{eq}$ and $L_{90}$ values from Figure 7 against the mean values obtained under southerly and all other wind directions (predominantly northerly). The variation about the mean level for each wind scenario is within the normal variance expected between any measurements. Notably, all of the hourly patterns are consistent with those in Figure 11, which suggests a strong influence from road and air activity.

**Figure 13: Comparison of mean noise levels (from Figure 7) with those under distinct wind conditions**

Given the correlation between ambient noise and road traffic activity, the distance between roads and any given receiver is a critical factor. Our short-term attended survey positions (Figure 6 and Table 5) were primarily chosen to consider the variation in road traffic noise levels with distance.

Analysis of data obtained at the short-term survey positions again supports the notion that meteorological variations are less influential than traffic conditions in terms of the ambient noise levels experienced. Table 7 compares background $L_{80}$ noise levels (which are typically governed by distant traffic) measured simultaneously at the logger and short-term positions. This data shows that the diurnal variation is generally the same at all measurement locations.
Table 7: Comparison of long-term and short-term

<table>
<thead>
<tr>
<th>Position (Figure 5)</th>
<th>Background level difference to logger*, dB</th>
<th>Standard Deviation, dB</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-1</td>
<td>1</td>
<td>Variation is consistent between all surveys</td>
</tr>
<tr>
<td>2</td>
<td>-2</td>
<td>1</td>
<td>Variation is consistent between all surveys</td>
</tr>
<tr>
<td>3</td>
<td>-1</td>
<td>2</td>
<td>Variation is consistent between all surveys</td>
</tr>
<tr>
<td>4</td>
<td>+11</td>
<td>5</td>
<td>Large variation due to traffic levels on nearby SH1 – large difference (12-17 dB) in daytime with continuous traffic and small difference (3-7 dB) at night with fluctuating/intermittent traffic</td>
</tr>
</tbody>
</table>

* Mean difference in background noise level (L_{A90}) between noise logger and supplementary short-term measurements

Overall, the long-term logger data is a good representation of noise levels experienced in the area (except adjacent to SH1), particularly as meteorological factors have been found not to be a key factor at these locations. Table 4 shows that there is also little difference in the average daytime noise levels whether a long daytime period (0700 to 2200 hrs) is considered, or if it is split into shoulder periods. As such the average day and night values in Table 4 can be taken to be representative of most receivers.

Our analysis indicates that the ambient noise levels will not significantly change once the Christchurch Southern Motorway – Stage 2 comes into operation in 2020.
4.0 OPERATIONAL NOISE ASSESSMENT CRITERIA

We have guidance from multiple sources in order to establish appropriate noise assessment criteria for the project once operational (i.e. once routine quarrying activity commences). Assessment criteria for initial short-term site establishment works is discussed further in Section 8.1.

4.1 Local Noise Performance Standards

4.1.1 Selwyn District Plan

As the application site is within the Selwyn District, rules relating to noise within the Selwyn District Plan are a key consideration. We understand that Selwyn District Council have recently initiated a plan review process. Any proposed changes are, however, yet to be notified and we have therefore not considered any future amendments to the District Plan.

The currently operative District Plan provides noise standards for activities within the rural zone at Chapter 9.16 of the Rural Volume. Rule 9.16.1 states that ‘any activity shall be conducted so as to comply with ... [the following noise limits in Table 8] in order to be a permitted activity’.

Table 8: Summary of applicable Selwyn District Plan noise standards

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Any Living Zone Boundary</th>
<th>Other Locations*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime (0730 – 2000 hrs)</td>
<td>55 dB $L_{A10}$</td>
<td>60 dB $L_{A10}$</td>
</tr>
<tr>
<td></td>
<td>85 dB $L_{Amax}$</td>
<td>85 dB $L_{Amax}$</td>
</tr>
<tr>
<td>Night-time (2001 – 0729 hrs)</td>
<td>40 dB $L_{A10}$</td>
<td>45 dB $L_{A10}$</td>
</tr>
<tr>
<td></td>
<td>70 dB $L_{Amax}$</td>
<td>70 dB $L_{Amax}$</td>
</tr>
</tbody>
</table>

* Noise limits assessed at the notional boundary of any dwelling, rest home, hospital, or classroom in any educational facility except where that dwelling, rest home, hospital or classroom is located within a Living Zone.

Rule 9.16.2 states that ‘any activity which does not comply with Rule 9.16.1 shall be a discretionary activity’ (our emphasis).

Some exemptions to the noise limits are given in Rules 9.16.3 and 9.16.6 but we do not consider that any of these apply to noise associated with this project. We note that Rule 9.16.6.1 exempts ‘noise from any motor vehicle or any mobile machinery (including farm machinery and stationary equipment not fixed to the ground)’. However, mobile machinery is one of the primary noise sources associated with this project, we do not consider it appropriate that it be exempt from assessment. The application of this rule has typically been disregarded in other projects with which we have been involved in the Selwyn District.

The Rural Zone rules require (in Section C0) noise to be measured in accordance with New Zealand Standard NZS 6801:1999 “Acoustics - Measurement of Environmental Sound” and assessed in accordance with the provisions of New Zealand Standard NZS 6802:1991 “Assessment of Environmental Sound”.

The rules further stipulate that ‘adjustments for special audible characteristics, if present, as provided for in Clause 4.3 and 4.4 of the Standard shall apply and will have the effect of imposing a numerical noise limit 5 dBA more stringent than the $L_{10}$ numerical limits stated in the rules’.

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* The notional boundary is defined in the Township volume of the Selwyn District Plan as ‘a line 20m from any side of a rural dwelling or the legal boundary where this is closer to the dwelling’.
4.1.2 Christchurch District Plan

Noise standards within Christchurch City are also considered due to the potential for any cross-boundary issues due to noise received across the district boundary to the north-east of Dawsons Road.

Rule 6.1.5.2.1 of the Christchurch District Plan prescribes zone-specific permitted activity standards for noise received in the following environments summarised in Table 9.

Table 9: Christchurch District Plan noise standards (from Table 1, Rule 6.1.5.2.1)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Residential Zones &amp; Rural Zones (notional boundary)</th>
<th>Rural Zones (site boundary) &amp; Open Space Zones</th>
</tr>
</thead>
</table>
| Daytime (0700 - 2200 hrs) | 50 dB $L_{Aeq}$  
(no $L_{max}$ limit) | 55 dB $L_{Aeq}$  
(no $L_{max}$ limit) |
| Night-time (2200 - 0700 hrs) | 40 dB $L_{Aeq}$ | 45 dB $L_{Aeq}$ |
|                   | 65 dB $L_{Amax}$ | 70 dB $L_{Amax}$ |

Rule 6.1.4.1 requires that, unless otherwise specified, noise should be measured in accordance with New Zealand Standard NZS 6801:2008 “Acoustics – Measurement of environmental sound” and assessed in accordance with New Zealand Standard NZS 6802:2008 “Acoustics - Environmental Noise” (except that provisions referring to Special Audible Characteristics [SAC] shall not be applied).

4.1.3 Cross-Boundary Noise Issues

The discussion of noise standards above shows that the two districts’ approaches to assessing environmental noise are not compatible. Comparing the basic elements:

- The noise limits differ, in terms of both level and assessment parameter;
- The times of application (day vs night) differ;
- The Christchurch District Plan refers to the more recent 2008 version of the noise standards, NZS 6801 and 6802; and
- There is no provision for an SAC adjustment in Christchurch.

The Christchurch District Plan, being published more recently, is generally a better representation of current industry best practice in acoustics. The Selwyn District Plan is uncommon among other current District Plans in New Zealand in that the daytime noise limits are relatively lenient (i.e. high), use $L_{10}$ rather than $L_{Aeq}$ criteria and the daytime period is relatively short.

In terms of current sensitivity to noise within Christchurch, the nearest residential zone is that located in Templeton, which is around 700 metres away. We consider the area’s normal noise standards (Table 9) appropriate.

Also of interest within Christchurch is the strip of Rural Urban Fringe (RuUF) Zone land between Dawsons Road and Templeton. At present we understand this is agricultural land and that there are no noise sensitive activities. However, should any future residential development occur in this area, this would bring Christchurch dwellings much closer to the quarry site boundary. The potential effects of such development are discussed further in Section 7.2.2.

4.2 National Environmental Noise Standards

4.2.1 NZS 6801 and 6802

The Selwyn District Plan refers to, and requires assessment in accordance with, NZS 6801:1999 and NZS 6802:1991. The Christchurch District Plan refers to the most recent versions of these standards,
which were both published in 2008. We consider that the 2008 versions of the Standards represent current industry best practice.

NZS 6802:2008 is commonly used in New Zealand to inform assessments of environmental effects. The Standard provides the following guidance on desirable upper limits of sound exposure at or within the boundary of any residential land use:

- **Daytime** – 55 dB $L_{Aeq}$ (15 min)
- **Evening** – 50 dB $L_{Aeq}$ (15 min)
- **Night-time** – 45 dB $L_{Aeq}$ (15 min) and 75 dB $L_{A_{max}}$

The noise levels provided in the Standard are intended to provide territorial authorities with appropriate guidance for the development of local noise criteria. (It notes that the inclusion of an evening period and its hours of application are a matter for the relevant local authority.)

Clause C8.6.2 of the Standard provides further discussion on these guidelines:

‘The recommended daytime limit of 55 dB $L_{Aeq}$ (15 min) is consistent with the guideline values for community noise in specific environments published by the World Health Organization. The World Health Organization identifies that during the daytime, few people are seriously annoyed by activities with levels below 55 dB $L_{Aeq}$. The night-time limit recommended should not exceed 45 dB $L_{Aeq}$ (15 min) outside dwellings so that people can sleep with windows open for ventilation and achieve the desirable indoor 30 to 35 dB $L_{Aeq}$ (15 min) level as a design level to protect against sleep disturbance.’

The 1991 and 2008 versions of NZS 6802 differ in their application of adjustments for the presence of “special audible characteristics” from a specific noise source. This correction accounts for the any particularly distinctive sound character, e.g. tonality or impulsiveness. However, noise from quarrying is not typified by such characteristics and therefore no adjustment is warranted under either version of the Standards.

### 4.2.2 Resource Management Act 1991

Regardless of any noise performance standards provided in local legislation or specific land-use consents, the RMA imposes overarching obligations on all generators of noise.

Section 16 of the Act concerns one’s duty to avoid unreasonable noise and states that:

‘Every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level.’

Section 17 also states that every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person.

### 4.3 International Guidance

The various iterations of the New Zealand Standards NZS 6801 and 6802 were all based on the contemporaneous international guidance regarding environmental noise, including for example International Standard ISO 1996. As such, we do not consider it necessary to present a detailed summary of such documents.

The key international guidance is that provided by the World Health Organization’s (WHO) Guidelines for Community Noise. This guidance is commonly used within New Zealand as a basis for assessing

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environmental noise exposure. For community or environmental noise, the critical health effects (those effects which occur at the lowest exposure levels) are:

- Sleep disturbance;
- Annoyance (slight, moderate, high); and
- Speech interference/communication disturbance.

The Guideline Values for these three critical health effects for community or environmental noise are presented in Table 10. These guidelines, based on extensive international research, are the exposure levels that represent the onset of the effect for the general population. That is, at these noise levels, critical health effects only begin to appear in a small number of vulnerable or sensitive groups.

**Table 10: WHO Guideline Values for the critical health effects of community or environmental noise**

<table>
<thead>
<tr>
<th>Specific Environment</th>
<th>Critical health effect(s)</th>
<th>dB L_{Aeq}</th>
<th>Time base (hours)</th>
<th>dB L_{Amax}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor living area</td>
<td>Serious annoyance, daytime &amp; evening.</td>
<td>55</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Moderate annoyance, daytime &amp; evening.</td>
<td>50</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>Dwellings, indoors Inside bedrooms</td>
<td>Speech Intelligibility and moderate annoyance, daytime &amp; evening.</td>
<td>35</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Sleep disturbance, night-time.</td>
<td>30</td>
<td>8</td>
<td>45</td>
</tr>
<tr>
<td>Outside bedrooms</td>
<td>Sleep disturbance, window open (outdoor values) night-time.</td>
<td>45</td>
<td>8</td>
<td>60</td>
</tr>
</tbody>
</table>

### 4.4 Discussion of Assessment Criteria

#### 4.4.1 Comparison of Guidance Documents

The numerical values from the range of criteria discussed above are collated in Table 11. This is a simplified table for a high-level comparison only – it ignores the nuances of each publication in terms of applicable time periods, assessment position and time-basis of parameters.

**Table 11: Comparison of noise assessment guidance**

<table>
<thead>
<tr>
<th>Time</th>
<th>Parameter</th>
<th>Selwyn District Plan</th>
<th>Christchurch District Plan</th>
<th>NZS 6802 (Dwelling)</th>
<th>WHO (Dwelling)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Living</td>
<td>Rural</td>
<td>Living</td>
<td>Rural</td>
</tr>
<tr>
<td>Day</td>
<td>Average</td>
<td>55 dB L_{A10}</td>
<td>60 dB L_{A10}</td>
<td>50 dB L_{Aeq}</td>
<td>55 dB L_{Aeq}</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>85 dB L_{Amax}</td>
<td>85 dB L_{Amax}</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Night</td>
<td>Average</td>
<td>40 dB L_{A10}</td>
<td>45 dB L_{A10}</td>
<td>40 dB L_{Aeq}</td>
<td>45 dB L_{Aeq}</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>70 dB L_{Amax}</td>
<td>70 dB L_{Amax}</td>
<td>65 dB L_{Amax}</td>
<td>70 dB L_{Amax}</td>
</tr>
</tbody>
</table>

Through comparing the numerical values above, the following is noted:

- Maximum (L_{max}) criteria tend to be omitted for daytime periods, when receivers are generally not especially sensitive to transient noise events;
- The Selwyn daytime average value of 60 dBA for rural zones is greater than the typical upper value of 55 dBA;
- Night-time average noise criteria are consistently 40 or 45 dBA (L_{10}/L_{eq}), depending on the sensitivity of the environment; and
- There is a wide range in maximum night-time noise limits – 60 to 75 dB L_{Amax}. 
4.4.2 Project Noise Criteria

We have also considered the criteria discussed above in terms of the existing ambient noise environment in order to derive appropriate assessment criteria for this project. We recommend that the noise limits apply at the boundary of site (or in the case of road reserves, at the boundary of the opposite site).

Daytime

As discussed in Section 3.0, during the day the area is subject to noise from a range of sources, including air, road and rail traffic and agricultural activities. A daytime noise limit of 55 dB $L_{Aeq}$ is considered appropriate for the surrounding rural area. This proposed limit is notably below that in the Selwyn District Plan, which recognises the rural zone as a principally business, rather than residential, area (Policy B3.4.1).

Evening

A lower level of quarry activity is proposed during the evening, from 1800 to 2200 hrs, and this will not occur every day. Ambient noise levels in the area do begin to decline after around 1800 hrs and there is often a greater sensitivity to noise in residential environments as more residents are home from work than during the day. As such, an evening noise limit of 50 dB $L_{Aeq}$ is recommended and this aligns well with Fulton Hogan’s reduced level of activity during this period.

Night-time

Noise levels during the night are significantly influenced by the varying volumes of road traffic. Traffic noise begins to increase from 0400 hrs (see Figure 7), which suggests higher noise limits may be appropriate during the early morning period, compared with the remainder of the night. The quarry’s proposed 0600 hrs start time is therefore acceptable in the context of the ambient environment.

Otherwise, a night-time noise limit of 45 dB $L_{Aeq}$ is recommended as this is typical for a rural area and broadly consistent with the provisions in the Selwyn District Plan. A maximum noise limit of 70 dB $L_{Amax}$ is consistent with the District Plan and generally in the middle of the guidance summarised in Table 11.

Assessment Considerations

As these are site boundary limits, the noise levels at the notional boundaries of existing receivers – where rural zone noise limits typically apply – will generally be lower. A site boundary limit is preferable as it is simpler from a noise monitoring or enforcement perspective as access to private land is not required. It also provides certainty for both Fulton Hogan and their neighbours in that the “noise footprint” of the site is clearly defined, irrespective of any future development around the quarry.

We note that it will not be technically possible to comply with these proposed limits at the entrance to the site where vehicles drive across the site boundary. This noise limit should therefore not apply at this location, and appropriate wording of consent conditions will be required to permit this to occur, which are discussed in Section 13.0.

Overall, we consider that noise emissions from the quarry that are consistent with the limits in Table 12 will result in noise levels at sensitive receivers that are in keeping with what may be expected in this environment, and therefore that noise effects will be acceptable.

4.4.3 Special Audible Characteristics

The nature of the proposed quarrying activity means that noise sources will have a relatively “broad band” noise characteristic when heard at the site boundary. As such, the overall character of noise from these sources does not warrant any adjustment of predicted noise levels or noise limits for special audible characteristics. Therefore, no SAC adjustment has been applied in the assessment of noise levels in this report.
4.5 **Summary of Recommended Assessment Criteria**

We recommend that the following noise limits in Table 12 apply to the activity, to be assessed at or beyond the site boundary (excluding road reserves, and except within a 300 metre radius of any site access point).

**Table 12: Recommended Roydon Quarry noise limits**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Hours</th>
<th>Site Boundary Noise Limit</th>
<th>dB $L_{Aeq}$</th>
<th>dB $L_{Amax}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime</td>
<td>0600 - 1800</td>
<td>55</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Evening</td>
<td>1800 - 2200</td>
<td>50</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Night-time</td>
<td>2200 - 0600</td>
<td>45</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>
5.0 NOISE GENERATION CALCULATIONS

We have calculated levels of noise from the proposed activity that will be received at noise-sensitive locations surrounding the site, based on the description of the proposal given Section 2.0.

The predicted lifespan of the quarry is relatively long, and the levels of noise generated and received at any given location will vary over time. We have considered how noise emissions will change with the proposed staging of the quarry and, overall, what will be a “worst-case” and “typical-case” at each receiver location.

Table 13 summarises the operational noise generation scenarios that we have calculated in detail. These scenarios have been selected to:

- Represent the closest (worst-case) activity levels for different groups of receivers around the site; and
- For more distant receivers, demonstrate how noise emissions will vary over the quarry’s lifespan.

This is to say that, for any given receiving position identified, at least one of the calculated scenarios will present the closest activity and highest noise level received, while others will show the variance during other stages of works.

**Table 13: Operational noise assessment calculation scenarios**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Stage (see Figure 2)</th>
<th>Critical Receivers</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary</td>
<td>Initial extraction</td>
<td>All nearby</td>
<td>Pit formation from ground level in central initial extraction area. Assumes excavator and loader working centrally and serviced by road truck movements to/from the site access. Includes bunds fully established around site perimeter.</td>
</tr>
<tr>
<td>Daytime A</td>
<td>Stage 1</td>
<td>South of site</td>
<td>Continuous fixed processing plant operation and peak-hour truck movements between stockpile/load-out area and site access. Extraction of pit late in Stage 1. Loader working at pit face; dump trucks transporting material back to processing plant.</td>
</tr>
<tr>
<td>Daytime B</td>
<td>Stage 3</td>
<td>East and west of site</td>
<td>Full processing plant as above. Late Stage 3 works. Loader working at pit face; conveyor transporting material back to processing plant. Rehabilitation work underway in Stage 1 and 2, including clean-fill trucks.</td>
</tr>
<tr>
<td>Daytime C</td>
<td>Stage 5</td>
<td>North of site</td>
<td>Full processing plant as above. Final extraction in Stage 5 with site exhausted. Conveyor servicing extraction in east and west corner and dump trucks operating near closest dwelling. Rehabilitation work complete in Stages 1-3 and underway in Stage 4 (includes clean-fill trucks)</td>
</tr>
</tbody>
</table>
### 5.1 Calculation Methodology

Computer noise modelling was undertaken using the SoundPLAN v7.4 suite of noise modelling software. This software implements calculation procedures described in International Standard ISO 9613-2:1996 “Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation”.

This method has the scope to take into account a range of factors affecting the sound propagation including:

- The magnitude of the noise source in terms of sound power;
- The distance between source and receiver;
- The presence of obstacles such as screens or barriers in the propagation path;
- The presence of reflecting surfaces;
- The hardness of the ground between the source and receiver;
- Attenuation due to atmospheric absorption; and
- Meteorological effects such as wind gradient, temperature gradient and humidity.

The effect of meteorological conditions is simplified in ISO 9613-2:1996 by calculating the average downwind sound pressure level. The Standard adopts the conservative approach of assuming “supportive” propagation conditions, assuming that wind is always blowing from the noise sources to the receiver locations (i.e. in all directions simultaneously).

The estimated accuracy associated with this method is shown in Table 14 overleaf.
Table 14: Estimated accuracy for broadband noise (based on ISO 9613-2:1996)

<table>
<thead>
<tr>
<th>Height, h*</th>
<th>0 &lt; d &lt; 100 m</th>
<th>100 m &lt; d &lt; 1,000 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 &lt; h &lt; 5 m</td>
<td>±3 dB</td>
<td>±3 dB</td>
</tr>
<tr>
<td>5 m &lt; h &lt; 30 m</td>
<td>±1 dB</td>
<td>±3 dB</td>
</tr>
</tbody>
</table>

Note: These estimates have been made from situations where there are no effects due to reflections or attenuation due to screening.

* h is the mean height of the source and receiver.
† d is the mean distance between the source and receiver.

5.1.1 Modelling Parameters

We have made the following assumptions in our modelling:

- Ground elevation across the entire modelled area is on a flat plateau (ground height, z = 0 m);
- The ground-type absorption coefficient is assumed as “mixed” throughout (G = 0.5);
- No acoustic screening or shielding from barriers, bunds or buildings outside of the site has been allowed for (other than the 3 metre high boundary bunds);
- All receiving dwellings are assumed to be single storey;
- Noise levels have been calculated at the notional boundary line, at 1.5 metres above ground; and
- Land information and cadastral boundaries based on data obtained from LINZ6.

We have assumed that quarrying will progress in accordance with the staging diagram in Figure 2. This means that all mobile machinery and vehicles will be located at the base of the pit, assumed to be at -10 metres relative to the surrounding flat ground height, and will work from south to north (other than for Stage 1, which will be worked in the opposite direction).

5.1.2 Assessment Considerations

Noise levels have been predicted to enable an assessment in accordance with NZS 6802:2008. The method described in this Standard requires the derivation of a “rating level” (LR) that is used for comparison with a given noise limit. This rating level accounts for:

- Adjustments for any special audible characteristics (e.g. tonality or impulsiveness); and
- Adjustments for duration (except for activities occurring at night).

In this case, no adjustments have been made to account for either of these factors as quarrying activity is assumed to be constant throughout any given time period and does not typically exhibit any special audible characteristics that warrant any adjustment (as discussed in Section 4.4.3).

The Standard also recommends the use of a “reference time interval” of 15 minutes. This is the time interval over which the time average sound pressure level is determined and is representative of noise levels received throughout the prescribed day or night-time period of interest.

The noise levels presented in this assessment have therefore, unless otherwise specified, been calculated as a 15 minute equivalent continuous average with no adjustments (i.e. LR = dB L_Aeq(15 min)).

In the case of vehicle activity, the number of movements is typically referred to on an hourly basis (including in Section 2.2.4 of this report). As a constant level of activity is assumed, the number of movements in a 15 minute period is taken to be 25% of the total hourly movements.

---

6 NZ Primary Parcels (NZTM 2000 Projection), Land Information New Zealand (LINZ), obtained 11 October 2017.
5.2 Noise Source Data

Our modelling has been based on noise source data that we have measured on similar quarry sites, including on some of Fulton Hogan’s existing quarries. We have also cross-referenced this data against generic noise source data provided in British Standard BS 5228-1:2009 “Code of practice for noise and vibration control on construction and open sites – Part 1: Noise”. The data in this standard generally correlate well with our previous measurements.

The source data used in our assessment is summarised in Table 15, expressed as a sound power level (SWL or $L_{WA}$) for fixed sources and sound event/exposure level (SEL or $L_{AE}$) for moving sources.

Table 15: Noise source data used for assessment

<table>
<thead>
<tr>
<th>Item</th>
<th>Noise Level</th>
<th>Source Height*, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front end loader</td>
<td>105 dB $L_{WA}$</td>
<td>1.5</td>
</tr>
<tr>
<td>Excavator</td>
<td>108 dB $L_{WA}$</td>
<td>2.0</td>
</tr>
<tr>
<td>Fixed processing plant:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Cone crusher</td>
<td>117 dB $L_{WA}$</td>
<td>4.0</td>
</tr>
<tr>
<td>– Vertical shaft impact crusher</td>
<td>97 dB $L_{WA}$</td>
<td>4.0</td>
</tr>
<tr>
<td>– Jaw crusher</td>
<td>119 dB $L_{WA}$</td>
<td>4.0</td>
</tr>
<tr>
<td>– Screen</td>
<td>111 dB $L_{WA}$</td>
<td>4.0</td>
</tr>
<tr>
<td>Mobile processing plant (crusher and screen units)</td>
<td>106 to 121 dB $L_{WA}$</td>
<td>3.0</td>
</tr>
<tr>
<td>Field conveyor system:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Intake structure</td>
<td>99 dB $L_{WA}$</td>
<td>3.0</td>
</tr>
<tr>
<td>– Belt transitions and drive motor</td>
<td>103 dB $L_{WA}$</td>
<td>3.0</td>
</tr>
<tr>
<td>– Conveyor belt</td>
<td>61 dB $L_{WA}$/m</td>
<td>2.0</td>
</tr>
<tr>
<td>Truck and trailer unit</td>
<td>86 dB $L_{AE}$ at 10 m</td>
<td>1.5</td>
</tr>
<tr>
<td>Articulated dump trucks</td>
<td>83 dB $L_{AE}$ at 10 m</td>
<td>1.5</td>
</tr>
</tbody>
</table>

* Modelled noise source height relative to source’s local terrain elevation (e.g. above pit base or above existing ground)

The most significant noise source associated with the project is the fixed processing plant. The data above are consistent with our modelling for Fulton Hogan’s McLeans Island quarry. We have had the opportunity to verify this data with on-site measurements on multiple occasions since the site was consented in 2013. The results of these field measurements align well with the results of our modelling, thus providing further confidence in the most critical noise source data.

We understand that electric conveyors will be used to move material across the site wherever possible. However, for the purposes of our modelling, we have considered scenarios both with the conveyor and with articulated dump trucks, as these could also be utilised occasionally. This provides a conservative assessment as conveyor systems will be significantly quieter than dump trucks. This difference is significant because noise from conveyors will not be audible for nearby receivers, whereas dump trucks will be at times.

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6.0 **CALCULATED NOISE LEVELS**

The results of our modelling are shown below, based on the scenarios described in Section 5.0. These only consider the noise from the primary operational phases and short-term site preparation works are discussed later in Section 8.0.

Table 16 provides the calculated noise levels for each of the assessment scenarios listed in Table 13. Noise contour plots are also provided on the following pages in Figure 14 to Figure 19. The contour plots also show the location of the point receivers listed below (by reference to the “ID” number).

<table>
<thead>
<tr>
<th>ID</th>
<th>Address</th>
<th>Form Pit</th>
<th>Stage 1</th>
<th>Stage 3</th>
<th>Stage 5</th>
<th>Evening</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3/469 Maddisons Road</td>
<td>35</td>
<td>42</td>
<td>43</td>
<td>44</td>
<td>42</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>4 Dawsons Road (dwelling)</td>
<td>41</td>
<td>46</td>
<td>46</td>
<td>48</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>4A/469 Maddisons Road</td>
<td>34</td>
<td>41</td>
<td>42</td>
<td>42</td>
<td>41</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>4B/469 Maddisons Road</td>
<td>33</td>
<td>40</td>
<td>41</td>
<td>42</td>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td>5</td>
<td>151 Curraghs Road</td>
<td>38</td>
<td>44</td>
<td>45</td>
<td>47</td>
<td>46</td>
<td>38</td>
</tr>
<tr>
<td>6</td>
<td>153 Curraghs Road</td>
<td>38</td>
<td>44</td>
<td>45</td>
<td>47</td>
<td>46</td>
<td>38</td>
</tr>
<tr>
<td>7</td>
<td>165 Dawsons Road</td>
<td>37</td>
<td>43</td>
<td>44</td>
<td>46</td>
<td>45</td>
<td>37</td>
</tr>
<tr>
<td>8</td>
<td>180 Maddisons Road</td>
<td>36</td>
<td>43</td>
<td>43</td>
<td>45</td>
<td>44</td>
<td>37</td>
</tr>
<tr>
<td>9</td>
<td>286 Curraghs Road</td>
<td>39</td>
<td>45</td>
<td>47</td>
<td>47</td>
<td>46</td>
<td>39</td>
</tr>
<tr>
<td>10</td>
<td>300 Maddisons Road</td>
<td>37</td>
<td>44</td>
<td>44</td>
<td>46</td>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>11</td>
<td>319 Maddisons Road</td>
<td>40</td>
<td>43</td>
<td>44</td>
<td>49</td>
<td>48</td>
<td>40</td>
</tr>
<tr>
<td>12</td>
<td>342 Maddisons Road</td>
<td>38</td>
<td>45</td>
<td>46</td>
<td>47</td>
<td>46</td>
<td>39</td>
</tr>
<tr>
<td>13</td>
<td>354 Maddisons Road</td>
<td>37</td>
<td>43</td>
<td>44</td>
<td>45</td>
<td>44</td>
<td>37</td>
</tr>
<tr>
<td>14</td>
<td>358 Maddisons Road</td>
<td>39</td>
<td>46</td>
<td>46</td>
<td>48</td>
<td>47</td>
<td>39</td>
</tr>
<tr>
<td>15</td>
<td>370 Maddisons Road</td>
<td>38</td>
<td>45</td>
<td>46</td>
<td>47</td>
<td>46</td>
<td>39</td>
</tr>
<tr>
<td>16</td>
<td>428 Maddisons Road</td>
<td>35</td>
<td>42</td>
<td>42</td>
<td>44</td>
<td>43</td>
<td>36</td>
</tr>
<tr>
<td>17</td>
<td>437 Maddisons Road</td>
<td>35</td>
<td>42</td>
<td>43</td>
<td>44</td>
<td>43</td>
<td>36</td>
</tr>
<tr>
<td>18</td>
<td>969 Waterholes Road</td>
<td>41</td>
<td>46</td>
<td>46</td>
<td>48</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>19</td>
<td>1033 Main South Road</td>
<td>44</td>
<td>48</td>
<td>49</td>
<td>50</td>
<td>47</td>
<td>42</td>
</tr>
<tr>
<td>20</td>
<td>1053 Main South Road</td>
<td>48</td>
<td>49</td>
<td>51</td>
<td>52</td>
<td>48</td>
<td>46</td>
</tr>
<tr>
<td>21</td>
<td>1090 Main South Road</td>
<td>45</td>
<td>49</td>
<td>52</td>
<td>51</td>
<td>48</td>
<td>43</td>
</tr>
<tr>
<td>22</td>
<td>1160 Main South Road</td>
<td>39</td>
<td>44</td>
<td>47</td>
<td>45</td>
<td>43</td>
<td>37</td>
</tr>
<tr>
<td>23</td>
<td>SDC Devine Acres LZ Boundary</td>
<td>38</td>
<td>43</td>
<td>44</td>
<td>45</td>
<td>42</td>
<td>37</td>
</tr>
<tr>
<td>24</td>
<td>Templeton LZ Boundary (N)</td>
<td>35</td>
<td>41</td>
<td>42</td>
<td>43</td>
<td>41</td>
<td>35</td>
</tr>
<tr>
<td>25</td>
<td>Templeton LZ Boundary (S)</td>
<td>35</td>
<td>40</td>
<td>41</td>
<td>42</td>
<td>40</td>
<td>34</td>
</tr>
</tbody>
</table>
Figure 14: Noise contour plot for Scenario 1 – pit formation

The noise contours within this figure were created by combining information from sound level measurements points. The sound level contour lines indicate the equal sound levels across the site. The contour lines are equivalent to the L_{Aeq}(15 min) levels.
Figure 15: Noise contour plot for Stage 1 excavation
Figure 16: Noise contour plot for Stage 3 excavation
Figure 17: Noise contour plot for Stage 5 excavation
Figure 18: Noise contour plot for the evening scenario
Figure 19: Noise contour plot for the night-time scenario
6.1 Calculated Vehicle Noise Variance

We note that, for the main daytime scenarios, the peak-hour truck movements have been modelled (184 per hour, as per Table 3). The noise contribution from typical-hour trucks will be around 2 dB lower. Of the noise sources modelled, trucks are the most significant contributor in many cases. As such, this 2 dB difference would result in a corresponding reduction in typical-hour cumulative noise levels for the majority of receivers.

6.2 Mobile Processing Plant

As previously discussed, mobile processing plant will be used sporadically within the quarry. Given that the frequency, duration and location of the use of this equipment will vary throughout the project, it is difficult to reconcile this with the normal operational scenarios discussed above. Noise from this plant has therefore been excluded from the noise contours above for simplicity.

Mobile plant will not operate within 250 metres of the site boundary (for dust control reasons). However, it could operate at any distance back from the working face of the quarry pit and will therefore not necessarily be subject to the same level of acoustic screening that extraction plant is. The counter to this is that, as mobile plant gets further from the boundary, it also gets further from receivers – and noise levels decrease with distance.

This relationship is shown in the matrix in Table 17 below, for a given combined sound power level of 121 dB $L_{WA}$ (from Table 15).

Table 17: Noise levels received from mobile plant (alone)

<table>
<thead>
<tr>
<th>Distance from site boundary to mobile plant</th>
<th>Distance from site boundary to receiver</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 m</td>
<td>100 m</td>
</tr>
<tr>
<td>250 m</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>42</td>
</tr>
<tr>
<td>350 m</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>41</td>
</tr>
<tr>
<td>450 m</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>40</td>
</tr>
<tr>
<td>550 m</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>39</td>
</tr>
<tr>
<td>650 m</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

This information shows that noise from the mobile plant alone is below the 55 dB $L_{Aeq}$ recommended daytime noise limit. As part of a separate analysis we have combined this data with the calculated operational noise levels (that were presented in Table 16) and determined that:

- Subject to the 250 metre setback, cumulative noise levels with the mobile plant will remain below the recommended 55 dB $L_{Aeq}$ daytime noise limit at all times;
- For the closest receivers (those within 100 metres of the northern boundary), the additional noise from the mobile plant at its closest will have the effect of increasing the highest operational noise levels from around 50 dB $L_{Aeq}$ to around 55 dB $L_{Aeq}$;
- However, when the mobile plant is farthest from the closest northern receivers, the overall quarry noise level will still be below 50 dB $L_{Aeq}$; and
- More distant receivers, such as in Templeton, will experience noise levels around 2 dB higher than during normal daily quarry operations (without the mobile plant), which is an imperceptible difference.
We note that the 250 metre setback for mobile plant is critical to ensure compliance. Without this, the cumulative noise level at the closest dwelling (319 Maddisons Road) would be 58 dB $L_{Aeq}$, which is 3 dB greater than the recommended daytime limit.

### 6.3 Maximum Noise Levels

Aside from the average noise levels discussed in the preceding sections, noise from quarrying can also be described by the $L_{max}$ parameter. This descriptor captures noise from transient events, such as “bangs” from impacts.

From our observations, typical impulsive noise sources in a quarry include:

- Tipping of aggregate from loaders to stockpiles or trailer decks (especially when empty);
- Peak engine revving from loaders or trucks under load, e.g. lifting material or driving uphill;
- Chassis rattle from trucks (often referred to as “body slam”); and
- Impact noise associated with maintenance activities, e.g. hammering steel.

We have analysed the various historic measurements we have obtained around quarries to ascertain likely maximum noise levels experienced. From our calculations, receivers at “typical” distances beyond the quarry boundary (within around 200 metres) will experience maximum noise levels in the range of 40 - 60 dB $L_{Amax}$.

Within this range, maxima from typical extraction and processing activities are 50 - 55 dB $L_{Amax}$. Higher noise levels from impulsive sources such as truck chassis rattle are generally 55 - 60 dB $L_{Amax}$.

For receivers at greater distances, these noise levels will reduce by at least 5 dB beyond 500 metres and 10 dB beyond 1 km.
7.0 OPERATIONAL NOISE ASSESSMENT

We have compared the predicted noise levels presented above against both the project assessment criteria described in Section 4.5 and the applicable local noise standards from the Selwyn District Plan.

7.1 Selwyn District Plan Rules

We note that the proposed hours of operation are inconsistent with those given in the District Plan for the day and night-time periods. As such there is a discrepancy in that the proposed “daytime” levels of activity must be compared against the night-time noise criteria defined in the Plan.

Table 18 below provides a comparison between the predicted levels and District Plan criteria. For simplicity, we have also applied criteria from Selwyn District Plan to equivalent zones (rural/living) within the Christchurch District to form the assessment below. We have also made an allowance of +3 dB to account for the District Plan’s use of the L_{10} parameter, as the noise levels have been predicted using the L_{eq} parameter. This factor is broadly consistent with our previous measurements of similar activities. This adjustment is only provided in order to facilitate the comparison in Table 18.

Table 18: Assessment against Selwyn District Plan noise standards

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Noise Limits, dB L_{10}</th>
<th>Max. Predicted Level, dB L_{10}</th>
<th>District Plan Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Living Zone</td>
<td>Rural Zone</td>
<td>Living Zone</td>
</tr>
<tr>
<td>Daytime</td>
<td>55</td>
<td>60</td>
<td>47</td>
</tr>
<tr>
<td>Night-time</td>
<td>40</td>
<td>45</td>
<td>47</td>
</tr>
</tbody>
</table>

* The Selwyn District Plan defines daytime as 0730 to 2000 hrs, and night-time as 2001 to 0729 hrs.

As the predicted noise levels exceed the night-time noise criteria, primarily due to the mismatch in time periods discussed above, the status of the activity is discretionary with respect to noise (Rule 9.16.2). This is shown in an alternate form in Table 19.

Table 19: Hourly assessment of District Plan compliance

<table>
<thead>
<tr>
<th>Time</th>
<th>00</th>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
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<tr>
<td>Night</td>
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<td></td>
</tr>
</tbody>
</table>

Aside from the average L_{10} noise limits, the District Plan also provides maximum noise limits of 85 dB L_{Amax} during the day and 70 dB L_{Amax} at night (see Table 8). Our calculations indicate that the lower night-time noise limit will be achieved at all receivers. Daytime maxima will remain comfortably below the limit at we also consider it very unlikely that the night-time noise limit would be breeched at any notional boundary position.

7.2 Zones within Christchurch City

7.2.1 Templeton Residential Zone

Within the Christchurch City area, the Templeton residential zone is the most noise sensitive receiving environment. Over the lifespan of the proposed quarry, the calculated noise levels are up to 44 dB L_{Aeq} during the day and 35 dB L_{Aeq} at night. The highest maximum noise levels are unlikely to exceed 55 dB L_{Amax}.

These calculated noise levels easily achieve both the Selwyn and Christchurch noise standards for residential zones. Any concern over which provisions ought to apply to this zone are therefore a moot point, as noise levels can be considered compliant under either standard.
7.2.2 Rural Urban Fringe Zone

In terms of the land east of Dawsons Road, the existing Christchurch City rural zone site boundary noise limit (55 dB $L_{Aeq}$) is achieved at both day and night (see Table 9).

However, we note that Christchurch District Plan also provides notional boundary limits for any dwellings within rural zones – 50 dB $L_{Aeq}$ daytime and 40 dB $L_{Aeq}$ night-time. Some parts of the RuUF Zone are subject to calculated noise levels above these standards and therefore would be exceeded if future residential development was to occur close to the quarry.

We consider that there is a low likelihood of such residential development occurring. We understand that this farmland (east of Dawsons Road and west of Templeton) is currently owned by Christchurch City Council, and that the most likely option for future development is for open space areas.

Furthermore, we understand that the intention of the RuUF Zone is to act as an interface between urban and rural. Given that the Christchurch District Plan has only recently been reviewed, it is likely that this buffer zone will be maintained for the foreseeable future. In addition, residential development is non-complying within this area as it falls within the 50 dB $L_{dn}$ aircraft noise contours. Objective 3.3.12 of the Christchurch District Plan aims to ‘avoid new sensitive activities within the 50 dB $L_{dn}$ Air Noise Contour and the 50 dB $L_{dn}$ Engine Testing Contour for Christchurch International Airport’.

In the unlikely event that future residential development did occur, we expect that any potential noise effects could be mitigated through liaison with Fulton Hogan. The options would include moderate amendments to the quarry’s operation, such as increased and/or additional bunds and/or setback distances, or specific noise control design for the any dwellings.

7.3 Daytime Noise Effects

Based on the calculated noise levels presented in Section 6.0, we consider that, for the main daytime period, noise effects associated with the activity will be acceptable in the local environment for the following reasons:

- The recommended assessment criterion of 55 dB $L_{Aeq}$ is achieved at the site boundary;
- Noise levels will therefore be comfortably below Selwyn District’s 60 dB $L_{A10}$ daytime noise limit; and
- Calculated noise levels are commensurate with the existing daytime ambient noise levels.

Comparing the calculated noise levels against common assessment criteria presented in Section 4.0, daytime noise effects can be described as acceptable for levels up to 55 dB $L_{Aeq}$.

In terms of the actual aural experience of local noise-sensitive receivers, audibility is the key factor that governs how “noticeable” noise from the quarry is. This is a relative assessment against the existing ambient environment, rather than comparison of absolute levels and criteria. The calculated noise levels – 42 to 54 dB $L_{Aeq}$ from Table 16 for main extraction – are within the range of ambient noise levels recorded – 37 to 63 dB $L_{Aeq}$ from Table 4.

7.3.1 “Northern” Receivers

For receivers to the north, west and east, away from SH1, predicted operational noise levels are mostly between 45 and 50 dB $L_{Aeq}$, and potentially up to 55 dB $L_{Aeq}$ during peak hours with mobile processing plant operating nearby. In terms of audibility, this means that typical noise levels from the quarry will be mostly below the ambient noise level (51 dB $L_{Aeq}$ on average at the long-term noise monitoring location), but more noticeable at the closest dwellings during peak levels of quarry activity with mobile plant operating nearby.

Similarly, comparing $L_{max}$ noise levels shows that the highest forecast levels of up to 60 dB $L_{Amax}$ are well below the upper range of maxima normally experienced in this environment (which are often
governed by aircraft noise). In our experience, people are generally less sensitive to moderate transient noise events during the day than at night. Whilst maximum events from the quarry may be audible at times, they are in keeping with the scale of existing noise in the environment.

7.3.2 “Southern” Receivers

The ambient noise environment for receivers in the vicinity of SH1 is dominated by the associated road traffic noise. Measured ambient noise levels generally exceed 65 dB $L_{Aeq}$ for the entirety of the daytime period.

As a result, the calculated noise levels from the activity are unlikely to be audible at these receivers in most cases. The highest predicted noise level of 54 dB $L_{Aeq}$ (at 1053 Main South Road during Stage 5 extraction) is still over 10 dB below the ambient noise level. Moreover, noise emissions to the south of the side are generally controlled by truck movements around the site access, which will be very similar in character to existing traffic noise on the highway.

7.3.3 Templeton and Distant Receivers

For more distant receivers, such as those in the Templeton Residential Zone, the existing ambient noise environment experienced will still be similar to that in the vicinity of the application site, as discussed in Section 3.0. Noise is experienced from the same environmental sources, i.e. road, rail and air traffic, residential noise and natural sounds.

The highest daytime noise levels (Section 7.2) of 44 dB $L_{Aeq}$ and 55 dB $L_{Amax}$ will be below the existing level of daytime noise in the area – typically 50 dB $L_{Aeq}$ from the sources described above with maxima from aircraft passing overhead regularly between 70 and 80 dB $L_{Amax}$.

In addition, as the predominant wind is from the north-east, Templeton will mostly be upwind of the site. Section 5.0 outlined how our modelling is based on worst-case downwind sound propagation. Noise levels under upwind conditions will be significantly lower, further reducing the likelihood of quarry noise being noticeable.

7.4 Evening & Night-time Noise Effects

After-hours activities are proposed for up to 150 days per annum. On these days, a limited range of operations will take place during the evening and only minimal loadout and haulage activities at night. Noise emissions during these times will remain below the recommended project criteria of 50 dB $L_{Aeq}$ during the evening and 45 dB $L_{Aeq}$ at night.

7.4.1 Evening

Typical guidance on noise levels within New Zealand, including that in Selwyn and Christchurch, does not provide any specific level of protection for the evening period. In many cases, the daytime period extends right up until 2200 hrs.

Fulton Hogan has offered a more restrictive noise limit following consultation and, in this case, we consider that the proposed limit is appropriate as it reflects how noise levels in this environment begin to taper off later on due to reduced traffic movements (refer Figure 13).

As a result, the calculated noise levels are proportionate to the evening noise environment with regard to the difference described between daytime calculated and ambient levels.

7.4.2 Night-time

The proposed level of night-time activity is very low in terms of quantity of plant operating, compared with the day. Even with our very conservative assumption of up to 40 trucks per hour at night, the calculated levels still comply with the recommended 45 dB $L_{Aeq}$ noise limit (other than at the site access point).
This recommended limit provides for a level of amenity that is consistent with that envisaged in the Selwyn District Plan. In many cases the calculated noise levels are substantially below even 40 dB $L_{Aeq}$ at night, which represents a high level of residential amenity. This level of protection is not necessarily commonly afforded to a rural environment and the current Selwyn District Plan rules are a reflection of this.

Although the predicted noise levels are relatively low, there is some level of effect simply due to introducing an activity into an environment where there is currently little occurring locally. In terms of noise, most of that received is due to more distant sources (at least for the most sensitive receivers to the north of the site).

Overall, we conclude that, for the receivers considered around the perimeter of the site, night-time operation of the quarry will result in acceptable noise effects for nearby residents because:

- Noise levels received within dwellings will be lower, even allowing for partially open bedroom windows for ventilation;
- Maximum noise levels received within bedrooms will be sufficiently low as to not result in sleep disturbance; and
- Receivers around SH1 are already subject to intermittent high noise levels from road and rail activity.

Noise effects for more distant receivers, such as those in Templeton or south of SH1 can reasonably be considered as negligible due to the additional distance from the site.

### 7.4.3 Early-morning Period

The quarry’s ‘daytime’ activity will commence from 0600 hrs, which is still classified as ‘night-time’ within the Selwyn District Plan. Despite this, our noise measurements show that the ambient noise level is already sufficiently elevated at this time to offset any increase in noise due to the start of quarry operations. It is particularly notable that this is also typically the busiest period for aircraft activity overhead.

Figure 11 depicts how, by 0600 hrs, the background noise level in the area due to traffic noise has already reached the typical range of noise levels experienced throughout the day. As such, we consider this period to be more closely aligned with the daytime, rather than night-time noise environment and do not anticipate any adverse noise effects from the commencement of quarry operations. The noise effects at this time are deemed acceptable.

### 7.5 Operational Noise Management

Effective and active management of the quarry is essential in ensuring that noise emissions remain within acceptable bounds and commensurate with the assumptions and methodology in this report. The operator and their subcontractors have a duty under the RMA to avoid the generation of unreasonable noise.

Fulton Hogan’s brief for the quarry includes a number of important noise control factors, including:

- Establishing noise control bunds around the site perimeter prior to quarrying activity;
- Not utilising tonal reversing or movement alarms on their plant or equipment (instead employing broadband sound or visual-only alternatives); and
- Favouring the use of electric conveyor systems over vehicle-based transport wherever practical.

While aspects such as those above could be adopted as conditions of consent (with appropriately wording), we make the overarching recommendation that the management remain mindful of enacting the best practicable option with all such noise matters and continue their liaison with local stakeholders once operational.
8.0 CONSTRUCTION NOISE

Site establishment works such as construction of the earth bund, initial topsoil stripping and rehabilitation activities are commonly assessed as “construction noise”, rather than as noise from typical quarry operations. These activities are considered separately to routine operation of the quarry because:

- They are temporary in nature and will not occur for prolonged periods;
- There are long-term benefits from constructing the bund and rehabilitating the site; and
- The character and duration of noise from such activities is consistent with rural activities which would otherwise be permitted on the site.

8.1 Construction Noise Limits

Noise from the activities described above is assessed under New Zealand Standard NZS 6803:1999 “Acoustics - Construction Noise”. This Standard is referred to by both the Selwyn and Christchurch District Plans and provides procedures for the assessment of noise from construction work, including maintenance and demolition work. Among examples of activities that are within the scope of the Standard is:

‘A perimeter drain or a noise bund around an open cast mine or quarry or installation of relocatable noise barriers.’

In terms of construction noise effects, the Standard notes that:

‘As noise from construction projects is generally of limited duration, people and communities will usually tolerate a higher noise level provided it is no louder than necessary, and occurs within appropriate hours of the day.’

The Standard provides noise criteria that vary with the duration of construction activities in a given location and are also dependant on the time of day. Recommended noise limits are given for the following durations:

- “Short-term” means construction work at any one location for up to 14 calendar days;
- “Typical duration” means construction work at any one location for more than 14 calendar days but less than 20 weeks; and
- “Long-term” means construction work at any one location with a duration exceeding 20 weeks.

The noise limits discussed below apply at 1 metre from the façade of buildings that may be affected by construction noise. This is a key difference to the notional boundary assessment positions used in NZS 6801/6802 and discussed earlier in this report in relation to operational noise.

8.1.1 Noise in Residential Environments

For residential zones and dwellings in rural areas, the Standard provides noise limits as shown in Table 20 (reproduced from Table 2 from NZS 6803:1999).

Daytime criteria are generally somewhat higher than for permanent noise sources, on the basis that the effects are of relatively short duration, whilst night-time criteria concern maintaining appropriate amenity at night to permit sleep.
### Table 20: Recommended upper limits for construction noise received in residential zones/rural dwellings

<table>
<thead>
<tr>
<th>Time of week</th>
<th>Time period</th>
<th>Typical Duration</th>
<th>Short-term Duration</th>
<th>Long-term Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>dB $L_{Aeq}$</td>
<td>dB $L_{Aeq}$</td>
<td>dB $L_{Aeq}$</td>
</tr>
<tr>
<td>Weekdays</td>
<td>0630-0730</td>
<td>60</td>
<td>65</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>0730-1800</td>
<td>75</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>1800-2000</td>
<td>70</td>
<td>75</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>2000-0630</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Saturdays</td>
<td>0630-0730</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>0730-1800</td>
<td>75</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>1800-2000</td>
<td>45</td>
<td>45</td>
<td>45</td>
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<tr>
<td></td>
<td>2000-0630</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Sundays and public holidays</td>
<td>0630-0730</td>
<td>45</td>
<td>45</td>
<td>45</td>
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<tr>
<td></td>
<td>0730-1800</td>
<td>55</td>
<td>55</td>
<td>55</td>
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<td></td>
<td>1800-2000</td>
<td>45</td>
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<td></td>
<td>2000-0630</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
</tbody>
</table>

8.1.2 Noise in Industrial or Commercial Environments

Table 3 of the Standard provides recommended upper limits for construction noise received in industrial or commercial areas for all days of the year, summarised in Table 21 below.

### Table 21: Recommended upper limits for commercial/industrial receivers

<table>
<thead>
<tr>
<th>Time period</th>
<th>Typical Duration</th>
<th>Short-term Duration</th>
<th>Long-term Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$dB L_{Aeq}$</td>
<td>$dB L_{Aeq}$</td>
<td>$dB L_{Aeq}$</td>
</tr>
<tr>
<td>0730-1800</td>
<td>75</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>1800-0730</td>
<td>80</td>
<td>85</td>
<td>75</td>
</tr>
</tbody>
</table>

8.2 Calculated Construction Noise Levels

We have modelled noise from construction activity using the same methodology described in Section 5.0. The only significant difference is that the predicted levels are at the façade of buildings, rather than the notional boundary. Façade reflections have been accounted for accordingly.

Two likely worst-case scenarios have been modelled:

1. Initial site establishment – bund construction adjacent to the closest dwelling, with topsoil stripping occurring in the initial extraction area; and
2. Final stage topsoil stripping – mobile machinery working behind bunds at existing ground level close to northern boundary and Maddisons Road dwellings.

Noise contour plots for these two scenarios are provided overleaf in Figure 20 and Figure 21 respectively.
Figure 20: Construction noise contour plot – worst-case
Figure 21: Construction noise contour plot – Stage 5
8.3 Construction Noise Assessment

The calculated noise levels presented above demonstrate that noise from construction phases will comfortably comply with both the short-term and typical duration noise standards given in NZS 6803 (Table 20).

The duration of such construction work is unlikely to affect any given receiver for more than 20 weeks, which is the long-term duration threshold. Furthermore, due to the long operational life of the quarry, different construction activities are likely to have long durations between them (e.g. from the stripping of one stage to the stripping of the subsequent). We therefore consider that either the typical or short-term assessment criteria are appropriate, depending on the specific nature of the activity.

Construction of the bunds will be the short-term activity that has the potential for the greatest noise effects as there will be no screening from noise at the start of this activity. Although we understand that the bund will be constructed all-at-once, we note that bund construction will only occur within any given area for a short period as the plant moves along the line.

The highest predicted noise level is 71 dB L_{Aeq} at 319 Maddisons Road, which is situated immediately adjacent to the site boundary and bund location. In this instance where a specific receiver is particularly likely to be impacted by the works, we recommend that Fulton Hogan liaise with landowners ahead of time in order to advise them of upcoming works and discuss what noise mitigation measures may be desirable. For example, if particular occupants are planning on being away for a known period of time, this is a good opportunity to undertake the relatively noisy activities.

In terms of overall construction noise effects, as the duration of these activities is short, and because of the long-term benefits of constructing the bund and rehabilitating the site, we consider that noise levels which comply with the recommended limits given in Table 2 of NZS 6803:1999 will be acceptable.

We also note that the character of noise from construction activities is consistent with rural activities which would be permitted on the site — examples are field or crop preparation such as ploughing or fertiliser application, where engine noise from large vehicles occurs intermittently for a period of a few days at a given location.

We recommend that the requirement to adopt the best practice measures in NZS 6803 becomes a condition of consent and that construction activity is limited to the daytime hours specified in this Standard (unless liaison with local stakeholders deems other time periods to be appropriate).
9.0 SITE-GENERATED VIBRATION

There are no significant vibration sources associated with the operation of the proposed quarry (noting that there is no blasting required). The closest vibration-generating activities that will occur close to sensitive receivers are:

- Boundary bund construction, using excavators and trucks; and
- Aggregate extraction by loaders at the edge of the quarry pit.

In our experience aggregate extraction results in very little vibration outside of the site, while bund construction is generally the activity with the most potential to generate vibration effects due to its proximity to receivers.

Both of these activities involve plant and equipment typical of construction activities. A number of documents provide guidance on the assessment and management of construction vibration and these are discussed below.

9.1 Vibration Assessment Criteria

Unlike for construction noise, there are no current national standards for the assessment of vibration from construction activities. The Selwyn District Plan refers to ‘New Zealand Standard 2631:1985-89 Parts 1-3’ in Rule 9.17.1.2. However, we understand that Standards New Zealand withdrew the NZS/ISO 2631 series in 2005 after technical criticism. This is therefore considered inappropriate as it is not a current and valid standard.

In lieu of any national guidance, the following criteria are commonly adopted to assess construction vibration in New Zealand:

- Building damage – German Standard DIN 4150-3:1999 “Structural Vibration - Effects of Vibration on Structures”; and

Both of these Standards provide vibration criteria in terms of the Peak Particle Velocity (PPV), which are summarised in the following sections.

9.1.1 Building Damage Criteria

The DIN 4150-3:1999 Standard provides conservative guidance designed to prevent any damage (even superficial) to buildings. It sets criteria for both long- and short-term vibration that apply in all axes at the building foundation or in horizontal axes at the highest floor adjacent to a façade wall.

The Standard defines ‘short-term’ vibration as ‘vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated’. Common sources include blasting, drop-hammer piling, dynamic consolidation. Long-term vibration is defined as all other vibration types not covered by the short-term vibration definition. Common sources include most construction machinery vibratory rollers, vibro-hammer piling. Some sources (e.g. construction traffic) could be either or both, in which case the more stringent long-term values should be adopted. The criteria are summarised in Table 22.

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Table 22: Summary of building damage risk vibration criteria from DIN 4150-3:1999

<table>
<thead>
<tr>
<th>Type of structure</th>
<th>Short-term</th>
<th></th>
<th>Long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PPV at</td>
<td>PPV at</td>
<td>PPV at</td>
</tr>
<tr>
<td></td>
<td>the</td>
<td>the highest</td>
<td>the highest</td>
</tr>
<tr>
<td></td>
<td>foundation</td>
<td>floor, mm/s</td>
<td>floor, mm/s</td>
</tr>
<tr>
<td></td>
<td>by frequency, mm/s</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 – 10 Hz</td>
<td>10 – 50 Hz</td>
<td>50 – 100 Hz</td>
</tr>
<tr>
<td>Commercial/Industrial</td>
<td>20</td>
<td>20 - 40</td>
<td>40 - 50</td>
</tr>
<tr>
<td>Residential/School</td>
<td>5</td>
<td>5 - 15</td>
<td>15 - 20</td>
</tr>
<tr>
<td>Historic or sensitive structures</td>
<td>3</td>
<td>3 - 8</td>
<td>8 - 10</td>
</tr>
</tbody>
</table>

The Standard states that ‘experience has shown that if [the guideline values] are complied with, damage will not occur. Exceeding the [guideline values] slightly does not necessarily lead to damage’.

9.1.2 Human Response Criteria

Annex B of British Standard BS 5228-2:2009 “Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration” provides guidance relating to human response to construction vibration in residential environments. These criteria are summarised in Table 23.


<table>
<thead>
<tr>
<th>Vibration (PPV)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.14 mm/s</td>
<td>Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.</td>
</tr>
<tr>
<td>0.3 mm/s</td>
<td>Vibration might be just perceptible in residential environments</td>
</tr>
<tr>
<td>1.0 mm/s</td>
<td>It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.</td>
</tr>
<tr>
<td>10 mm/s</td>
<td>Vibration is likely to be intolerable for any more than a very brief exposure to this level.</td>
</tr>
</tbody>
</table>

Comparing these values with those derived from the DIN Standard above, it is clear that people are likely to perceive and potentially adversely respond to vibration levels significantly below those which may cause superficial building damage (such as cracking in paint or plasterwork). Additionally, people are generally more sensitive to vibration at frequencies higher than those which cause building damage.

In addition, the BS 5228-2 guidance above also generally agrees with that given in Norwegian Standard NS 8176E:2005 “Vibration and Shock: Measurement of Vibration in Buildings from Land Based Transport and Guidance to Evaluation of its Effects on Human Beings”. Annex A of this Standard provides exposure-response curves based on an extensive study of residents’ reactions to vibration levels in their homes, which are shown in Figure 22.

Four levels of community annoyance are shown in Figure 22, ranging from merely being able to perceive the vibration, up to being highly annoyed about the vibration. For each of these levels, the extent of community annoyance is expressed in terms of the percentage of the exposed community that experience the given level of annoyance.
Although the NS 8176E Standard concerns transport-generated vibration, the exposure-effect curves given do not distinguish between different source types and the curves nonetheless provide a useful reference for vibration perceptibility in terms of its average effect on a population.

In terms of New Zealand guidance, we note that similar vibration amenity criteria to those discussed above have recently been adopted in by Auckland Council. The Auckland Unitary Plan specifies the following vibration limits within buildings, given in Table 24.

Table 24: Vibration limits in buildings (Table E25.6.30.1 of the Auckland Unitary Plan [OIP version])

<table>
<thead>
<tr>
<th>Receiver</th>
<th>Peak Particle Velocity (PPV) Limit, mm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day – 0700-2200 hrs</td>
</tr>
<tr>
<td>Occupied activity sensitive to noise</td>
<td>2</td>
</tr>
<tr>
<td>Other occupied buildings</td>
<td>2</td>
</tr>
</tbody>
</table>

These criteria apply to vibration measured in any axis at the corner of the floor of the storey of interest for multi-storey buildings, or within 500 mm of ground level at the foundation of a single-storey building.

9.1.3 Vibration Generation

The closest dwelling to the boundary of the application site is that at 319 Maddisons Road, where the façade is around 19 metres from the boundary at its closest point. Beyond this the next closest structures are at least 90 metres from the boundary, with the second closest dwelling (153 Curraghs Road) around 94 metres away.
Vibration received at a location from any given source will vary depending on a number of factors that determine the ground propagation conditions, e.g. soil type, density, elasticity, etc. Figure 23 shows predicted vibration propagation over distance from an excavator for different ground types. This is from the NZTA’s construction guidance\(^9\) that has been developed based on empirical data discussed in their extensive research\(^{10}\). The ground categories are broadly from: 1 – weak or soft; to 4 – hard, competent rock.

**Figure 23: Predicted vibration from a Sumitomo SH120 excavator (Figure 4.31 of NZTA’s construction noise guide)**

The footnote to the NZTA’s figure above notes that:

‘... some of these data have been measured at distances less than 10m and subsequently corrected for distance. Using the 10m source data generally results in an over-prediction of the vibration level at distances less than 50m compared to using the original source data at the closer distance ...’

In practice, our recent measurement experience with similar sources indicates that the guidance in Figure 22 is somewhat conservative, as is generally the case for many “prediction” methodologies. For example, our own measurement data indicates typical levels of:

- 1.1 mm/s at 10 metres from Zaxis 330LC excavator loading dump truck;
- 0.2 mm/s at 19 metres from Zaxis 670LCH excavator loading dump truck; and
- 1.5 mm/s at 10 metres from an excavator operating a diaphragm wall rig.

On the basis of the data above, the conservative NZTA guidance suggest that vibration levels from an excavator working at 20 metres may vary between 2.5 and 3.8 mm/s, whereas our own measurements indicate that the upper levels of vibration will be between 1 and 2 mm/s.

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9.1.4 Vibration Assessment

Even the most conservative (highest) estimations of vibration generation above are comfortably below the residential building damage criterion of 5 mm/s.

At the closest receiver distance of 20 metres vibration from excavator use on the boundary for bund construction may be felt within the dwelling at times. Despite this, the highest estimates are still far below the intolerable threshold (BS 5228).

In practice, whether vibration is easily perceptible depends on the operating conditions – both the specifics of the ground and building and the operator’s manner of use. We expect that any vibration generated will be acceptable providing the occupant is given prior notice of the works occurring.

Aside from bund construction, vibration from other activities received at the closest dwelling, will be minimal. Similarly, vibration received at any other property from all activities (including bund construction) is not likely to be perceptible within dwellings.
10.0 QUARRY TRAFFIC ON PUBLIC ROADS – NOISE

Although road traffic noise generated outside of the site is not considered against the District Plan noise standards, it is appropriate to consider whether any adverse effects may occur as a result of the additional traffic movements.

The potential for adverse noise effects from road traffic noise can arise from two aspects, either:

- A proposed activity generates a substantial increase in vehicle movements, and therefore noise; or
- Where predicted traffic noise levels exceed the existing ambient noise levels or applicable guidance.

These matters will be considered in the following sections.

10.1 Assessment Criteria

In terms of national guidance, road traffic noise is outside of the scope of the usual environmental noise assessment Standard, NZS 6802. Guidance is instead given in New Zealand Standard NZS 6806:2010 “Acoustics - Road-traffic noise - New and altered roads”.

10.1.1 NZS 6806

For high-flow roads, traffic noise effects generally correlate best with longer term average noise levels. The lowest external noise criterion given in this Standard is 57 dB $L_{A_{eq}}$(24 hr), assessed at the façade of any sensitive building (e.g. dwelling) and based on the average annual daily traffic (AADT).

However, we note that NZS 6806 does not apply to existing roads, only new and altered roads with traffic volumes above 2000 AADT (at the design year). The Standard explains in clause 3.4.2 that:

‘People’s response to noise from traffic flows less than 2000 AADT is mostly to individual noise as a transient maximum sound level.’

Furthermore, the Standard states (C1.3.1) that:

‘Noise criteria recommended in this Standard are not intended to apply to low volume roads, for example those in isolated rural areas servicing a small number of dwellings ... or business activities which generate low traffic volumes.’

Overall, we consider that the guidance in NZS 6806 is generally not relevant to this project.

10.1.2 Noise Level Guidance

Similar mining and quarrying sites in recent years have adopted assessment criteria that were derived in part from detailed consideration over the application of both NZS 6802 and NZS 6806 to such site-specific traffic noise.

A daytime traffic noise criterion of 55 dB $L_{A_{eq}}$(1 hr) is commonly applied to noise from heavy vehicles. There is no similar commonly adopted guidance for acceptable limits of night-time noise exposure, other than refer to the WHO and NZS 6802 guidance discussed respectively in Section 4.3 and Section 4.2.1 of this report.

10.1.3 Noise Level Change

As discussed above, in lieu of any applicable absolute noise level criteria, it is appropriate to consider the degree of noise change in an environment and any resulting noise effects. As a guide, Table 25 describes the typical subjective reaction to any difference in noise level and demonstrates how this may result in a given level of adverse effects.

---

11 A commonly cited Environment Court case related is Brookby Quarries Limited (ENV-2014-AKL-000048)
Table 25: Change in noise level

<table>
<thead>
<tr>
<th>Change in Sound Level (dBA)</th>
<th>Subjective Reaction</th>
<th>Impact or RMA Adverse Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>Imperceptible change</td>
<td>Negligible/less than minor</td>
</tr>
<tr>
<td>3 - 4</td>
<td>Just perceptible change</td>
<td>Slight/Minor</td>
</tr>
<tr>
<td>5 - 8</td>
<td>Appreciable change</td>
<td>Noticeable</td>
</tr>
<tr>
<td>9 - 11</td>
<td>Doubling of loudness</td>
<td>Significant/Substantial</td>
</tr>
<tr>
<td>&gt; 12</td>
<td>More than a doubling of loudness</td>
<td>Severe</td>
</tr>
</tbody>
</table>

In our experience the categories above correlate well with reactions to road traffic noise, particularly for high-flow roads where effects are more related to the continuous levels of “steady” sound, rather than the transient events of individual vehicles passing.

10.2 Daytime Traffic Noise

10.2.1 State Highway Traffic

As shown in Figure 4 (Section 2.2.4) the majority of quarry traffic will utilise the state highway network and will take the shortest route to access this – along Jones Road and to SH1 via Dawsons Road. From Stantec’s ITA, we understand that there are currently 26,060 vehicles per day on SH1, of which 3,390 are heavy vehicles (approximately 13%).

In terms of the impact of quarry traffic, the worst-case segment of road will be between Dawsons Road and Pound Road, where the quarry traffic begins to disperse throughout the major road network (based on the distribution map in Appendix B).

For this segment, 1,300 heavy vehicle movements are forecast for the quarry’s maximum day scenario. Table 26 provides the resultant change in road traffic noise level from SH1.

Table 26: Change in road traffic noise level on SH1

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Daily Traffic</th>
<th>Heavies</th>
<th>% Heavies</th>
<th>Noise Level</th>
<th>Change in noise level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing SH1</td>
<td>26,060</td>
<td>3,390</td>
<td>13</td>
<td>61 dB L&lt;sub&gt;Aeq&lt;/sub&gt; (24 hr)</td>
<td>1 dB</td>
</tr>
<tr>
<td>Existing SH1 + Quarry (Peak Day)</td>
<td>27,360</td>
<td>4,690</td>
<td>17</td>
<td>62 dB L&lt;sub&gt;Aeq&lt;/sub&gt; (24 hr)</td>
<td></td>
</tr>
</tbody>
</table>

* Noise level presented for nominal 60 metre distance from road edge and used for comparative purposes only.

This analysis shows that there is no appreciable increase in road traffic noise level as a result of the quarry operations, as there is simply so much existing traffic on the road that the effects of any increase are negligible.

For receivers at greater distances from the highway than the example in Table 26 above, the absolute level of noise received will be lower, but the difference in noise level with and without the quarry traffic will be the same – below 1 dB and imperceptible.

10.2.2 Local Road Traffic

We have performed a similar analysis to the above for local roads around the quarry. Table 27 presents the change in noise level on each road considered following the addition of quarry traffic.

---

12 Traffic noise levels have been calculated using the NZTA’s Road Traffic Noise Calculator, which implements the UK Calculation of Road-Traffic Noise (CRTN) method, with adaptations for New Zealand road surfaces.
### Table 27: Change in daily traffic noise levels after addition of quarry traffic

<table>
<thead>
<tr>
<th>Road</th>
<th>Road Segment</th>
<th>24 hr Noise Level Change, dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jones Road</td>
<td>West of Curraghs Road</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>East of Dawsons Road</td>
<td>0</td>
</tr>
<tr>
<td>Hamptons Road</td>
<td>South of Waterholes Road</td>
<td>+1</td>
</tr>
<tr>
<td>Curraghs Road</td>
<td>Maddisons Road to Newtons Road</td>
<td>+1</td>
</tr>
<tr>
<td>Dawsons Road</td>
<td>Maddisons Road to Newtons Road</td>
<td>0</td>
</tr>
</tbody>
</table>

As with daily traffic on SH1, it is clear from Table 27 that there will be a negligible increase in daily traffic noise levels as a result of the additional quarry traffic.

### 10.3 Traffic Outside of Daytime Hours

Despite there being little change in daily traffic noise levels, we expect that the most sensitive periods for nearby receivers are likely to be those outside of the core daytime hours, so the early morning, evening and during the night.

We understand that there will be relatively low numbers of heavy vehicles outside of normal daytime operating hours, and that vehicles will be prohibited from using smaller local roads at night (e.g. Dawsons, Curraghs). As such, we expect that all night-time traffic will travel via SH1.

As there are low numbers of both heavy quarry traffic and existing vehicle movements on these local roads outside of daytime hours, it is more appropriate to consider noise levels on an hourly basis, rather than as daytime averages (as is normally the case with traffic noise). Furthermore, the CRTN calculation method discussed above is not appropriate for roads with low traffic volumes.

We have calculated noise levels for some key examples to consider what the potential impacts of traffic noise might be at these times. These are discussed in the following sections, but generally we find there will be little increase.

#### 10.3.1 Dawsons Road

The dwelling at 4 Dawsons Road is the closest to the truck route to and from SH1. This location will receive noise from traffic both Dawsons Road and SH1.

We have calculated the worst-case change in noise level, where the highest assumed night-time activity level – 40 quarry trucks per hour – coincides with the quietest night-time period between 0200 and 0300 hrs.

Based on a truck noise level of 86 dB $L_{Aeq}$ at 10 metres (Table 15), and assuming a 10 dB reduction from the boundary fence, the property will receive approximately:

- 50 dB $L_{Aeq(1 hr)}$ from existing traffic
- 54 dB $L_{Aeq(1 hr)}$ with quarry traffic
10.3.2 Jones Road

We have also considered noise from a small number of trucks utilising Jones Road (west of Curraghs) during the night. Although, the portion of daytime quarry traffic on this route is only 4%, we have conservatively assumed 10% of the 40 trucks at night – so 4 truck movements per hour.

The closest dwellings appear to be set back around 30 metres from Jones Road, at which the calculated noise levels are:

- 53 dB $L_{Aeq}(1\text{ hr})$ from existing traffic
- 55 dB $L_{Aeq}(1\text{ hr})$ with quarry traffic

10.3.3 Curraghs Road

Although heavy traffic movements will not be permitted up smaller roads during the night, we note that the ‘daytime’ movements can occur from 0600 hrs, which is still considered as ‘night’ in the District Plan and, moreover, occupants of dwellings may still be in bed at this time.

Figure 10 shows that traffic volumes on Maddisons Road are reasonably elevated by 0600 hrs, compared to earlier in the night.

Based on a conservative assumption of 4 quarry trucks per hour, the noise levels received at 153 Curraghs Road are:

- 56 dB $L_{Aeq}(1\text{ hr})$ from existing traffic
- 57 dB $L_{Aeq}(1\text{ hr})$ with quarry traffic

10.3.4 Maximum Noise Levels

For road traffic noise received at dwellings during the night, the maximum ($L_{max}$) noise levels received are of critical importance. This parameter can be considered a more reliable measure of potential noise effects for low flow roads, where averaging could potentially disguise noise effects in some cases.

We typically expect that maximum noise levels from trucks will be below 70 dB $L_{max}$ beyond a distance of around 20 metres from the road. Some dwellings are closer to roads than this and already receive high maximum noise levels from passing vehicles. For example, our short-term measurement position at 300 Maddisons Road (position 2 in Figure 6) is a similar distance from the road to the dwelling at 370 Maddisons Road. Maximum noise levels measured here ranged between 82 and 88 dB $L_{max}$. 
It is important to note that the maximum noise level from a passing truck associated with the proposed quarry will be indistinguishable from other heavy traffic on the road. As there are so few proposed quarry truck movements on local roads during the night or early-morning periods, there will not be any notable increase in the frequency of maximum ($L_{max}$) noise events.

10.4 Assessment of Traffic Noise

Based on the analysis presented in the preceding sections, there are no significant indications that adverse noise effects are likely to arise as a result of the additional traffic associated with the quarry. During the day, the relatively high levels of traffic on both SH1 and local roads, compared with the proposed quarry traffic, is sufficiently high that there will not be any perceptible increase in road traffic noise levels.

Despite the greater sensitivity to noise at night, our calculations show that there is still little increase in traffic noise when assessed during the worst hour (i.e. quietest hour during the night). The early onset of daily traffic movements during the early-morning period approaching the peak hour means that there is effectively a “daytime” level of sound masking for noise from the activity from other existing sources.

In general, we consider there to be a low likelihood of adverse noise effects arising due to the quarry’s proposed traffic movements.
11.0 QUARRY TRAFFIC ON PUBLIC ROADS – VIBRATION

Our experience with similar quarrying and mining projects is that vibration generated by trucks associated with the activity using the public road network does not result in any different level of effects to the traffic otherwise using those roads.

In particular we note that the majority of vehicle movements associated with the proposed quarry will travel via SH1, with few movements occurring on smaller local roads. However, we are aware that vibration from trucks has been raised as a concern by residents near proposed quarries and as such have undertaken a review of the situation.

There are no local or national criteria that govern vibration from road traffic. The most appropriate measure of effect is therefore to consider the level of change and perceptibility that receivers may experience. The construction vibration criteria discussed in Section 9.1 provide guidance on how vibration in general is received, particularly in residential environments.

In order to quantify the levels of vibration likely to be experienced, we have undertaken a series of measurements to determine:

- Typical levels generated by heavy vehicles and quarry trucks;
- Existing levels of vibration present in the environment around the application site.

The results of these measurements are detailed in the following section.

11.1 Vibration Survey Results

11.1.1 Heavy Vehicle Vibration Measurements

We have surveyed vibration from heavy vehicles on Pound Road and Miners Road in Christchurch. These roads carry a high level of quarry traffic, some of which is associated with some of Fulton Hogan’s other quarrying operations. The results are shown in Figure 24 below.

Figure 24: Heavy traffic vibration measurements on local roads

Note measurement distance is from road centreline.
The data above shows that recorded vibration from all types of heavy vehicles generally remained below 0.5 mm/s (with one exception at around 0.6 mm/s) at all measurement distances. This information was recorded outside at the road verge in free-field conditions. Further details on the survey instrumentation is provided in Appendix D2.

11.1.2 Existing Ambient Vibration Measurements

Following the heavy vehicle surveys detailed above, we replicated the measurement exercise on Maddisons Road, near the application site. This location was surveyed on two occasions to account for any variety in traffic patterns. The combined results of these surveys are shown in Figure 25.

Figure 25: Traffic vibration measurements on Maddisons Road (near Curraghs Road)

The results are broadly in line with those presented for heavy vehicles in Figure 24 in that vibration remained below 0.5 mm/s, other than in three instances. As might be expected, the upper levels of vibration from quarry trucks and other heavy vehicles is marginally above that from cars, albeit not significantly so.

11.2 Traffic Vibration Analysis

From comparing the data above, it is clear that vibration from quarry trucks is similar to that from all other road traffic and generally remain at very low levels.

The bulk of vibration events measured from all types of vehicle in all locations fall below 0.3 mm/s, which is notable as the typical threshold of perceptibility for vibration in residential environments given in BS 5228-2 (see Table 23).

Some vibration events from heavy vehicles were measured up to a maximum of 0.6 mm/s, which we note is comfortably below the 1 mm/s value that BS 5228-2 suggests may cause complaints.

Furthermore, in typical single storey dwellings there is generally a reduction in vibration transfer from the ground to the foundation and then a further decrease from the foundation in to the remainder of the building.

Where any quarry traffic does utilise local roads and pass close to dwellings, the vibration generated will be indistinguishable from that generated by any other heavy traffic (there was no significant
statistical difference between quarry traffic and other heavy vehicles in our measurements). As such we do not expect that any adverse effects will occur, noting that there are no regular traffic routes associated with the quarry that consistently rely on smaller roads, although these may be used from time-to-time.
### 12.0 ASSESSMENT SUMMARY AND CONCLUSIONS

Our assessment of the proposed quarry has considered a wide number of factors. Table 28 below summarises the key parts of the discussion provided in this report.

**Table 28: Assessment summary remarks**

<table>
<thead>
<tr>
<th>Assessment factor</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient noise levels and existing environment</td>
<td>Ambient noise levels governed by transport noise (road, rail and air). Levels near Maddisons Road vary between approx. 50 dB $L_{Aeq}$ daytime and 35-45 dB $L_{Aeq}$ night-time, while levels near SH1 are above 65 dB $L_{Aeq}$ during the day and above 55 dB $L_{Aeq}$ at night. Wind direction does not significantly influence the ambient noise levels received in the area. Levels of ambient noise from road traffic will not change appreciably once CSM2 is operational.</td>
</tr>
<tr>
<td>Operational noise &amp; vibration</td>
<td>Noise emissions from the quarry will exceed the Selwyn District Plan noise standards (due to daytime activity occurring in the ‘night-time’ period). However, noise from the quarry will achieve our recommended project assessment criteria for day, evening and night. Noise effects from quarry noise will therefore be acceptable for adjacent noise-sensitive receivers. Vibration from the site may be perceptible on occasion for the closest receivers, but levels will remain low and the effects will be acceptable.</td>
</tr>
<tr>
<td>Construction noise &amp; vibration</td>
<td>For most receivers, large distances to site mean that compliance with standard construction criteria (NZS 6803) is easily achieved. Some notable short-term elevated levels during bund construction on boundary of nearest dwelling.</td>
</tr>
<tr>
<td>Additional heavy road traffic</td>
<td>Over 90% of the quarry traffic will travel via SH1. However, road traffic noise levels from this road will not increase, despite this. Minimal noise level increases on local roads could occur if trucks used minor roads at night – although our assessment demonstrates that up to 4 movements per hour at night will result in acceptable effects. Vibration from quarry trucks will be consistent with that from other heavy traffic and will generally remain low. Vibration will be imperceptible for all receivers not immediately adjacent to roads.</td>
</tr>
</tbody>
</table>

On the basis of the discussion in this report, summarised in Table 28 above, we expect that noise and vibration emissions associated with the quarry will be acceptable in the local environment, and that no significant adverse effects will occur.

Fulton Hogan have demonstrated that they are committed to adopting the best practicable option in the design and operation of the proposed quarry. There is a need for effective management and adherence to any restrictions voluntarily adopted to ensure that noise effects remain consistent with the operational methodology assessed in this report.

To provide further certainty in this regard, we have made a number of recommendations throughout this report, which can be adopted as appropriately worded conditions of consent. Suggested wording for conditions are provided in the following section to assist the consenting process.
13.0 RECOMMENDATIONS

In order to ensure acceptable noise effects at nearest residents, we have provided the following suggested text that may be drafted into conditions of consent:

1. The consent holder shall ensure that all activities on the site, measured in accordance with the provisions of NZS 6801:2008 “Acoustics – Measurement of environmental sound”, and assessed in accordance with NZS 6802:2008 “Acoustics - Environmental Noise”, shall not exceed the following noise limits beyond the boundary of the site, during the following times:

   - Daytime 0600 to 1800 hrs 55 dB $\text{L}_{\text{Aeq}}$
   - Evening 1800 to 2200 hrs 50 dB $\text{L}_{\text{Aeq}}$
   - Night 2200 to 0600 hrs 45 dB $\text{L}_{\text{Aeq}}$ and 70 dB $\text{L}_{\text{Amax}}$

2. In order to permit vehicle access onto the site, the noise limits in Item 1 shall not apply within 300 metres of any site entrance.

3. Construction activities including topsoil stripping, bund construction and site rehabilitation, shall be conducted in accordance with NZS 6803:1999 “Acoustics - Construction Noise”, and shall comply with the “typical duration” noise limits contained within Table 2 of that Standard.

4. Should vehicle reversing alarms be required, only broadband noise alarms are to be used. Tonal reversing alarms are not permitted.
APPENDIX A  GLOSSARY OF TERMINOLOGY

Ambient  The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.

Background Sound  See $L_{A90(t)}$

$dB$  Decibel - the unit of sound level. Expressed as a logarithmic ratio of sound pressure $P$ relative to a reference pressure of $Pr=20 \mu$Pa i.e. $dB = 20 \times \log(P/Pr)$

$dB_{A}$  The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.

Frequency  The number of pressure fluctuation cycles per second of a sound wave. Measured in units of Hertz (Hz).

Hertz (Hz)  Hertz is the unit of frequency. One hertz is one cycle per second. One thousand hertz is a kilohertz (kHz).

Impulsive Sound  Transient sound having a peak level of short duration, typically less than 100 milliseconds

$L_{A10(t)}$  The A-weighted noise level equalled or exceeded for 10% of the measurement period. This is commonly referred to as the average maximum noise level.

The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.

$L_{A90(t)}$  The A-weighted noise level equalled or exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.

$L_{A_{eq}(t)}$  The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level.

$L_{A_{max}}$  The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.

$L_{dn}$  The day night noise level which is calculated from the 24 hour $L_{A_{eq}}$ with a 10 dB penalty applied to the night-time (2200-0700 hours) $L_{A_{eq}}$.

Masking Noise  Intentional background noise that is not disturbing, but due to its presence causes other unwanted noises to be less intelligible, noticeable and distracting.

Notional Boundary  A line 20 m from any side of a rural dwelling, or the legal boundary where this is closer to the dwelling.


<table>
<thead>
<tr>
<th><strong>Octave Band</strong></th>
<th>A range of frequencies where the highest frequency included is twice the lowest frequency. Octave bands are referred to by their logarithmic centre frequencies, these being 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz for the audible range of sound.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PPV</strong></td>
<td><strong>Peak Particle Velocity.</strong> For Peak Particle Velocity (PPV) is the measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment.</td>
</tr>
<tr>
<td><strong>Rating level (L_a)</strong></td>
<td>A derived level used for comparison with a noise limit</td>
</tr>
<tr>
<td><strong>SEL or L_{AE}</strong></td>
<td><strong>Sound Exposure Level.</strong> The sound level of one second duration which has the same amount of energy as the actual noise event measured. Usually used to measure the sound energy of a particular event, such as a train pass-by or an aircraft flyover</td>
</tr>
<tr>
<td><strong>Special Audible Characteristics (SAC)</strong></td>
<td>Distinctive characteristics of a sound which are likely to subjectively cause adverse community response at lower levels than a sound without such characteristics. Examples are tonality (e.g. a hum or a whine) and impulsiveness (e.g. bangs or thumps).</td>
</tr>
<tr>
<td><strong>SPL or L_p</strong></td>
<td><strong>Sound Pressure Level.</strong> A logarithmic ratio of a sound pressure measured at distance, relative to the threshold of hearing (20 µPa RMS) and expressed in decibels.</td>
</tr>
<tr>
<td><strong>SWL or L_w</strong></td>
<td><strong>Sound Power Level.</strong> A logarithmic ratio of the acoustic power output of a source relative to $10^{-12}$ watts and expressed in decibels. Sound power level is calculated from measured sound pressure levels and represents the level of total sound power radiated by a sound source.</td>
</tr>
</tbody>
</table>
APPENDIX B  QUARRY TRAFFIC DISTRIBUTION MAP

Distribution map for “Maximum Day” traffic, from Stantec’s ITA. Note that the relative proportion of traffic movements are the same for their “Median Day” scenario.
APPENDIX C  CHRISTCHURCH AIRPORT NOISE CONTOURS

The aircraft noise contours (excluding on-aircraft engine testing) in the vicinity of the site are shown below.
## APPENDIX D  SURVEY DETAILS

### D1  Noise Measurements

The key details of the attended noise surveys are as follows:

<table>
<thead>
<tr>
<th>Survey Reference</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D &amp; E</th>
<th>F</th>
</tr>
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<tbody>
<tr>
<td>Date</td>
<td>27 Feb</td>
<td>1 Mar</td>
<td>5 Mar</td>
<td>17 Mar</td>
<td>20 Mar</td>
</tr>
<tr>
<td>Time Period, hrs</td>
<td>1100 - 1230</td>
<td>0130 - 0330</td>
<td>1130 - 1300</td>
<td>0400 - 0545</td>
<td>0600 - 0730</td>
</tr>
<tr>
<td>Personnel</td>
<td>Gary Walton</td>
<td>Gary Walton</td>
<td>Gary Walton Alex West</td>
<td>Gary Walton</td>
<td>Gary Walton</td>
</tr>
<tr>
<td>Model</td>
<td>Brüel &amp; Kjær Type 2250</td>
<td>Brüel &amp; Kjær Type 2250</td>
<td>Brüel &amp; Kjær Type 2250</td>
<td>Brüel &amp; Kjær Type 2250</td>
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</tr>
<tr>
<td>Serial No.</td>
<td>2683036</td>
<td>2488377</td>
<td>A. 2683036 B. 2488377</td>
<td>2683036</td>
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<td>Calibration Due</td>
<td>04/10/2018</td>
<td>02/08/2018 A. 04/10/2018 B. 02/08/2018</td>
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<td>04/10/2018</td>
<td>04/10/2018</td>
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<tr>
<td>Model</td>
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<td>Brüel &amp; Kjær Type 4231</td>
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<td>1882775</td>
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<td>NE</td>
<td>SW</td>
<td>SW</td>
<td>NE</td>
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<tr>
<td>Wind Speed, m/s</td>
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<td>3 - 4</td>
<td>1 - 3</td>
<td>Approx. 1</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Cloud Cover</td>
<td>Overcast</td>
<td>Overcast</td>
<td>Overcast</td>
<td>Overcast</td>
<td>Clear</td>
</tr>
</tbody>
</table>

Field calibration of the equipment was carried out before all measurements, and the calibration checked after measurements. Observed change was less than 0.1 dB in all cases.
D2 Vibration Measurements

The key details of the equipment used in each of the vibration surveys are as follows:

**Instrumentation:** Instantel Minimate Pro6, serial MP12633, calibration due 23/02/2019
  - Instantel DIN 315 Hz triaxial geophone, serial SD12580, calibration due 23/02/2019
  - Instantel DIN 315 Hz triaxial geophone, serial SD12581, calibration due 23/02/2019

**Sensor Location:** On road verge, coupled with ground spikes and covered with a sandbag

**Configuration:** 2 second histogram recording

**Sensor Check:** Field sensor checks were performed before commencement of monitoring and rechecked after monitoring was concluded. All sensor checks were completed successfully.
APPENDIX E  NOISE LOGGER DATA

E1  Time History Graph
### E3 Weather Data Table

All data other than wind direction obtained from weather history for Christchurch International (NZCH) on Weather Underground, available from:

www.wunderground.com/history/airport/NZCH/

Wind direction based on manual interpretation of Weather Underground history chart (Figure 8) and daily recorded observations from Meteorological Service of New Zealand (MetService).

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp., °C</th>
<th>Humidity, %</th>
<th>Pressure, hPa</th>
<th>Wind, m/s</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
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APPENDIX F  TRAFFIC DATA

The plots below show average hourly data for each of the key local roads, based on our statistical analysis of traffic count data provided to us by Stantec. Data for State Highway 1 sourced from NZTA.