MARSHALL DAY Acoustics

# NEW DUNEDIN HOSPITAL: DEMOLITION NOISE AND VIBRATION ASSESSMENT (CADBURY'S BLOCK)

Rp 004 R02 20190708 | 23 July 2020

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Project: **NEW DUNEDIN HOSPITAL: DEMOLITION**

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# EXECUTIVE SUMMARY

We have undertaken an assessment of noise and vibration associated with demolition works required for the New Dunedin Hospital project (NDH). This report specifically focusses on above-ground demolition of the **'Cadbury's Block'** (except the associated warehouse structure).

Our assessment is summarised in this report and we have focussed on:

- Noise emissions in relation to the New Zealand construction noise standard, NZS 6803:1999;
- Provisions relating to construction noise in the proposed (2GP) Dunedin City District Plan; and
- Vibration emissions in relation to both the District Plan requirements and international guidance commonly used to assess construction vibration in New Zealand.

Our calculations indicate that the construction noise limits given in Rule 4.5.4.1 of the proposed Dunedin City District Plan (2GP) will be exceeded at times. As predicted noise levels are more than 5 dB above the permitted performance standard, the activity will have **non-complying status with regard to noise**.

The District Plan construction noise limits are based on the guidance given in NZS 6803:1999. This Standard provides further guidance on the appropriate management and mitigation of construction noise, which is also of relevance to demolition activities. This Standard notes that, "noise from construction is generally of limited duration, [so] communities will usually tolerate a higher noise level provided it is no louder than necessary".

Our assessment shows that the noise limits will be exceeded in a few instances when demolition works occur at the boundaries of the Cadbury Block. We note that one instance of elevated noise levels is anticipated as a result of cumulative effects, as detailed in Table 12.

We also note that the existing noise environment in the area is already relatively high, principally due to road traffic noise levels from SH1. **Ambient noise levels are above the daytime 70 dB $L_{Aeq}$ criterion**, hence exceeding this limit by a small margin will not necessarily result in adverse effects. NZS 6803 notes that "the high background level may warrant less stringent noise limits than those recommended", but the District Plan does not allow for any adjustment of the noise limits.

Specific focus has been given to the Otago Daily Times (ODT) building at 260 Cumberland St, which is the only receiver that directly adjoins the worksite. The existing Cadbury's structures will provide some screening to this building while they remain in place. Even when demolition of the closest structures commences, internal noise levels within the ODT offices are expected to be below 50 dB $L_{Aeq}$, which is the limit given in NZS 6803. However, a small number of high risk activities may elevate internal levels beyond this and specific management and controls will be required for these works (e.g. party wall works).

Overall, we consider that the noise and vibration levels at all receivers will be generally reasonable, subject to the suitable implementation of a Noise and Vibration Management Plan (NVMP) for the NDH project as a whole. The NVMP should outline the Best Practicable Option (BPO) measures to mitigate construction noise and vibration.

Most receivers are set back by at least the width of the road corridor from the works. We expect that vibration levels will comply with the relevant criteria beyond 30 metres from any works. Vibration risks can therefore comfortably be managed within the scope of the NVMP, which will facilitate the monitoring of demolition effects and, with a particular focus on adjacent heritage structures. Specific monitoring is also likely to be required for the ODT building, which is well within 30 metres of the closest works.

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## 1.0 INTRODUCTION

Marshall Day Acoustics (MDA) has been engaged by the Ministry of Health (MoH) to assess noise and vibration arising from the clearance of land required for the New Dunedin Hospital project (NDH).

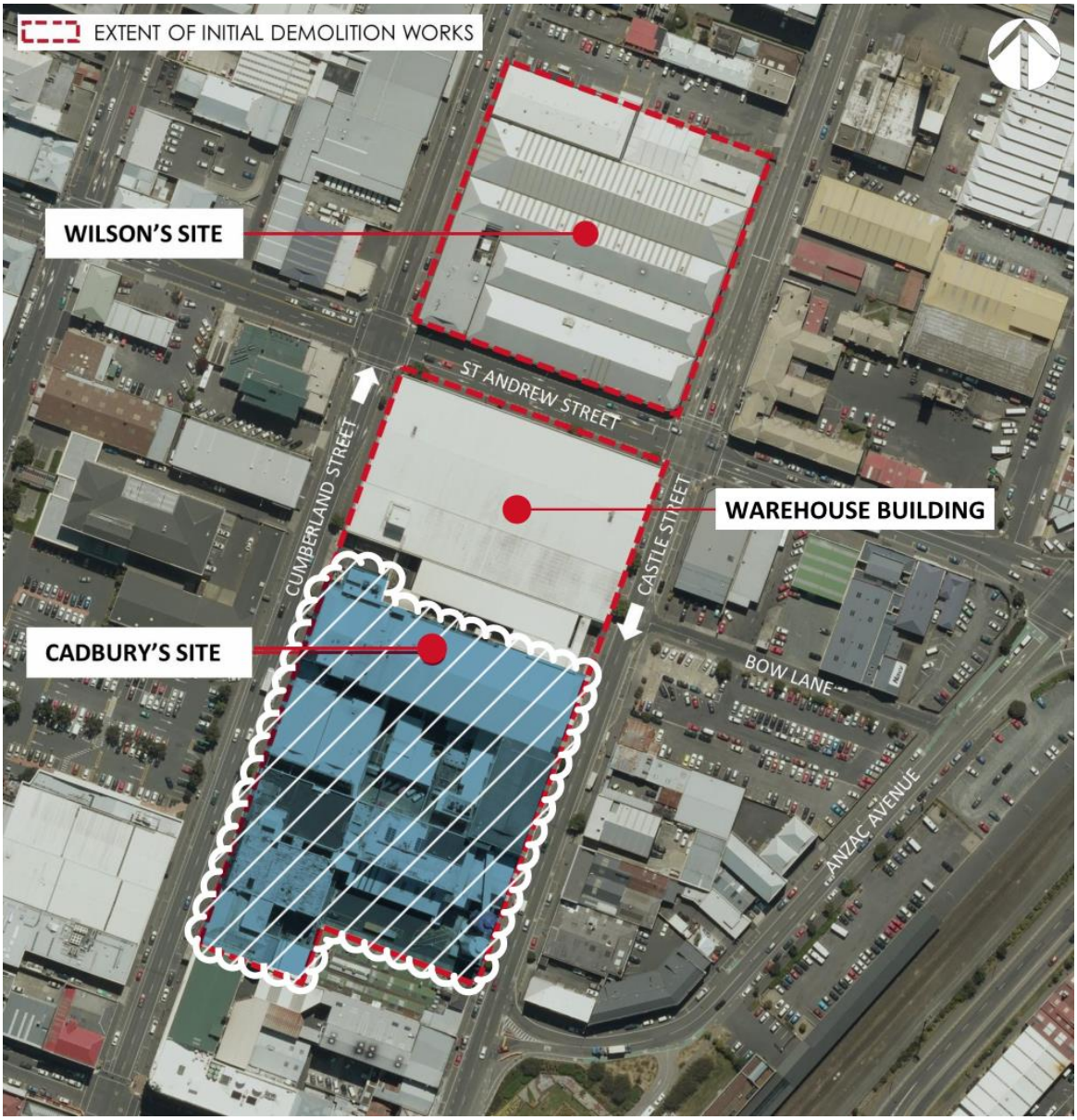
This report covers above-ground demolition of the remainder of the **'Cadbury's Block'**, aside from the separately-consented deconstruction of the associated warehouse building. While the NDH project will occur across two large blocks of land within the CBD (as shown in Figure 1 below), the resource consent for demolition will be split into distinct packages.

We have only focussed on the initial site clearance and demolition phase of the project; effects associated with future construction and operation are beyond the scope of this report.

Our assessment provides an indication of compliance in respect of the applicable District Plan noise and vibration limits, and assesses the effects on surrounding activities. We have also developed a framework for the management of demolition noise and vibration in the form of a draft Noise and Vibration Management Plan, which is intended to assist in minimising potential adverse effects.

Appendix A contains a glossary of acoustical terminology used in this report.

**Figure 1: Overview of project and proposed demolition areas**



## 2.0 RELEVANT PERFORMANCE STANDARDS

The performance standards for noise and vibration arising from demolition activities are provided in the District Plan, with reference to other national and international standards. These are summarised in the following sections.

For the purpose of this report, we have used the broader description of 'construction' to apply to demolition activities, as the types of equipment used and means to assess effects are similar.

### 2.1 Dunedin City District Plan

We understand that the rules in the proposed 2GP now have legal effect (as of November 2018) and that the relevant rules are not subject to appeal.

Under the proposed 2GP, the application site falls under the CEC North Zone, while the land to the east and west is zoned as Industrial and Central Business District, respectively.

Rules for construction noise and vibration are provided under Rule 4 – Temporary Activities. Rule 4.3.1.2 provides that construction activity has 'permitted status' is if meets the performance standard for noise, given at Rule 4.5.4.1. These standards reflect the NZS 6803:1999 criteria, which are discussed below in Section 2.2.

We note that the permitted status under Rules 4.3.1.2 and 4.5.4.1 is only dependant on noise and not vibration. Rule 4.5.4.1 provides that:

- Exceeding the noise performance standards by <5 dB results in discretionary status;
- Exceeding the noise performance standards by ≥5 dB results in non-complying status;
- However, the rule is silent on the implications of contravening the construction vibration limits.

Regarding vibration, clause (b) specifies that, *"vibration from construction must not exceed a maximum particle velocity measured on any foundation of an adjacent building on another site, or the same site if different ownership, of 25mm/second for commercial buildings or 10mm/second for buildings housing noise sensitive activities".*

Rule 4.5.4.2 relates to hours of operation and specifies that 'temporary events' must not exceed certain hours. This rule does not apply to construction noise, for which time periods are provided in Rule 4.5.4.1.

### 2.2 NZS 6803:1999

New Zealand Standard NZS 6803:1999 "*Acoustics - Construction Noise*" is directly applicable to this project and provides both recommended noise limits and a range of noise management measures intended to reduce noise effects as far as practical.

Separate noise limits are provided for residential and commercial receivers in recognition of their different sensitivity to noise. The recommended upper noise limits from NZS 6803 are provided in Table 1 and Table 2. The noise limits apply at 1m from external façades of occupied buildings.

**Table 1: NZS 6803 recommended upper limits for construction noise received in residential zones and dwellings in rural areas**

| Time of week | Time period | Typical duration | | Short-term duration | | Long-term duration | |
|---|---|---|---|---|---|---|---|
| | | dB $L_{Aeq}$ | $L_{AFmax}$ | dB $L_{Aeq}$ | $L_{AFmax}$ | dB $L_{Aeq}$ | $L_{AFmax}$ |
| Weekdays | 0630 – 0730 | 60 | 75 | 65 | 75 | 55 | 75 |
| | 0730 – 1800 | 75 | 90 | 80 | 95 | 70 | 85 |
| | 1800 – 2000 | 70 | 85 | 75 | 90 | 65 | 80 |
| | 2000 – 0630 | 45 | 75 | 45 | 75 | 45 | 75 |
| Saturdays | 0730 – 1800 | 75 | 90 | 80 | 95 | 70 | 85 |
| | 1800 – 0630 | 45 | 75 | 45 | 75 | 45 | 75 |
| Sundays and public holidays | 0730 – 1800 | 55 | 85 | 55 | 85 | 55 | 85 |
| | 1800 – 0630 | 45 | 75 | 45 | 75 | 45 | 75 |

*Duration: Typical – Construction work at any one location for more than 14 calendar days but less than 20 weeks*
*Short-term – Construction work at any one location for up to 14 calendar days*
*Long-term – Construction work at any one location with a duration exceeding 20 weeks*

**Table 2: NZS 6803 recommended upper limits for construction noise received in commercial areas for all days of the year[1]**

| Time of week | Time period | Typical duration | Short-term duration | Long-term duration |
|---|---|---|---|---|
| | | dB $L_{Aeq}$ | dB $L_{Aeq}$ | dB $L_{Aeq}$ |
| All days | 0730 – 1800 | 75 | 80 | 70 |
| | 1800 – 0730 | 80 | 85 | 75 |

Notes in the Standard to the tables above:

1. *"The night time limits in Table 2 shall apply to activities carried out in industrial or commercial areas where it is necessary to prevent sleep interference, specifically where there are residential activities, hospitals, hotels, hostels, or other accommodation facilities located within commercial areas. The limits in Table 2 may also be used to protect other specific noise sensitive activities at certain hours of the day."* [NZS 6803:1999 Note 7.2.5]
2. *"One major factor which should be considered is whether there is a relatively high background sound level (L90) due to noise from sources other than construction work at the location under investigation. In such cases limits should be based on a determination of the existing level of noise in the area (a "background plus" approach)."* [NZS 6803:1999 Note 7.2.6]

With regard to the last note, the Standard states at C7.2.6 that:

> *"In urban areas, traffic noise may control the background sound level at relatively high levels, for example 60 dBA $L_{90}$. In such circumstances, the high background level may warrant less stringent noise limits than those recommended in* [the tables above]*."*

[1] The District Plan (2GP) additionally applies the Table 2 limits to: *"… Port and commercial and mixed use zones"*.

## 2.3 Discussion of Noise Criteria

### 2.3.1 Land Use and Zoning

For this project the receiving environment is commercial and mixed use in nature and therefore the commercial area noise limits from Table 2 apply under Rule 4.5.4.1 a.ii. However, we note that the presence of dwellings within the mixed use areas means that the more stringent Table 1 noise limits should apply to these properties.

We consider this appropriate as, whilst the receiving environment around the site is generally commercial in nature, several properties have a residential function (e.g. dwellings or visitor accommodation) and it is appropriate to provide appropriate protection of sleep at night. Higher night-time noise limits would otherwise be appropriate for an exclusively commercial area, as most buildings will not be occupied at night.

### 2.3.2 Application of NZS 6803:1999

*Numerical Limits*

Considering the anticipated demolition timeframes of the overall NDH project, we recommend that the NZS 6803 long-term noise criteria be adopted in this instance. To best manage noise effects:

- The Table 1 noise limits should apply to any site with a residential function; and
- The Table 2 noise limits should apply to any other occupied site.

For long-term duration projects, the core daytime noise limits are the same for residential and commercial areas – 70 dB $L_{Aeq}$. However, if works occur at night or during the early morning or late evening, then the residential and commercial limits would differ. For this reason, it is important to note the type of occupancy of a receiving building and apply the correct limits accordingly.

*Background Noise Levels*

We note that the existing background noise levels are already elevated in this area due to traffic noise (discussed further in Section 3.1.1). However, while NZS 6803 provides for less stringent noise limits in such cases, the District Plan does not provide any mechanism by which the applicable noise limits can be adjusted accordingly. As such, we have not made any recommendations in this regard.

Although we anticipate that construction activities will mostly be able to comply with the NZS 6803 limits, there are likely to be occasions when the limits are exceeded. For example, this may occur when work is occurring at the edge of the site, directly opposite a receiver with no screening.

In respect of noise, this will make the activity either discretionary or non-complying under the District Plan (2GP), depending on the magnitude of the difference. Despite this, provision C7.2.6 of the Standard is a positive indication that potential adverse noise effects would be limited due to the existing noise environment.

### 2.3.3 Cumulative Noise

It is also important to be mindful of cumulative noise effects from other areas of the project. The demolition phases will overlap at times so, although the whole demolition scope will be split into separate consenting packages, noise effects can occur on a global basis and it is the long-term nature of the overall project that must be considered against the NZS 6803 criteria.

## 2.4 Vibration Performance Standards

As discussed above, the District Plan (2GP) provides the following vibration assessment criteria:

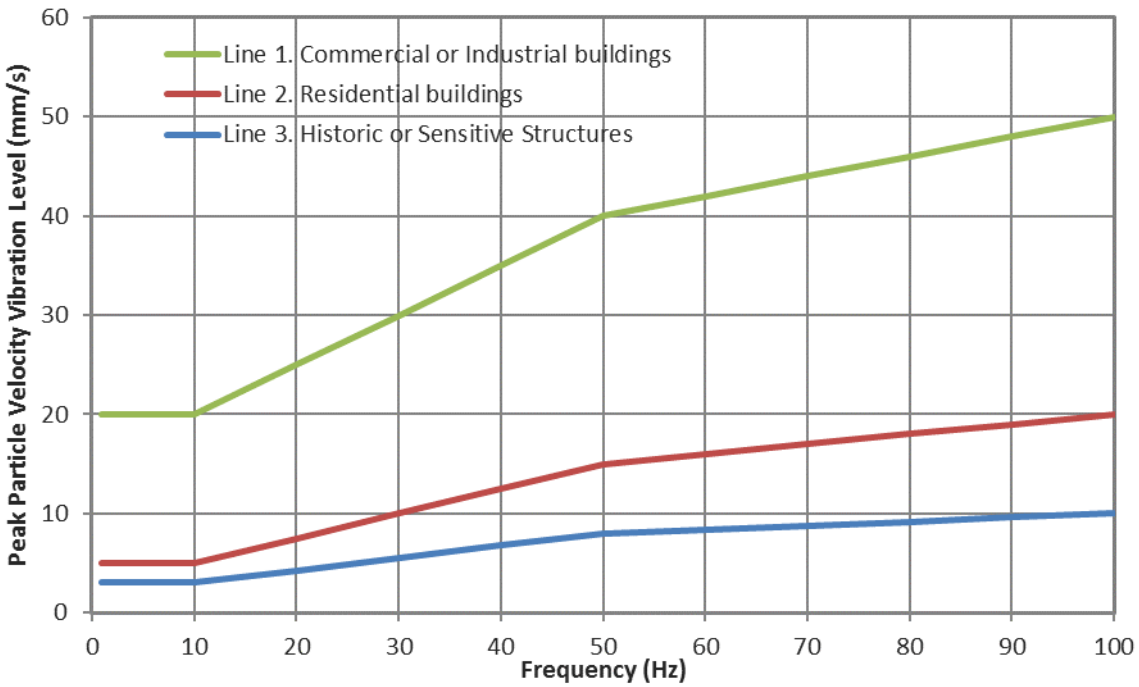
**Table 3: Vibration performance standards from Rule 4.5.4.1 (b) of the District Plan (2GP)**

| Receiver Type | Vibration Limit (mm/s PPV) |
|---|---|
| Buildings housing noise sensitive activities[2] | 10 |
| Commercial buildings | 25 |

Construction and demolition work that potentially affects the structure of buildings is normally assessed in New Zealand to the vibration guidelines in German Standard DIN 4150-3:2016 *"Vibration in buildings – Part 3: Effects on structures"*. These guideline values are intended to ensure that material vibration damage to structures does not occur. The short-term (transient)[3] vibration limits in Figure 2 and Table 4 overleaf apply at building foundations. The vibration limits in all other cases are summarised in Table 5.

The criteria relate to the avoidance of cosmetic building damage, such as cracking in paint or plasterwork. Cosmetic building damage effects are deemed 'minor damage' in the Standard and can generally be easily repaired. The cosmetic building damage thresholds are much lower those that would result in structural damage. The Standard states: *" Experience shows that **no** damage due to vibration adversely affecting serviceability … will occur if these guideline values are complied with"*.

**Figure 2: Short-term (transient)[3] vibration at building foundations (DIN 4150-3:2016, Figure 1)**




[2] Noise sensitive activities are defined in the 2GP as: *"Activities where people are more likely to be sensitive to a high level of noise because they are sleeping, studying, seeking medical treatment, or engaged in religious activity"*.

[3] Short-term (transient) vibration is defined in DIN 4150-3:2016 "*vibration that does not occur often enough to cause material fatigue and whose development over time and duration is not suitable for producing a significant increase in vibration due to resonance in the particular structure*".

**Table 4: Short-term (transient)[3] vibration limits (DIN 4150-3:2016, Table 1)**

| Structure Type | Peak Particle Velocity (PPV) Vibration Level (mm/s) | | | | |
|---|---|---|---|---|---|
| | Foundation, all directions | | | Topmost floor, horizontal direction | Floor slab, vertical direction |
| | 1-10 Hz | 10-50 Hz | 50-100 Hz | All frequencies | All frequencies |
| Commercial or Industrial buildings | 20 | 20 to 40 | 40 to 50 | 40 | 20 |
| Residential buildings | 5 | 5 to 15 | 15 to 20 | 15 | 20 |
| Historic or Sensitive Structures | 3 | 3 to 8 | 8 to 10 | 8 | 20 |

**Table 5: Long-term[4] vibration limits (DIN 4150-3:2016, Table 4)**

| Structure Type | Peak Particle Velocity (PPV) Vibration Level (mm/s) | |
|---|---|---|
| | Topmost floor, horizontal direction | Floor slab, vertical direction |
| Commercial or Industrial buildings | 40 | 10 |
| Residential buildings | 15 | 5 |
| Historic or Sensitive Structures | 8 | 2.5 |

We note that the District Plan (2GP) vibration limits (Table 3) are much less restrictive then the guidance given in DIN 4150-3:2016. However, for comparison, we also note similar guidance is given in British Standard BS 5228-2:2009 *"Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration"*, as shown in Table 6 below.

**Table 6: Transient vibration guide values for cosmetic damage (BS 5228-2:2009, Table B.2)**

| Structure Type | Peak Particle Velocity (PPV) Vibration Level (mm/s) | |
|---|---|---|
| | 4 to 15 Hz | 15 Hz and above |
| Reinforced or framed structures<br>Industrial and heavy commercial buildings | 50 mm/s at 4 Hz and above | 50 mm/s at 4 Hz and above |
| Unreinforced or light framed structures<br>Residential or light commercial buildings | 15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz | 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above |

With respect to the criteria in Table 6, the Standard notes that:

> *"Minor damage is possible at vibration magnitudes which are greater than twice those given in* [Table 6]*, and major damage to a building structure can occur at values greater than four times the tabulated values. Definitions of the damage categories are presented in BS 7385-1:1990, 9.9.*
>
> *The guide values in* [Table 6] *relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due*

[4] Long-term (continuous) vibration is types not covered by the short-term vibration definition.

*to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in* [Table 6] *might need to be reduced by up to 50%".*

Lowering the BS 5228-2:2009 low frequency guidance (i.e. around 15 Hz) by 50% yields values consistent with the District Plan guidance in Table 3.

We recommend that the guidance in DIN 4150-3:2016 is followed as far as practicable. Where compliance with these values cannot be maintained, the criteria in the District Plan and BS 5228-2:2009 provide a suitable backstop that still ensures an adequate degree of protection.

# 3.0 ENVIRONMENTAL CONTEXT

## 3.1 Existing Environment

As shown previously in Figure 1, the NDH site is in a metropolitan area and hence immediately surrounded by a number of properties, including:

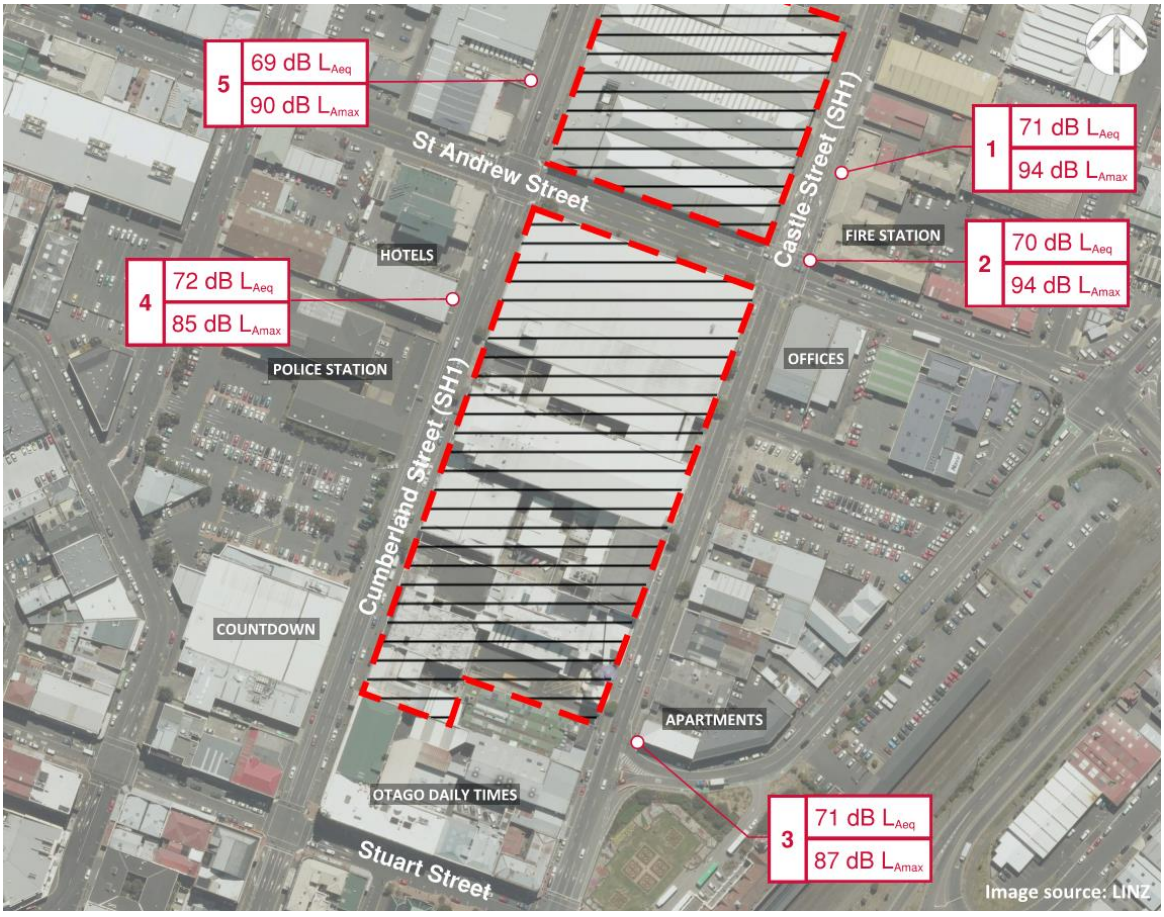
- Dunedin Police Station;
- Dunedin Central Fire Station (a heritage building);
- New World & Countdown Supermarkets;
- Apartments, hotels and mixed-use facilities;
- Miscellaneous industrial workshops and commercial premises; and
- The Otago Daily Times (ODT) Building (also heritage listed).

The existing noise environment in the area is generally governed by road traffic noise. State Highway 1 runs either side of the site on Cumberland and Castle Streets. Smaller east-west streets also carry reasonable levels of traffic (Hanover, St Andrew and Stuart Streets). We have surveyed existing traffic noise levels in the area in order to establish current levels of noise exposure.

### 3.1.1 Noise Surveys

We obtained noise measurements on 17 and 18 July 2019 at various locations around the application site. The results are summarised in Figure 3 below. Further details about the survey are provided in Appendix B. Measured background noise levels were broadly consistent between the positions and ranged from 58 to 63 dB $L_{A90}$ across all of the measurements.

**Figure 3: Summary of short-term noise monitoring results**



### 3.1.2 Traffic Analysis

The results of our short-term ambient noise monitoring indicate relatively consistent traffic noise levels in the vicinity of SH1. To better understand typical diurnal variance, we have analysed data on typical traffic volumes. We have focussed on the state highways, as these are the dominant roads.

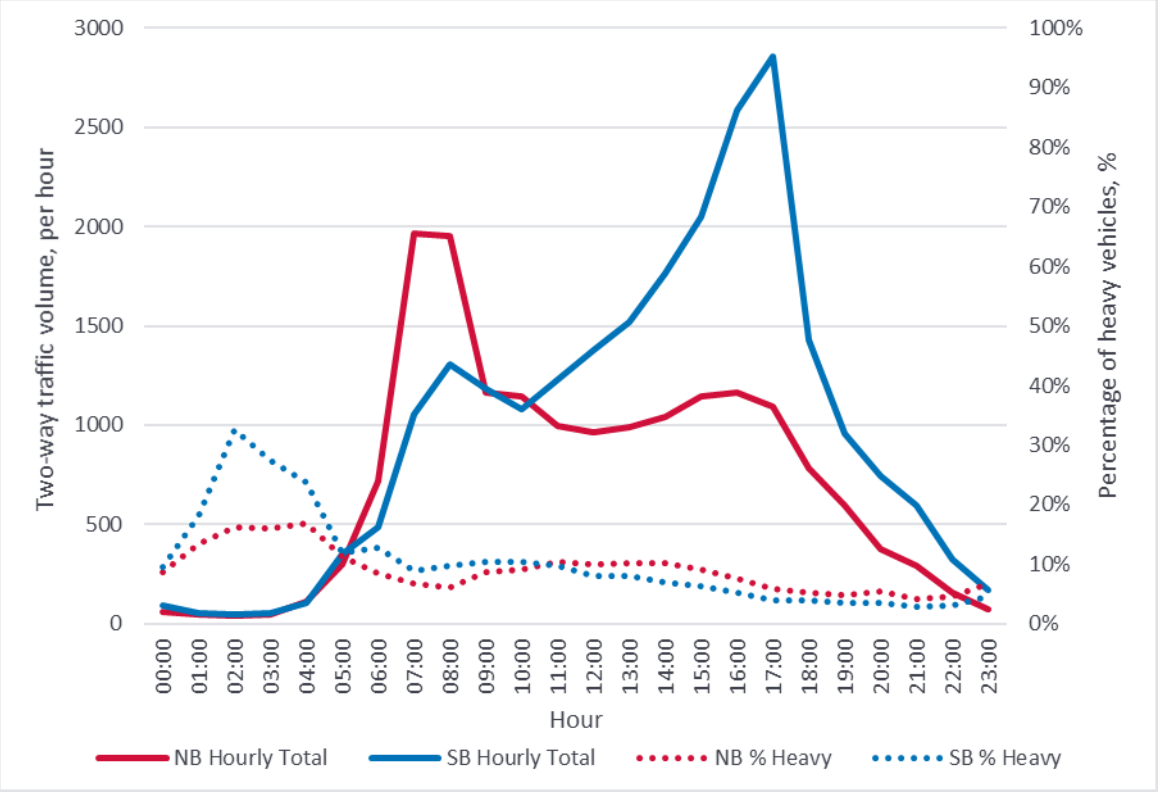
Table 7 summarises NZTA traffic count data from 2015 for SH1, just north of the application site (north of Hanover Street). Detailed publicly available data is limited for areas close to the site, but this provides an indication of the volume of daily traffic. Other public sources of information (e.g. Auckland Motorways' *Mobile Road*) also broadly indicate 15,000 vehicles per day each on Cumberland and Castle Streets.

**Table 7: Summary of 2015 NZTA average daily traffic count data for site 706**

| Metric | SH1 northbound (Cumberland St) | SH1 southbound (Castle St) |
|---|---|---|
| AADT | 14954 | 14906 |
| % Heavy Vehicles | 3 | 3 |

Figure 4 indicates the hourly distribution of traffic at the closest detailed telemetry site on SH1 in Burnside, south of the city. We assume the hourly profile will be similar in the CBD.

**Figure 4: Typical daily traffic profile (from NZTA telemetry site 63, 2018 data)**



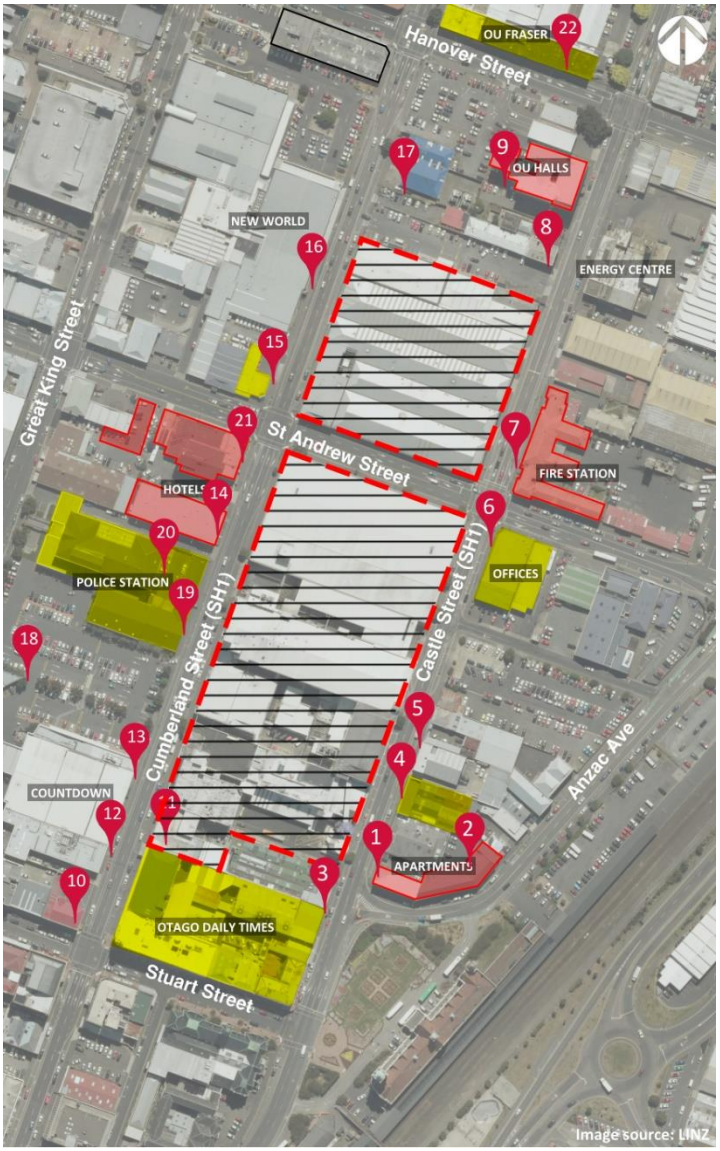

The daily profile above shows that there is minimal traffic throughout the quietest period of the night, with significant morning and evening peaks, relative to the normal daytime level.

Based on the traffic data above, we calculate that noise levels at the façades of buildings immediately fronting SH1 will be not less than 71 dB $L_{Aeq\,(24\,hr)}$. This is consistent with our short-term measured noise levels, which were broadly in the middle of the day, outside of peak times. During this period, we would expect a +0-2 dB correction to the 24 hour $L_{eq}$ to obtain the short-term, 1 hr, $L_{eq}$. During peak periods, the 1 hr level may be up to +1-2 dB higher again, while significantly lower at night.

## 3.2 Sensitive Receivers

We have analysed the adjacent buildings to establish how sensitive they may be to noise, which typically depends on the exact usage. Figure 5 below indicates the adjoining receivers we have identified, along with their address in the accompanying table. Red shaded buildings occupy residential-type use, while yellow shaded buildings are commercial offices or similar where a moderate level of noise sensitivity may be expected. Unshaded buildings are typically less-sensitive commercial or industrial premises.

**Figure 5: Noise sensitive receivers adjacent to the application site**




| ID | Address |
|---|---|
| 1 | 3 Anzac Ave (Apartments) |
| 2 | 5 Anzac Avenue (Apartments) |
| 3 | 12 Castle St |
| 4 | 53 Castle St |
| 5 | 61 Castle St |
| 6 | 83 Castle St |
| 7 | 85 Castle St (Fire Station) |
| 8 | 172 Castle St |
| 9 | 192 Castle St (OU Halls) |
| 10 | 70 Cumberland St |
| 11 | 260 Cumberland St (ODT) |
| 12 | 261 Cumberland St (Countdown)_S |
| 13 | 261 Cumberland St (Countdown)_N |
| 14 | 333 Cumberland St (Quest) |
| 15 | 359 Cumberland St |
| 16 | 371 Cumberland St (New World) |
| 17 | 420 Cumberland St |
| 18 | 1 Great King St |
| 19 | 25 Great King St (Police)_E |
| 20 | 25 Great King St (Police)_W |
| 21 | 137 St Andrew St (Victoria Hotel) |
| 22 | OU Fraser Building, Hanover St |

With regard to the noise limits discussed in Section 2.2, it is appropriate to apply the residential noise limits (Table 1) to red buildings and the commercial/mixed use limits (Table 2) to all other buildings.

We note that the Dunedin Central Fire Station is included as 'residential' as we understand that, in addition to its office facilities, the station has sleeping quarters and crews remain on site 24/7.

## 4.0 SITE CLEARANCE AND DEMOLITION METHODOLOGY

### 4.1 Overall Project Phasing

We understand that the demolition will likely progress from north to south within each block, with works likely to be undertaken simultaneously in each block if practicable.

The key portions of the works have been split into 10 buildings or groups, labelled A to I. We have further divided the large building areas into smaller source areas for the purpose of our noise generation calculations, but this is not presented below. Building J (the former Dairy building) is being retained as part of the NDH project.

We understand that the existing buildings are as follows (bold text highlights parts of this consent package). Specific details around the Cadbury's Block works are provided overleaf.

- Building A is a 2 storey masonry building, the site of which will form the Wilson's staging area;
- Buildings B and C are 1 storey masonry buildings;
- Buildings D and E are 2 storey masonry buildings;
- Building F is a large former Cadbury's storage warehouse, which will be the staging area for the Cadbury's block;
- **Building G is a 5 storey masonry building, previously Cadbury's manufacturing and packing;**
- **Building H, further subdivided into seven portions, consists of several different buildings from 1-4 storeys high, including two silos; and**
- **Building I was previously occupied by Cadbury World.**

**Figure 6: Indicative demolition staging plan**

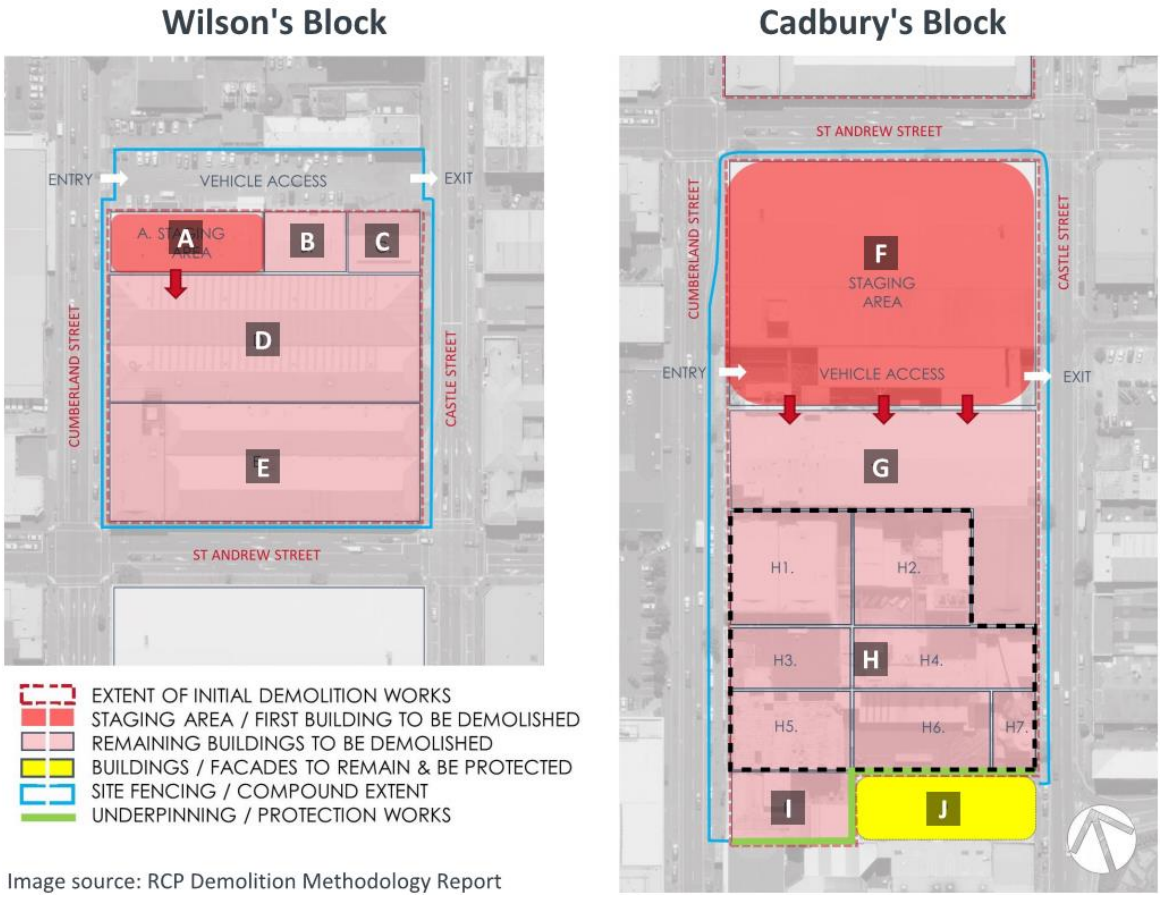



Image source: RCP Demolition Methodology Report

## 4.2 Cadbury's Block Plan

The buildings within the Cadbury's Block are varied with differing heights and construction types. We note that the site of Building 'F' once cleared (the former warehouse) will form the staging area for these works.

### 4.2.1 Building Group G

These are the most significant structures, at five storeys high and of heavyweight masonry construction. The height of these buildings means that a crane will likely be required to deconstruct the top two storeys, with the remainder of the buildings then demolished using a high-reach excavator with multi-processor and grapple attachments.

### 4.2.2 Building Group H

By contrast, the buildings in the central portion of the Cadbury's Block are lower height, typically between one to four storeys. The lower portions of these buildings are generally masonry structures, with the top storey being of lightweight construction. These buildings are all likely to removed through use of standard excavators with multi-processor attachments.

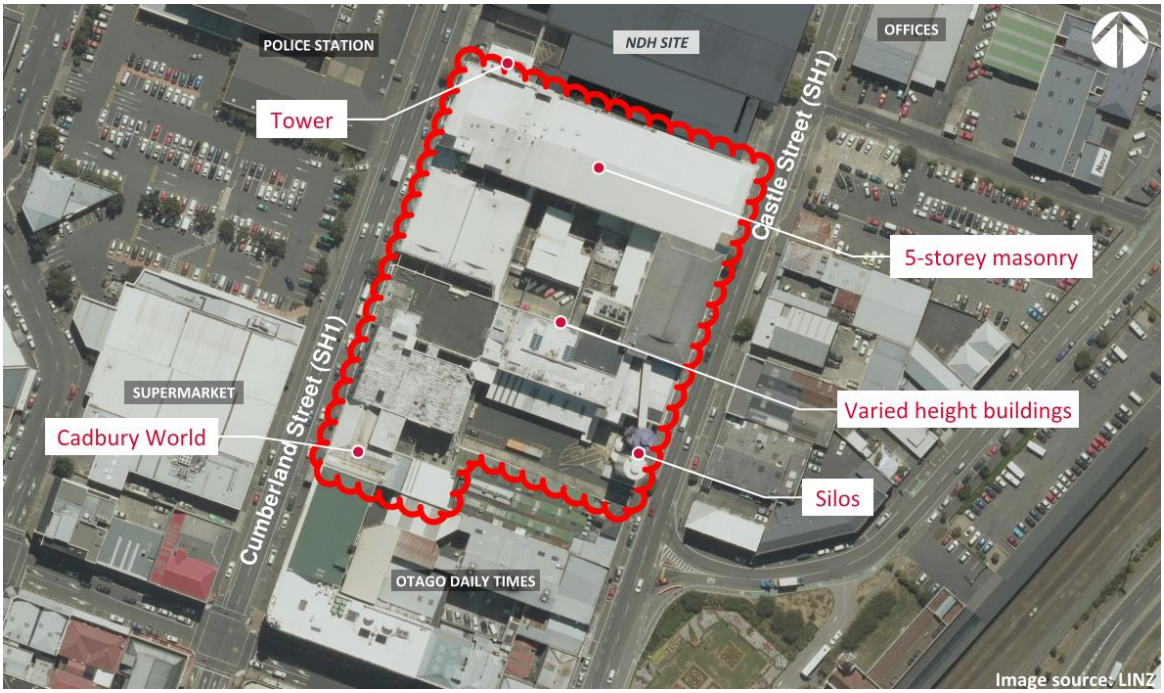
A crane will be required to deconstruct the two silos in the south-eastern corner of the site. The height of the silos and space required for the crane means that a short-duration road closure may be required for these works.

### 4.2.3 Building Group I

This portion, in the south-western corner of the worksite was formerly the Cadbury World site and abuts the heritage-listed ODT building to the south. As such this building will require deconstruction with specialist engineering input. While the exact works methodology is therefore still unknown, we understand this is likely to comprise three phases:

- Manual deconstruction of the roof;
- Demolition of the main structure using a standard excavator with multi-processor attachments; and
- Manual deconstruction of the remaining portion of the building adjacent to the ODT façade.

**Figure 7: Details of the 'Cadbury's Block' site**



## 4.3 Proposed Activity Programme

Indicative dates for key works phases associated with the deconstruction of the Cadbury's Block are given below.

**Table 8: Indicative programme for Cadbury's Block demolition**

| Activity | Start Date | Duration |
|---|---|---|
| Strip-out (Building G) | July 2020 | 2 weeks |
| Strip-out (Building H) | July 2020 | 2 months |
| Strip-out (Building I) | August 2020 | 2 weeks |
| Hard demolition (Building G) | March 2021 | 3 months |
| Hard demolition (Building H) | July 2021 | 7 months |
| Hard demolition (Building I) | January 2022 | 2 weeks |

The master programme for the demolition works of the buildings G-I is provided in Appendix C.

The programme shows that demolition of the Cadbury's Block will overlap to an extent with some adjacent works on the Wilson's Block and Cadbury Warehouse sites, so we have been mindful of cumulative noise effects. However, we note that there is reasonable spatial separation between the Wilson's and Cadbury's works areas, which limits the sensitivity of receivers to the north to southern work areas.

## 5.0 CALCULATED NOISE LEVELS

We have undertaken our assessment based on the calculation procedures out lined in NZS 6803:1999 which, in turn, references BS 5228-1:1997 *"Code of practice for noise and vibration control on construction and open sites – Part 1"*.

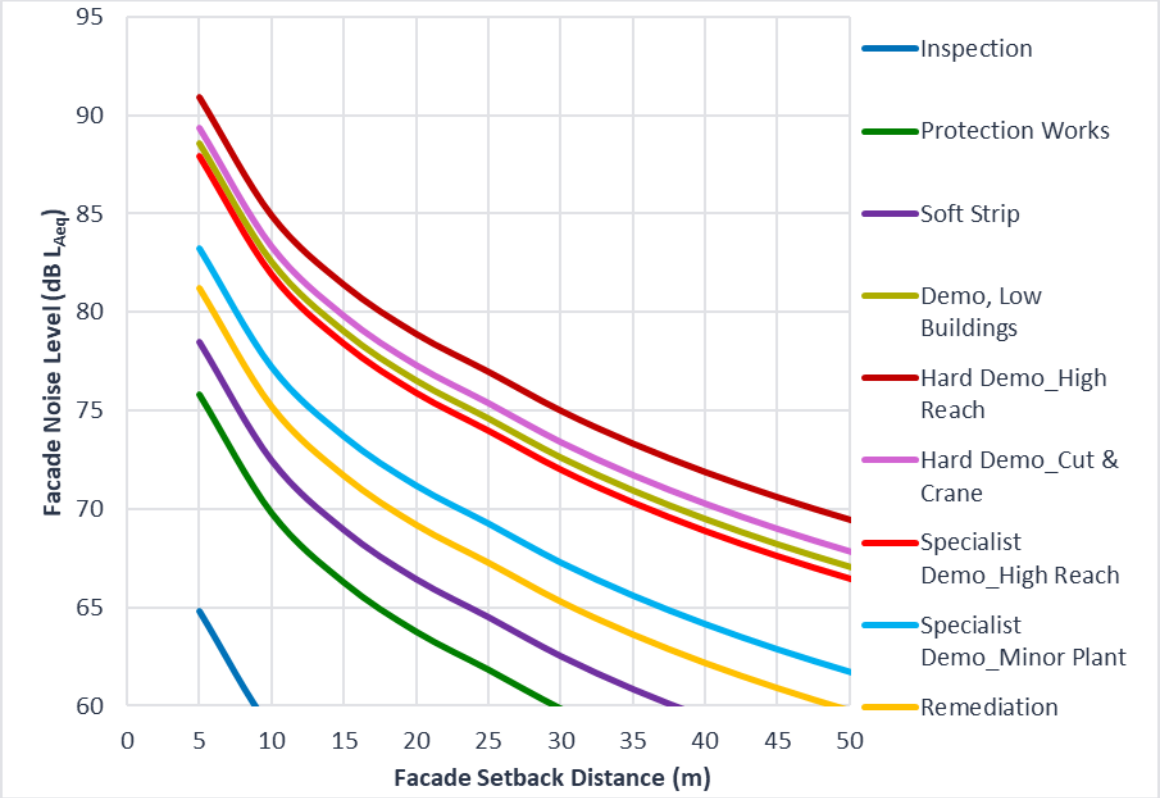
It should be noted that these noise levels represent the likely worst-case for each activity and at the highest or worst-affected floor of the receiving building. The levels will not be experienced on a continuous basis for the duration of the project. Similarly, where activities overlap, the worst-case levels are assumed for each, which is unlikely to occur in practice.

Noise propagation for each of the key activity types is provided in Table 9 to demonstrate how noise decays with distance. This data is also shown as a graphical plot in Figure 8, while the detailed list of noise sources assumed in these calculations is provided in Appendix D.

**Table 9: Indicative noise levels at 1m from a building façade (incl. effective barrier mitigation)**

| Activity | Activity Level | Activity Mitigation | Façade Noise Level, dB $L_{Aeq}$ at distance, m | | | | | Required Setback, m |
|---|---|---|---|---|---|---|---|---|
| | dB $L_{Aw}$ | dB | 5 | 10 | 20 | 50 | 100 | (70 dBA) |
| Inspection | 104 | 20 | 65 | 59 | 53 | 43 | 36 | 3 |
| Protection Works | 105 | 10 | 76 | 70 | 64 | 54 | 47 | 10 |
| Soft Strip-Out | 107 | 10 | 78 | 72 | 66 | 57 | 49 | 13 |
| Hard Demo (Low Buildings) | 108 | 0 | 89 | 83 | 77 | 67 | 60 | 38 |
| Hard Demo (High Reach) | 110 | 0 | 91 | 85 | 79 | 69 | 62 | 47 |
| Hard Demo (Cut & Crane) | 108 | 0 | 89 | 83 | 77 | 68 | 60 | 41 |
| Specialist Demo (High Reach) | 107 | 0 | 88 | 82 | 76 | 66 | 59 | 36 |
| Specialist Demo (Minor Plant) | 102 | 0 | 83 | 77 | 71 | 62 | 54 | 23 |
| Remediation | 100 | 0 | 81 | 75 | 69 | 60 | 52 | 18 |

**Figure 8: Indicative noise levels at 1m from a building façade (incl. effective barrier mitigation)**




At this stage, minimal mitigation has been assumed for each activity, for example where site boundary hoarding or retained façades provide some acoustic screening can be reasonably assured. Once the exact methodology and phasing has been confirmed then an appropriate allowance can be made for increased levels of noise mitigation to specific plant items or activities as required. No further mitigation has been allowed for in our calculations except where stated.

## 5.1 Cumulative Noise Levels

It is necessary to establish where activities may overlap and generate higher cumulative noise levels at receivers. The activity noise levels presented above have been combined for when activities occur concurrently, based on noise levels at the following distances:

- 30 metres – representative of activity at the edge of site, opposite a receiver across SH1 **(this consent)**, noting that the 'acoustic centre' of activity will typically be inward of the site boundary;
- 50 metres – activity occurring opposite or close to a receiver, but not on the edge of the site **(this consent)**; and
- 100 metres – for concurrent NDH project activities in **other consents** (Table 9 maximum value).

Noting that the phasing does not realistically permit two activities to occur simultaneously at the minimum distance, the following two scenarios are presented:

1. Closest activity combined with distant activities (worst case, Table 10); and
2. Combinations of distant activities at both 50 and 100 metres (typical case, Table 11).

Again, we note that these calculations generally assume little or no mitigation between source and receiver, thus do not account for shielding due to intervening buildings, etc.

Table 10: Combined noise level matrix for close and distant activities

| | | Close Cadbury's Activity (30m) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Distant Activity (50/100m) | None | Inspection | Protections | Soft Strip | Demo, Low Bldg | Demo, High Rch | Demo, Crane | Spec Dem, High | Spec Dem, minor | Remediation |
| Distant Cadbury's Activity (50m) | None | - | 49 | 60 | 63 | 73 | **75** | 74 | 72 | 68 | 66 |
| | Inspection | 43 | 50 | 60 | 63 | 73 | **75** | 74 | 72 | 68 | 66 |
| | Protection Works | 54 | 55 | 61 | 63 | 73 | **75** | 74 | 72 | 68 | 66 |
| | Soft Strip | 57 | 58 | 62 | 64 | 73 | **75** | 74 | 73 | 68 | 66 |
| | Demo, Low Buildings | 67 | 67 | 68 | 68 | 74 | **76** | **75** | 74 | 70 | 69 |
| | Demo, High Reach | 69 | 69 | 70 | 70 | **75** | **76** | **75** | 74 | 72 | 71 |
| | Demo, Cut & Crane | 68 | 68 | 69 | 69 | 74 | **76** | **75** | 74 | 71 | 70 |
| | Special Demo, High Reach | 66 | 67 | 67 | 68 | 74 | **76** | **75** | 73 | 70 | 69 |
| | Special Demo, Minor Plant | 62 | 62 | 64 | 65 | 73 | **76** | 74 | 73 | 69 | 67 |
| | Remediation | 60 | 60 | 63 | 65 | 73 | **75** | 74 | 73 | 68 | 67 |
| Warehouse Activity (100m) | Inspection | 36 | 49 | 60 | 63 | 73 | **75** | 74 | 72 | 68 | 66 |
| | Establish Office | 57 | 58 | 62 | 64 | 73 | **75** | 74 | 73 | 68 | 66 |
| | Erect Hoarding | 52 | 54 | 61 | 63 | 73 | **75** | 74 | 72 | 68 | 66 |
| | Soft Strip | 49 | 52 | 61 | 63 | 73 | **75** | 74 | 72 | 68 | 66 |
| | Demo, Warehouse | 58 | 59 | 62 | 64 | 73 | **75** | 74 | 73 | 68 | 66 |
| | Demo, Wall | 52 | 54 | 61 | 63 | 73 | **75** | 74 | 72 | 68 | 66 |
| | Demo, Concrete | 45 | 51 | 60 | 63 | 73 | **75** | 74 | 72 | 68 | 66 |
| Below Ground | Foundation works at 50m | 69 | 69 | 70 | 70 | 74 | **76** | **75** | 74 | 71 | 71 |
| | Foundation works at 100m | 62 | 62 | 64 | 65 | 73 | **76** | 74 | 73 | 69 | 67 |

**Table 11: Combined noise level matrix for activities at greater distances**

| | | Distant Cadbury's Activity (50m) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Distant Activity (50/100m) | None | Inspection | Protections | Soft Strip | Protections | Demo, Low Bldg | Demo, High Rch | Demo, Crane | Spec Dem, High | Spec Dem, minor |
| Distant Cadbury's Activity (50m) | None | - | 43 | 54 | 57 | 67 | 69 | 68 | 66 | 62 | 60 |
| | Inspection | 43 | 46 | 55 | 57 | 67 | 69 | 68 | 66 | 62 | 60 |
| | Protection Works | 54 | 55 | 57 | 59 | 67 | 70 | 68 | 67 | 62 | 61 |
| | Soft Strip | 57 | 57 | 59 | 60 | 67 | 70 | 68 | 67 | 63 | 62 |
| | Demo, Low Buildings | 67 | 67 | 67 | 67 | 70 | 71 | 70 | 70 | 68 | 68 |
| | Demo, High Reach | 69 | 69 | 70 | 70 | 71 | 72 | 72 | 71 | 70 | 70 |
| | Demo, Cut & Crane | 68 | 68 | 68 | 68 | 70 | 72 | 71 | 70 | 69 | 68 |
| | Special Demo, High Reach | 66 | 66 | 67 | 67 | 70 | 71 | 70 | 69 | 68 | 67 |
| | Special Demo, Minor Plant | 62 | 62 | 62 | 63 | 68 | 70 | 69 | 68 | 65 | 64 |
| | Remediation | 60 | 60 | 61 | 62 | 68 | 70 | 68 | 67 | 64 | 63 |
| Warehouse Activity (100m) | Inspection | 36 | 44 | 54 | 57 | 67 | 69 | 68 | 66 | 62 | 60 |
| | Establish Office | 57 | 57 | 59 | 60 | 68 | 70 | 68 | 67 | 63 | 62 |
| | Erect Hoarding | 52 | 52 | 56 | 58 | 67 | 70 | 68 | 67 | 62 | 60 |
| | Soft Strip | 49 | 50 | 56 | 58 | 67 | 69 | 68 | 67 | 62 | 60 |
| | Demo, Warehouse | 58 | 58 | 60 | 61 | 68 | 70 | 68 | 67 | 63 | 62 |
| | Demo, Wall | 52 | 52 | 56 | 58 | 67 | 70 | 68 | 67 | 62 | 60 |
| | Demo, Concrete | 45 | 47 | 55 | 57 | 67 | 69 | 68 | 66 | 62 | 60 |
| Below Ground | Foundation works at 50m | 69 | 69 | 69 | 69 | 71 | 72 | 72 | 71 | 70 | 70 |
| | Foundation works at 100m | 62 | 62 | 62 | 63 | 68 | 70 | 69 | 68 | 65 | 64 |

The values given in the matrices above indicate that, for most activities and combinations, the predicted noise levels will meet the 70 dB $L_{Aeq}$ permitted activity standard. However, some activities or combinations have the potential to exceed either the discretionary (red text, <75 dB $L_{Aeq}$) or non-complying (red shading, ≥75 dB $L_{Aeq}$) thresholds.

## 5.2 Noise Levels at Critical Receivers

To provide some more context to the values above, this section provides examples of the highest noise levels at the closest sensitive receiver locations. These examples include cumulative noise from other NDH activities.

While not discussed in this report, other activities are scheduled to occur concurrently, provided there are no project delays. These include activities in both the Cadbury's warehouse and Wilson's consent packages. Note that the examples below account for the highest noise levels from works

associated with this consent, rather than the highest overall for the project, which may be due to works consented separately (e.g. below-ground works).

Table 12 sets out how the maximum noise level has been calculated for each receiver. Due to the overlap of scheduled activities, the 'critical period' referenced is the time in which the maximum level could occur – it is not anticipated to occur on a continuous basis for this period.

Noise received at the ODT building (260 Cumberland St) is discussed separately in the following section.

**Table 12: Examples of worst-case cumulative noise level calculations**

| Receiver | Date | Critical Period | Activities | Noise Level, dB $L_{Aeq}$ | | |
|---|---|---|---|---|---|---|
| | | | | This consent | Below-ground-works | Total |
| 261 Cumberland St (Countdown) | Aug 20 | 2 wks | Soft Strip (Buildings H3, H5-6, I) | 65 | - | **65** |
| 137 St Andrews St (Victoria Hotel) | Oct 21 | 1 wk | High Reach Demo Building H2, Below-Ground Works Building E | 60 | 75 | **75** |
| 85 Castle St (Fire Station) | Oct 21 | 1 wk | High Reach Demo Building H4, Below-Ground Works Building E | 60 | 75 | **75** |
| 25 Great King St (Police) | Aug 21 | 2 wks | High Reach Demolition Building G | 75 | - | **75** |
| 25 Great King St (Police) | May 21 | 3 wks | Top-Down Demolition Building G | 74 | - | **74** |
| 261 Cumberland St (Countdown) | Nov 21 | 2 wks | High Reach Demolition Building H5 | 75 | - | **75** |
| 3 Anzac Ave (Apartments) | Jan 22 | 3 days | High Reach Demolition Building H7 | 75 | - | **75** |

The data above shows that, where elevated noise levels are indicated, it is either due to below-ground works from the Wilson's Block or demolition occurring at the boundary of the Cadbury's Block.

## 5.3 Otago Daily Times Building

The ODT building is a unique receiver for this project in that it is the only one that immediately adjoins the worksite and does not benefit from separation by the road corridor. Moreover, works will occur right up to the party wall due to the demolition of Building I.

The ODT buildings south of the retained Dairy building are industrial in nature (being printing and production areas) and therefore not especially sensitive to noise. Conversely, the western areas bordering Cumberland Street have been described as 'intermittent office use' and are hence likely to be sensitive, at least at times.

While it remains, the presence of Building I will provide a buffer to the majority of NDH works, both in terms of spatial separation and as a noise barrier. NZS 6803 effectively recommends a long-term noise limit inside commercial buildings of 50 dB $L_{Aeq}$ (Clause 7.2.7). Noise from works will remain comfortably below this criterion until Building I demolition begins in Jan 2022.

Hard demolition of Building I is scheduled for around two weeks from this date. Whilst we are not familiar with the layout or construction of the ODT building, we have estimated internal noise levels received during this time based on some generic assumptions.

Table 9 indicates that the highest noise levels during the specialist deconstruction works in Building I are 83 and 88 dB $L_{Aeq}$ (at 5 metres). Taking these as incident noise levels on the ODT façade, and with an allowance for flanking transmission via the side walls/windows, we anticipate that the internal noise level within the ODT west building will still remain below 50 dB $L_{Aeq}$.

However, this does not account for potential structure-borne transmission of noise during party wall works if there is any bridging between the structures (e.g. hammering or drilling on the opposite side of the wall). Internal levels may be higher in such cases and lead to disturbance. Works on the party wall itself will be for a short period at the end of Building I demolition. Similarly, the removal of the structure that currently forms the courtyard wall is likely to result in a short period of elevated noise levels as the wall is taken down.

## 6.0 DISCUSSION OF DEMOLITION NOISE

The analysis in the preceding section confirms that the proposed activities have the potential to exceed the applicable long-term duration noise limits from NZS 6803:1999 when work is occurring close to adjacent properties.

Short term exceedances of the applicable noise limits can be unavoidable in some situations. However, NZS 6803 acknowledges that such exceedances are often considered reasonable if they are of a limited duration and Best Practicable Option (BPO) measures are implemented to avoid, remedy and mitigate the noise emissions as far as practicable.

### 6.1 Daytime Noise Emissions

Our calculations show that cumulative noise emissions will exceed the daytime noise limits at times at a small number of noise-sensitive receivers, as below. However, of these, only those highlighted in bold are directly as a result of activities in this consent package (refer Table 12).

- **3 Anzac Ave (Apartments)**
- **53 Castle St**
- **83 Castle St**
- 85 Castle St (Fire Station)
- **333 Cumberland St (Quest)**
- **359 Cumberland St**
- **25 Great King St (Police Station)**
- 137 St Andrews St (Victoria Hotel)

With regard to the Dunedin District Plan, the highest predicted noise levels exceed the permitted activity standard (NZS 6803 limits) by more than 5 dB (including a cumulative noise contribution). As such, the activity has **non-complying status** according to Rule 4.5.4.1 of the 2GP.

As discussed in Section 5.0, the calculations have been undertaken on a worst-case basis and, in reality, we anticipate that some relief will be afforded to receivers as the levels and location of activities vary. Appropriate management and additional noise mitigation measures may further reduce noise levels beyond those predicted, noting that we have assumed minimal mitigation.

Table 10 shows that most 'hard demolition' activities have a risk of exceeding the 70 dB $L_{Aeq}$ daytime limit when occurring close to receivers. The information in Table 11 indicates that this risk is minimal once the activity is further away at around 50 metres, which essentially represents any point other than the closest activities. These tables, along with Table 12, indicate a slight elevation of risk due to cumulative noise influence from other NDH activities, but this is relatively minor. It is generally the closest activities that will result in the highest noise levels.

The results of our ambient noise monitoring indicate that daytime noise levels are typically already in excess of 70 dB $L_{Aeq}$ at the façades of buildings on SH1. Thus, where the construction noise limits are exceeded by a small margin, the scale of effect will be quite low compared with in a quieter environment, such as a suburban residential area.

Considering wider noise effects, buildings further away than those focussed on in our assessment will receive lower noise levels due to the greater separation distance and because of acoustic screening from intervening structures. Passing pedestrian traffic will temporarily experience high levels of construction noise at times, but we note that no leisure areas (e.g. parks) are nearby where people would be likely to experience adverse effects for a prolonged period.

Section 5.3 highlights that, while noise within the ODT buildings will generally remain at a reasonable level in terms of demolition activities, some specific risk periods will occur in which potential adverse effects would best be dealt with through liaison with the buildings' owner and/or occupants.

## 6.2 Night-time Noise Emissions

Demolition activities will not typically occur at night and therefore adjacent apartments and visitor accommodation will maintain an appropriate noise environment for adequate protection of sleep.

It may at times be necessary to schedule some activities at night in order to facilitate emergency works or to best accommodate the requests of specific stakeholders (e.g. undertaking high-impact works while a commercial premise is unoccupied). Such instances should be avoided as a matter of course and should only occur when absolutely necessary.

Infrequent occurrences of night works are likely to be acceptable on this basis and where prior notification of affected residents has taken place.

## 6.3 Noise Management and Mitigation

It has become best practice for projects of this scale to have a Noise and Vibration Management Plan (NVMP) which can identify potential breaches of the noise and vibration limits and put appropriate mitigation or management measures in place to ensure effects are reasonable.

At this stage of the project it is not appropriate to specify noise mitigation methods in detail, as the working methodology is not sufficiently developed. However, such issues are ideally captured in an NVMP.

The development of an NVMP for the overall NDH project should be a requirement on the successful Contractor(s), and should include:

- The performance standards that must, where practicable, be complied with;
- Predicted noise and vibration levels for relevant equipment and/or activities;
- Mitigation considerations to identify the BPO with respect to demolition noise and vibration;
- Noise and vibration monitoring requirements, with triggers and feedback mechanisms; and
- Communication, consultation and complaints response protocols.

We have provided a draft NVMP as Appendix F. This is intended to apply to the project as a whole, so not all aspects are relevant to this application. The NVMP identifies a number of critical receiving environments for which mitigation will need to be considered in detail by the Contractor:

1. Noise received in the office areas of the ODT building(s) during works on the party wall;

   Office spaces are likely to remain occupied during these works, unless prior arrangements can be made with the property managers. If this is unavoidable than care should be taken to minimise the scale, intensity and duration of works on the wall as far as practicable. Construction of a secondary wall structure within the occupied offices may, for example, be a means of facilitating ongoing use of the office space.

2. Noise received at the Dunedin Central Fire Station – in particular at the crew's sleeping quarters;

   The nature of the crew's work might mean that personnel have unconventional sleep patterns. The effects on resting and actively working personnel will require specific management by the Contractor, through liaison with Fire and Emergency New Zealand (FENZ), once the works methodology is further developed.

3. Noise arising during underpinning activity and sheet piling around Buildings B and C, which although owned by the MoH, may remain tenanted during a portion of these works.

## 6.4 Overall Noise Effects

With regard to overall noise effects, while demolition or construction noise is usually undesirable, it is ultimately temporary and not necessarily unreasonable when all the relevant factors are taken into consideration.

The foreword of New Zealand Standard NZS 6803:1999 "*Acoustics – Construction Noise*" states:

> "*Construction noise is an inherent part of the progress of society. As noise from construction is generally of limited duration, people and communities will usually tolerate a higher noise level provided it is* ***no louder than necessary, and occurs with appropriate hours of the day****. The Resource Management Act 1991 requires the* ***adoption of the best practicable option to ensure*** *the emission of noise from premises does not exceed a* ***reasonable level****. The Act also imposes a duty on every person to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by, or on behalf of, that person*."

We consider that the noise levels will be generally reasonable with the adoption and implementation of a Noise and Vibration Management Plan (NVMP). This NVMP should outline the Best Practicable Option (BPO) measures to mitigate construction noise and vibration.

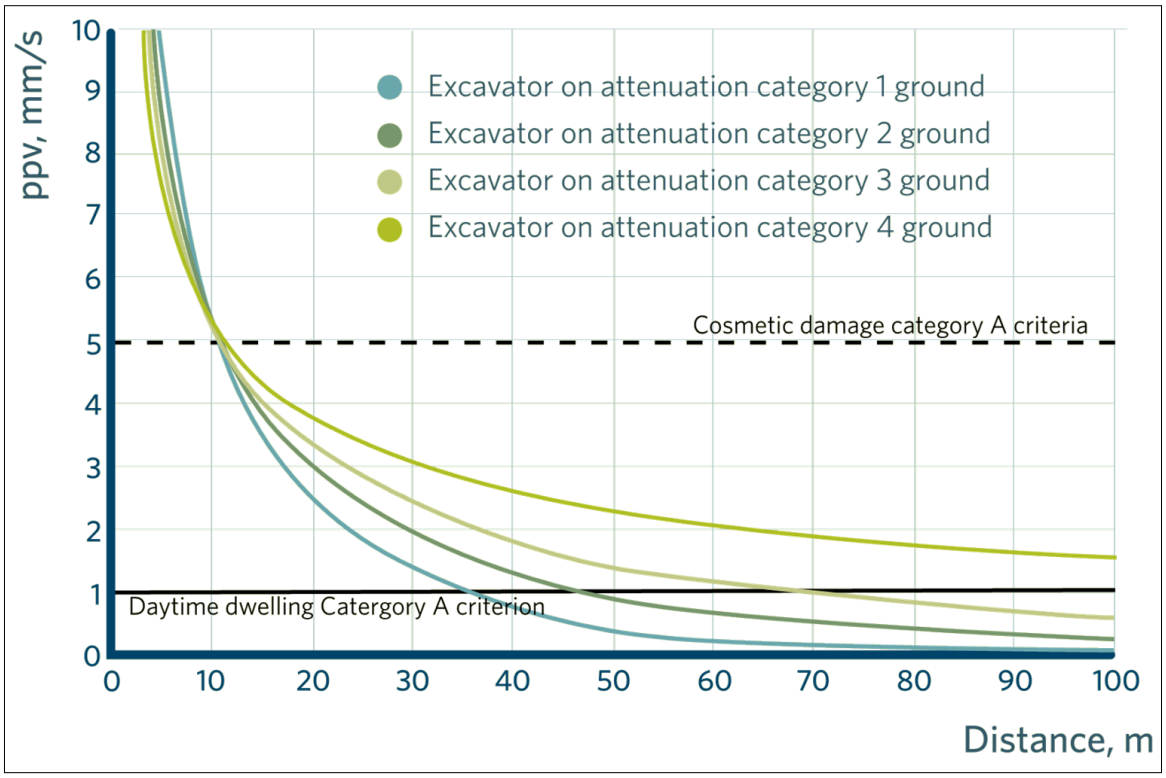
## 7.0 DEMOLITION VIBRATION LEVELS

In comparison to the prediction of noise, calculating vibration levels is more complex. This is primarily due to the propagation through non-uniform ground, combined with the coupling between the vibration source and the ground; and between the ground and the receiving building.

### 7.1.1 Empirical Analysis

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 9 provides an example of shows predicted vibration propagation over distance from an excavator for different ground types. This is from the NZTA's construction guidance[5] that has been developed based on empirical data discussed in their extensive research. The ground categories are broadly from: 1 – weak or soft; to 4 – hard, competent rock.

**Figure 9: Predicted vibration from a 12 tonne excavator (Figure 4.31 of NZTA's construction noise guide)**




In practice, our recent measurement experience with similar sources indicates that the NZTA guidance 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.

[5] *State Highway Construction and Maintenance Noise and Vibration Guide*. NZ Transport Agency (2013).

### 7.1.2 Set Back Distances

Table 13 summarises the expected set back distances required for the most probable vibration generating sources on site and the indicative separation distance to achieve compliance with the most stringent criteria reviewed – that from DIN 4150-3:2016 (based on generic ground conditions).

**Table 13: Indicative distances to comply with vibration limits at building foundations**

| Equipment | Cosmetic Building Damage Setback (m)[6] | | |
|---|---|---|---|
| | Heritage 2.5 mm/s PPV | Residential 5 mm/s PPV | Commercial 10 mm/s PPV |
| Vibratory Roller | 30 | 14 | 6 |
| Excavator (mid-size) | 15 | 4 | 1 |
| Sheet piling | 30 | 11 | 4 |
| Concrete/rock-breaker | 16 | 10 | 7 |

The separation distances indicate that appropriate vibration management measures should be taken where vibration-generating activities are occurring close to buildings. Measures can include a structural condition assessment of identified buildings, installation of "tell-tale" crack monitors, and/or vibration monitoring during critical periods.

## 7.2 Vibration Effects

We anticipate that the criteria for residential and commercial buildings should be comfortably achieved where the receivers are on the opposite side of roads to the worksite. Table 13 indicates that compliance is also likely for heritage structures across the state highway (approximately 30 metres from works area to opposing façades), but we note that this is marginal.

While the primary vibration concern is typically structural or cosmetic building damage, people may be disturbed at levels that are significantly lower. Potentially affected parties should be informed about the vibration levels they may experience, along with general notifications around noise disturbance, and assured that vibration damage can only occur at magnitudes well above the threshold of perception.

In some cases, construction vibration can excite building structures. This is experienced as 'reradiated noise' within the building, rather than felt as vibration, but is the result of a structural transmission path. Predictions of reradiated noise levels are complex and site specific. Where necessary, a suitability qualified acoustic specialist should be engaged to provide guidance. Reradiated noise effects will be consistent with airborne noise effects for a given noise level.

Communication with affected parties in conjunction with vibration monitoring is considered the most practicable approach to minimising any effects on nearby affected parties.

## 7.3 Vibration Mitigation and Management

As with noise, vibration control and management measures should be contained with the project's NVMP (as described in Section 6.3). In addition to general risk management and monitoring thresholds, the following project-specific issues should be addressed:

1. Monitoring requirements for underpinning works, where sheet piling will occur close to the façades of occupied buildings (likely to require sensitivity testing during the start-up phase to determine the effects of local ground conditions).

[6] Based on regression analysis of available vibration measurements, plus a 100% safety factor.

2. Appropriate assessment criteria for vibration-sensitive equipment in adjoining buildings, with specific reference to ODT's printing press. Appendix E has example guidance that may provide suitable limits (from BS 5228-2:2009). We note that monitoring of existing baseline vibration levels and liaison with ODT regarding hours of operation may be of benefit in this instance.
3. Monitoring of heritage structures and occupied sensitive working areas with the NDH building, likely to be required throughout Building I demolition works.

## 8.0 PROPOSED CONDITIONS OF CONSENT

Overall, we are satisfied that, based on the provisional methodologies, the proposed demolition can be managed in an appropriate way to ensure that noise and vibration effects are reasonable.

To provide certainty that the works will occur in a manner consistent with this assessment, we recommend that the following conditions be included in any consent granted.

1. Demolition noise shall comply with the recommended residential and commercial noise limits for long term construction taken from Tables 1 and 2 of NZS 6803: 1999 *"Acoustics - Construction Noise"* as far as practicable.

   Note: this should apply on a cumulative basis to all demolition activities associated with the NDH project.

2. A Noise and Vibration Management Plan (NVMP) must be prepared by a suitably qualified person and submitted to Dunedin City Council 5 days prior to the commencement of the works. At a minimum, the NVMP must address the relevant measures in Annex E of NZS 6803:1999 "*Acoustics - Construction Noise*" and Appendix B of DIN 4150-3:2016 "*Vibration in buildings – Part 3: Effects on structures*". The NVMP must be implemented throughout the project and a copy must be maintained on site.

## 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. |
| **dB** | Decibel<br>The unit of sound level.<br><br>Expressed as a logarithmic ratio of sound pressure P relative to a reference pressure of Pr=20 μPa i.e. dB = 20 x log(P/Pr) |
| **dBA** | 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). |
| **$L_{A10\,(t)}$** | 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.<br><br>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. |
| **$L_{Aeq\,(t)}$** | The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. |
| **$L_{Amax}$** | The A-weighted maximum noise level. The highest noise level which occurs during the measurement period. |
| **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. |
| **PPV** | Peak Particle Velocity<br>For Peak Particle Velocity (PPV) is the measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment. |
| **Resonance** | When a forcing frequency is the same as a resonant frequency of the structure, the structure is said to be in resonance. |
| **RMS Velocity** | For most applications where there is continuous vibration, vibration is measured in terms of root mean square RMS velocity (mm/sec), measured in any direction. Used for vibration annoyance. |
| **Special Audible Characteristics** | 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). |
| **SPL or $L_P$** | Sound Pressure Level<br>A logarithmic ratio of a sound pressure measured at distance, relative to the threshold of hearing (20 μPa RMS) and expressed in decibels. |
| **SWL or $L_W$** | Sound Power Level<br>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. |

## APPENDIX B NOISE SURVEY DETAILS

The key details of the noise survey are as follows:

| | |
|---|---|
| **Date**: | 17 July 2019, 1400 - 1600 hrs and 18 July 2019, 1000 - 1200 hrs |
| **Personnel**: | Markus Schmid, Marshall Day Acoustics |
| **Weather**: | 8 °C, minimal cloud, 1.5 - 3 m/s wind from the north-east |
| **Instrumentation**: | Brüel & Kjær Type 2250 analyser, serial 3010261, calibration due 22/05/2021<br>Brüel & Kjær Type 4231 calibrator, serial 3004051, calibration due 28/09/2019 |
| **Calibration**: | Field calibration of the equipment was carried out before measurements, and the calibration checked after measurements. Observed change less than 0.1 dB. |

## APPENDIX C CADBURY'S BLOCK WORKS PROGRAMME

Indicative programme of works (based on programme schedule dated 1/04/2020)

| Task Name | Start Date | End Date | Work Building Location |
|---|---|---|---|
| | | | A-C D E F G H I |
| CADBURY'S SITE DEMOLITION | 25/02/20 | 31/08/20 | |
| SOFT STRIP & SERVICE RELOCATION | 25/02/20 | 25/08/20 | |
| Site Establishment | 25/02/20 | 02/03/20 | |
| Soft Strip-Out - Building F | 11/03/20 | 13/03/20 | |
| Soft Strip-Out - Building G | 24/07/20 | 13/08/20 | |
| Soft Strip-Out - Buildings H1-H7 | 04/08/20 | 31/08/20 | |
| Soft Strip-Out - Building I | 12/08/20 | 25/08/20 | |
| ABOVE GROUND WORKS | 31/03/20 | 07/02/22 | |
| Hard Demo - Building F | 31/03/20 | 06/04/20 | |
| Hard Demo - Building G | 03/03/21 | 04/06/21 | |
| Hard Demo - Buildings H1-H7 | 01/07/21 | 27/01/22 | |
| Hard Demo - Building I | 21/01/22 | 07/02/22 | |
| BELOW GROUND WORKS | 05/04/22 | 17/08/22 | |
| Foundation Removal - Building F | 05/04/22 | 18/04/22 | |
| Foundation Removal - Building G | 05/04/22 | 16/05/22 | |
| Foundation Removal - Buildings H1-H7 | 05/04/22 | 17/08/22 | |
| Foundation Removal - Building I | 19/05/22 | 01/06/22 | |

## APPENDIX D DETAILED ACTIVITY NOISE LEVEL CALCULATIONS

| Activity | Equipment | BS 5228 Ref. | No. | Source SWL | Usage Time | Source Control | Source Rating $L_r$ | Activity SWL | Activity Control |
|---|---|---|---|---|---|---|---|---|---|
| | | | | dB $L_{Aw}$ | % | dB | dB $L_{Aw}$ | dB $L_{Aw}$ | dB |
| **Inspection** | | | | | | | | **104** | **20** |
| Boarding windows | Hand-held hammer | D2.15 | 1 | 112 | 10% | 0 | 102 | | |
| Cutting timber | Hand-held electric circular saw | D7.75 | 1 | 105 | 25% | 0 | 99 | | |
| **Protection Works** | | | | | | | | **105** | **10** |
| Boarding windows | Hand-held hammer | D2.15 | 1 | 112 | 10% | 0 | 102 | | |
| Cutting timber | Hand-held electric circular saw | D7.76 | 1 | 109 | 10% | 0 | 99 | | |
| Miscellaneous | Handheld cordless nail gun | C4.95 | 1 | 101 | 30% | 0 | 96 | | |
| Lifting | Telescopic handler | C4.55 | 1 | 98 | 40% | 0 | 94 | | |
| **Soft Strip** | | | | | | | | **107** | **10** |
| Breaking stud partition | Lump hammer breaking stud partition | C1.19 | 2 | 97 | 20% | 0 | 93 | | |
| Breaking windows | Lump hammer breaking windows | C1.20 | 1 | 109 | 10% | 0 | 99 | | |
| Cutting timber | Hand-held electric circular saw | D7.76 | 1 | 109 | 10% | 0 | 99 | | |
| Breaking up/cutting steel | Gas cutter | C1.18 | 1 | 107 | 10% | 0 | 97 | | |
| Miscellaneous | Angle grinder (grinder steel) | C4.93 | 1 | 108 | 15% | 0 | 100 | | |
| Lifting | Telescopic handler | C4.55 | 1 | 98 | 50% | 0 | 95 | | |
| Distribution of material | Lorry | C2.34* | 1 | 108 | 10% | -5 | 103 | | |
| **Hard Demolition – Low Buildings** | | | | | | | | **108** | **0** |
| Breaking up concrete | Pulverizer mounted on excavator | C1.4 | 1 | 104 | 50% | 0 | 101 | | |

| Activity | Equipment | BS 5228 Ref. | No. | Source SWL | Usage Time | Source Control | Source Rating $L_r$ | Activity SWL | Activity Control |
|---|---|---|---|---|---|---|---|---|---|
| | | | | dB $L_{Aw}$ | % | dB | dB $L_{Aw}$ | dB $L_{Aw}$ | dB |
| Dumping brick rubble | Tracked excavator (loading dump truck) | C1.10 | 1 | 113 | 10% | 0 | 103 | | |
| Dumping brick rubble | Articulated dump truck (dumping rubble) | C1.11 | 1 | 108 | 30% | 3 | 100 | | |
| Miscellaneous | Angle grinder (grinder steel) | C4.93 | 1 | 108 | 20% | 0 | 101 | | |
| Breaking up concrete | Hand-held pneumatic breaker | C1.6 | 1 | 111 | 20% | 10 | 94 | | |
| **Hard Demolition – High Reach Excavator** | | | | | | | | **110** | **0** |
| Breaking up concrete | Pulverizer mounted on excavator | C1.4 | 1 | 104 | 20% | 0 | 97 | | |
| Dumping brick rubble | Tracked excavator (loading dump truck) | C1.10 | 1 | 113 | 15% | 0 | 105 | | |
| Dumping brick rubble | Articulated dump truck (dumping rubble) | C1.11 | 1 | 108 | 30% | 0 | 103 | | |
| Miscellaneous | Angle grinder (grinder steel) | C4.93 | 1 | 108 | 20% | 0 | 101 | | |
| Breaking up concrete | Hand-held pneumatic breaker | C1.6 | 1 | 111 | 10% | 0 | 101 | | |
| Lifting | Telescopic handler | C4.55 | 1 | 98 | 50% | 0 | 95 | | |
| Cutting concrete slabs | Hand-held circular saw (petrol) | C5.36 | 1 | 115 | 5% | 0 | 102 | | |
| **Hard Demolition – Cut & Crane** | | | | | | | | **108** | **0** |
| Lifting | Mobile telescopic crane | C4.39 | 1 | 105 | 75% | 0 | 104 | | |
| Breaking up/cutting steel | Gas cutter | C1.18 | 1 | 107 | 5% | 5 | 89 | | |
| Core drilling concrete | Core drill (electric) | C4.69 | 1 | 113 | 5% | 5 | 95 | | |
| Cutting concrete floor slab | Petrol hand-held circular saw | C4.70 | 1 | 119 | 5% | 5 | 101 | | |
| Cutting concrete blocks | Hand-held circular saw (cutting paving slabs) | C4.73 | 1 | 112 | 5% | 5 | 94 | | |
| Dumping brick rubble | Tracked excavator (loading dump truck) | C1.10 | 1 | 113 | 10% | 5 | 98 | | |

| Activity | Equipment | BS 5228 Ref. | No. | Source SWL | Usage Time | Source Control | Source Rating $L_r$ | Activity SWL | Activity Control |
|---|---|---|---|---|---|---|---|---|---|
| | | | | dB $L_{Aw}$ | % | dB | dB $L_{Aw}$ | dB $L_{Aw}$ | dB |
| Dumping brick rubble | Articulated dump truck (dumping rubble) | C1.11 | 1 | 108 | 30% | 0 | 103 | | |
| **Specialist Deconstruction – High Reach** | | | | | | | | **107** | **0** |
| Breaking up concrete | Pulverizer mounted on excavator | C1.4 | 1 | 104 | 20% | 0 | 97 | | |
| Miscellaneous | Angle grinder (grinder steel) | C4.93 | 1 | 108 | 20% | 0 | 101 | | |
| Breaking up concrete | Hand-held pneumatic breaker | C1.6 | 1 | 111 | 10% | 0 | 101 | | |
| Lifting | Telescopic handler | C4.55 | 1 | 98 | 50% | 0 | 95 | | |
| Cutting concrete slabs | Hand-held circular saw (petrol) | C5.36 | 1 | 115 | 5% | 0 | 102 | | |
| **Specialist Deconstruction – Minor Plant** | | | | | | | | **102** | **0** |
| Breaking stud partition | Lump hammer breaking stud partition | C1.19 | 2 | 97 | 20% | 5 | 88 | | |
| Breaking windows | Lump hammer breaking windows | C1.20 | 1 | 109 | 10% | 5 | 94 | | |
| Cutting timber | Hand-held electric circular saw | D7.76 | 1 | 109 | 10% | 5 | 94 | | |
| Breaking up/cutting steel | Gas cutter | C1.18 | 1 | 107 | 10% | 5 | 92 | | |
| Miscellaneous | Angle grinder (grinder steel) | C4.93 | 1 | 108 | 10% | 5 | 93 | | |
| **Remediation** | | | | | | | | **100** | **0** |
| Mixing concrete | Small Cement mixer | C4.23 | 1 | 89 | 50% | 5 | 81 | | |
| Lifting | Lifting platform | C4.57 | 1 | 95 | 30% | 0 | 90 | | |
| Lifting | Lifting platform (idling) | C4.58 | 1 | 91 | 70% | 0 | 89 | | |
| Miscellaneous | Handheld cordless nail gun | C4.95 | 1 | 101 | 5% | 0 | 88 | | |
| Boarding windows | Hand-held hammer | D2.15 | 1 | 112 | 5% | 0 | 99 | | |

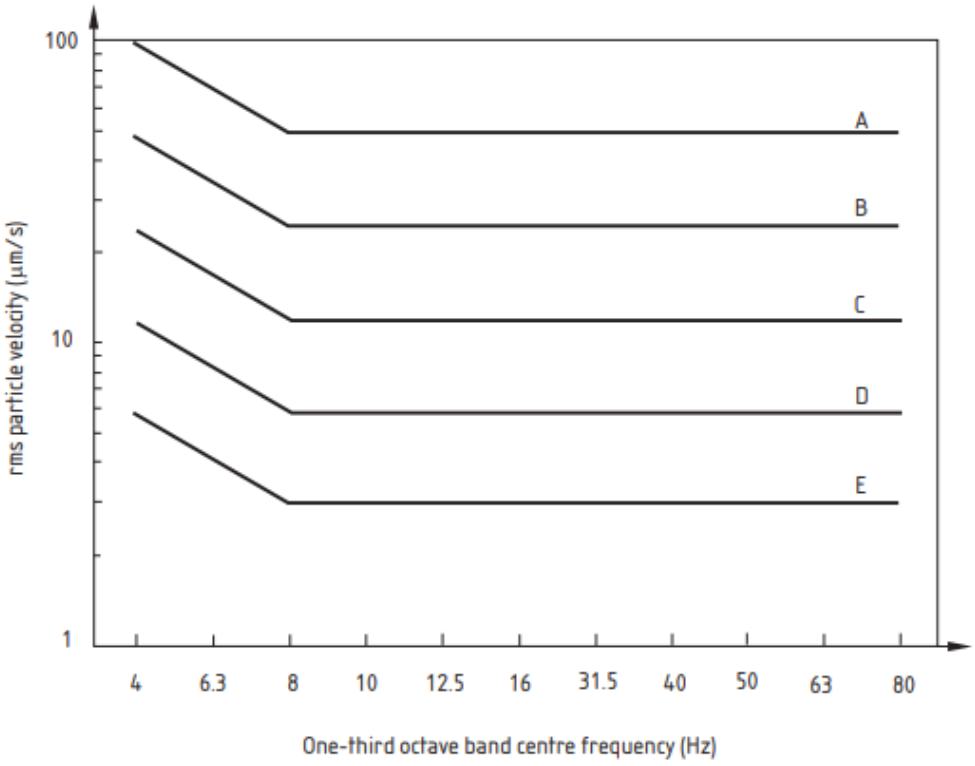
## APPENDIX E EXAMPLE VIBRATION CRITERIA FOR SENSITIVE EQUIPMENT

The following data is reproduced from Figure B.2 and Table B.3 of British Standard BS 5228-2:2009 *Code of practice for noise and vibration control on construction and open site – Part 2: Vibration* and is provided as a guide for the vibration magnitudes at which the operation of particularly sensitive mechanical or electrical equipment can be compromised.

The Standard also notes that:

> *"Where there is uncertainty concerning the level of transmitted vibration and its acceptability to the particular environment, it is advisable to investigate the actual conditions and requirements in detail. Preliminary trials and monitoring can then be designed to establish a suitable procedure for the work. Alternatively, vibration criteria can be established through discussion with the manufacturer, supplier or operator. Where case-specific information is not available, or if otherwise appropriate, reference may be made to information from other sources, such as previous experience or published information. Figure B.2 illustrates a suite of curves showing the sensitivity to vibration of a variety of equipment, taken from* [a] *reference* [see footnote 7]*."*

**Figure 10: Reproduction of Figure B.2 from BS 5528-2:2009 (Example of vibration criteria)**




*NOTE For key to graph, see Table B.3.*

[7] Citation in BS 5228-2:2009: Ungar E.E., Sturz D.H. and Amick C.H. Vibration control design of high technology facilities. *Sound and vibration*, July 1990.

**Table 14: Reproduction of Table B.3 from BS 5528-2:2009 (Key to vibration criteria illustrated in Figure B.2)**

| Curve (from Figure B.2) | Facility, equipment or use | rms vibration velocity, µm/s |
|---|---|---|
| A | Bench microscopes at up to 400× magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators. Microelectronics manufacturing equipment – Class A: Inspection, probe test, and other manufacturing support equipment. | 50 |
| B | Micro surgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400×; optical equipment on isolation tables. Microelectronics manufacturing equipment – Class B: aligners, steppers, and other critical equipment for photolithography with line widths of 3 µm or more. | 25 |
| C | Electron microscopes at up to 30 000× magnification; microtomes; magnetic resonance imagers. Microelectronics manufacturing equipment – Class C: aligners, steppers, and other critical equipment for photolithography with line widths of 1 µm. | 12 |
| D | Electron microscopes at greater than 30 000× magnification; mass spectrometers; cell implant equipment. Microelectronics manufacturing equipment – Class D: aligners, steppers, and other critical equipment for photolithography with line widths of 0.5 µm; includes electron-beam systems. | 6 |
| E | Microelectronics manufacturing equipment – Class E: aligners, steppers, and other critical equipment for photolithography with line widths of 0.25 µm; includes electron-beam systems; un-isolated laser and optical research systems. | 3 |

## APPENDIX F CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN

(following pages)

MARSHALL DAY Acoustics

# NEW DUNEDIN HOSPITAL: DEMOLITION NOISE AND VIBRATION MANAGEMENT PLAN

Rp 002 20190708 | 21 August 2019

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Project: **NEW DUNEDIN HOSPITAL: DEMOLITION**

Prepared for: **Ministry of Health**
**133 Molesworth Street**
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**Wellington 6011**

Attention: **Paul Perniskie**

Report No.: **Rp 002 20190708**



## Document Control

| Status: | Rev: | Comments | Date: | Author: | Reviewer: |
|---|---|---|---|---|---|
| DRAFT | | Draft for resource consent | 21 Aug 2019 | G Walton | |

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## 1.0 INTRODUCTION

Marshall Day Acoustics (MDA) has been engaged by the Ministry of Health (MoH) to prepare a Noise and Vibration Management Plan (NVMP) for the demolition phase of the New Dunedin Hospital project (NDH).

This NVMP is required to satisfy [INSERT Consent Condition]. It identifies the performance standards for the Project and sets out best practicable options (BPO) for noise and vibration management.

This NVMP should be implemented throughout the demolition and construction period. It should be considered a 'living document' that is expanded and updated as the Project progresses and working conditions become clearer. It is intended to be the primary tool to manage the Project's construction noise and vibration effects.

A glossary of terminology is included in Appendix A.

## 2.0 PROJECT DESCRIPTION

### 2.1 Overview

The works involve [Expand as required e.g. short description of the project or specific activity relevant to this document].

Site maps identifying [works, sensitive receivers, land marks, etc.] are attached in Appendix B.

The works are scheduled for approximately [X months], between [month year] and [month year]. Therefore, the long-duration construction noise limits apply (Section 3.2).

Construction hours will be 0730 – 1800 hrs, Monday to Saturday.

### 2.2 Construction Methodology

The construction methodology for this Project is summarised as follows:

- [e.g. site clearance works] (X days / weeks / months)
- [e.g. excavation and foundations] (X days / weeks / months)
- [e.g. building construction] (X days / weeks / months)

### 2.3 Contact Details

Contact details for the relevant personnel are included in Table 1. The <INSERT Project Manager> is ultimately responsible for implementing this NVMP.

**Table 1: Contacts**

| Role | Name | Organisation | Phone | Email |
|---|---|---|---|---|
| Project Manager | TBC | TBC | TBC | TBC |
| Acoustic Specialist | TBC | TBC | TBC | TBC |
| Public Complaints | TBC | TBC | TBC | TBC |

## 3.0 PERFORMANCE STANDARDS

### 3.1 Conditions of Consent

This NVMP is required to satisfy the following (proposed) conditions of consent:

1. <INSERT conditions of consent>

### 3.2 Noise

Construction noise must be measured and assessed in accordance with the provisions of New Zealand Standard NZS 6803:1999 "*Acoustics - Construction Noise*". The noise limits apply at 1m from external façades of occupied buildings.

The relevant construction noise limits from [Condition X (refer Section 3.1), are summarised in Table 2.

**Table 2: Construction noise levels for activities sensitive to noise[1] (e.g. occupied dwellings)**

| Time of week | Time period | Long-term duration[2] | |
|---|---|---|---|
| | | dB $L_{Aeq}$ | $L_{AFmax}$ |
| Weekdays | 0630 – 0730 | 55 | 75 |
| | 0730 – 1800 | 70 | 85 |
| | 1800 – 2000 | 65 | 80 |
| | 2000 – 0630 | 45 | 75 |
| Saturdays | 0730 – 1800 | 70 | 85 |
| | 1800 – 0630 | 45 | 75 |
| Sundays and public holidays | 0730 – 1800 | 55 | 85 |
| | 1800 – 0630 | 45 | 75 |

### 3.3 Vibration – Cosmetic Building Damage

Condition Y (refer Section 3.1) requires construction vibration to be measured and assessed in accordance with German Standard DIN 4150-3:1999 "*Structural vibration – Part 3: Effects of vibration on structures*". The short-term (transient)[3] vibration limits in Figure 1 apply at building foundations in any axis. The vibration limits in all other cases are summarised in Table 3.

[1] Activities sensitive to noise are defined as "*Any dwelling, visitor accommodations, boarding house, marae, Papakainga, integrated residential development, retirement village, supported residential care, care centres, lecture theatres in tertiary education facilities, classrooms in education facilities and healthcare facilities with an overnight stay facility*".

[2] Construction work at any one location with a duration exceeding 20 weeks.

[3] Short-term (transient) vibration is "*vibration which does not occur often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated*".

**Figure 1: Short-term (transient)[1] vibration at building foundations (DIN 4150-3:2016, Figure 1)**

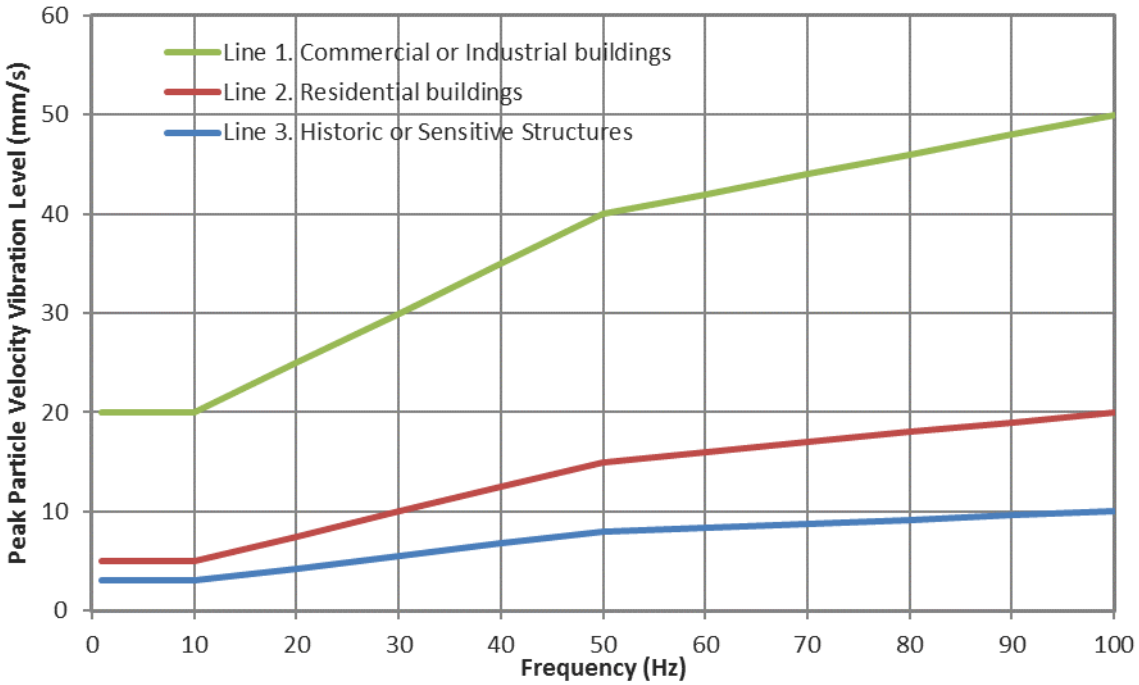



**Table 3: Vibration at horizontal plane of highest floor (DIN 4150-3:2016, Tables 1 and 3)**

| Structure Type | Peak Particle Velocity Vibration Level (mm/s) | |
|---|---|---|
| | Short-term (transient)[3] | Long-term (continuous)[4, 5] |
| Line 1. Commercial or Industrial buildings | 40 | 10 |
| Line 2. Residential buildings | 15 | 5 |
| Line 3. Historic or Sensitive Structures | 8 | 2.5 |

The criteria relate to the avoidance of cosmetic building damage, such as cracking in paint or plasterwork. Cosmetic building damage effects are deemed 'minor damage' in the Standard and can generally be easily repaired. The cosmetic building damage thresholds are much lower than those that would result in structural damage. The Standard states: "*Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur*."

## 4.0 PREDICTED LEVELS

### 4.1 Noise

Table 4 provides indicative construction noise levels for proposed activities. It should be used by the Project Manager (or nominated person) prior to construction to inform what equipment will require mitigation and/or management and when. It should be kept up to date by the project's Acoustic Specialist when new information becomes apparent through noise monitoring (Section 7.1) or other means.

[4] Long-term (continuous) vibration includes types not covered by the short-term vibration definition

[5] The long-term (continuous) criteria can apply at all floor levels, but levels are normally highest at the top floor

**Table 4: Indicative noise levels at 1m from a building façade[6] with effective noise barriers[7]**

| Equipment | Sound Power Level (dB $L_{Aeq}$) | Noise Level (dB $L_{Aeq}$) | | | Setback (m) |
|---|---|---|---|---|---|
| | | 10 m | 20 m | 50 m | 70 dB $L_{Aeq}$ |
| INSERT noise sources | | | | | |

The noise level received inside a noise sensitive space (e.g. an office or living room) will depend on the external noise level, sound insulation performance of the façade (particularly the glazing) and room details (such as the room dimensions and surface finishes). These factors can vary widely.

The Construction Noise Standard (NZS 6803) recommends noise limits assessed at 1m from the external façade of a building, assuming a façade sound level difference of 20 decibels. However, 20 decibels is particularly conservative for modern buildings. With knowledge of the façade glazing type, the sound insulation performance can generally be estimated as follows:

- Sealed glazing 30 decibels façade sound level difference
- Openable windows (closed) 20 – 25 decibels façade sound level difference
- Open windows 15 decibels façade sound level difference

Table 5 and Table 6 provides guidance on the effects in noise sensitive spaces during the day and night respectively, depending on the external noise level and façade glazing type. The potential effects are colour coded as follows:

Typically acceptable

Annoyance and reduction in work efficiency for some occupants (day)
Sleep disturbance for some occupants (night)

Annoyance and degradation of communication quality for most occupants (day)
Sleep disturbance for most occupants (night)

[6] In accordance with the requirements of NZS 6803: 1999 (Section 3.2), inclusive of 3 decibels façade reflection

[7] Assuming 10 decibels shielding from effective noise barriers (Section 5.5)

**Table 5: Daytime noise levels in commercial & industrial buildings and habitable rooms**

| External Noise Level (dB $L_{Aeq}$) | Estimated Internal Noise Level (dB $L_{Aeq}$) | | | |
|---|---|---|---|---|
| | Sealed glazing | Openable windows (modern building) | Openable windows (historic building) | Open windows |
| 90 – 95 | 60 – 65 | 65 – 70 | 70 – 75 | 75 – 80 |
| 85 – 90 | 55 – 60 | 60 – 65 | 65 – 70 | 70 – 75 |
| 80 – 85 | 50 – 55 | 55 – 60 | 60 – 65 | 65 – 70 |
| 75 – 80 | 45 – 50 | 50 – 55 | 55 – 60 | 60 – 65 |
| 70 – 75 | 40 – 45 | 45 – 50 | 50 – 55 | 55 – 60 |

**Table 6: Night-time noise levels in visitor accommodation bedrooms**

| External Noise Level (dB $L_{Aeq}$) | Estimated Internal Noise Level (dB $L_{Aeq}$) | | | |
|---|---|---|---|---|
| | Sealed glazing | Openable windows (modern building) | Openable windows (historic building) | Open windows |
| 70 – 75 | 40 – 45 | 45 – 50 | 50 – 55 | 55 – 60 |
| 65 – 70 | 35 – 40 | 40 – 45 | 45 – 50 | 50 – 55 |
| 60 – 65 | 30 – 35 | 35 – 40 | 40 – 45 | 45 – 50 |
| 55 – 60 | 25 – 30 | 30 – 35 | 35 – 40 | 40 – 45 |
| 50 – 55 | 20 – 25 | 25 – 30 | 30 – 35 | 35 – 40 |
| 45 – 50 | 15 – 20 | 20 – 25 | 25 – 30 | 30 – 35 |

## 4.2 Vibration

Table 7 provides indicative construction vibration levels for proposed activities that have the potential to result in vibration in building structures. It should be used by the Project Manager (or nominated person) prior to construction to inform what equipment will require mitigation and/or management and when. It should be kept up to date by the Acoustic Specialist when new information becomes apparent through vibration monitoring (Section 7.2) or other means.

**Table 7: Indicative distances to comply with vibration limits at building foundations**

| Equipment | Cosmetic Building Damage Setback (m)[8] | | |
|---|---|---|---|
| | Heritage 2.5 mm/s PPV | Residential 5 mm/s PPV | Commercial 10 mm/s PPV |
| INSERT vibration data | | | |

[8] Based on regression analysis of available vibration measurements, plus a 100% safety factor

| Equipment | Cosmetic Building Damage Setback (m)[8] | | |
|---|---|---|---|
| | Heritage 2.5 mm/s PPV | Residential 5 mm/s PPV | Commercial 10 mm/s PPV |

In some cases, construction vibration can excite building structures. This is heard as 'reradiated noise', rather than felt as vibration within the building, but is still the result of a structural transmission path. Predictions of reradiated noise levels are complex and site specific. Where necessary, a suitability qualified acoustic specialist should be engaged to provide guidance. Reradiated noise effects can be estimated using the guidance in Table 5 and Table 6 in Section 4.1.

## 5.0 MITIGATION AND MANAGEMENT

### 5.1 Training

All staff will participate in an induction training session prior to the start of construction, with attention given to the following matters:

- Construction noise and vibration limits
- Activities with the potential to generate high levels of noise and/or vibration (Section 4.0)
- Noise and vibration mitigation and management procedures (Section 5.0)
- The sensitivity of receivers and any operational requirements and constraints identified through communication and consultation (Section 6.0)

Awareness of current noise and vibration matters on, or near active worksites, will be addressed during regular site meetings and/or 'toolbox' training sessions.

### 5.2 Equipment Selection

When selecting construction equipment, where practicable:

- Prioritise quieter construction methodologies (e.g. bored piling instead of drop hammer piling)
- Prioritise electric motors over diesel engines
- Prioritise rubber tracked equipment over steel tracked equipment
- Equipment should be suitably sized for the proposed task
- Equipment should be maintained and fitted with exhaust silencers and engine covers
- Avoid tonal reversing or warning alarms (suitable alternatives may include flashing lights, broadband audible alarms or reversing cameras inside vehicles)

### 5.3 Scheduling

Where practicable, avoid night works. Where necessary, noisy works should be programmed early in the evening or night-time period to avoid sleep disturbance. Note that people tend to be less disturbed by low frequency, continuous engine noise, than intermittent noise or activities with special audible character (e.g. reversing beepers, whistling, banging tailgates or shouting).

Stakeholder engagement will be critical and should be undertaken for occupiers of properties within 100m of the night works (Section 6.0).

## 5.4 General Measures

Complaints can arise whether or not noise and vibration levels comply with the Project limits. To avoid complaints, general mitigation and management measures include, but are not be limited to, the following:

- Avoid unnecessary noise, such as shouting, the use of horns, loud site radios, rough handling of material and equipment, and banging or shaking excavator buckets
- Avoid steel on steel contact such as during the loading of scaffolding on trucks
- Avoid high engine revs through appropriate equipment selection and turn engines off when idle
- Maintain site accessways to avoid pot holes and corrugations
- Mitigate track squeal from tracked equipment, such as excavators (may include tensioning and watering or lubricating the tracks regularly)
- Minimise construction duration near sensitive receivers
- Stationary equipment (e.g. generators) should be located away from noise sensitive receivers and site buildings and material stores used to screen them
- Orient mobile machinery to maximise the distance between the engine exhaust and the nearest sensitive building façade (e.g. excavators)
- Utilise noise barriers and enclosures where appropriate (Section 5.5)
- Implement specialised mitigation measures for concrete cutting (Section 5.6), concrete breaking (Section 5.7), piling (Section 5.8)
- Ensure advanced communication is complete (Section 6.0) prior to commencing activities that are predicted to exceed the noise and vibration performance standards (Section 4.0)
- Where nearby sensitive receivers are identified with particularly noise and/or vibration sensitive equipment and/or activities (e.g. medical centres or laser eye surgery), a suitably qualified and experienced specialist (e.g. Member of the Acoustical Society of New Zealand) should review the performance standards (Section 4.0) to ensure they are appropriate and participate in consultation (Section 6.2).
- Undertake monitoring as appropriate (Section 7.0)

## 5.5 Noise Barriers

### 5.5.1 Temporary Noise Barriers

Temporary noise barriers should be used where a construction noise limit is predicted to be exceeded (Section 4.1) and the barriers would noticeably reduce the construction noise level. They should be installed prior to works commencing and maintained throughout the works. Effective noise barriers typically reduce the received noise level by 10 decibels.

Where practicable, the following guidelines should be incorporated in the design and utilisation of temporary noise barriers:

- The panels should be constructed from materials with a minimum surface mass of 6.5 kg/m$^2$. Suitable panels include 12 mm plywood or the following proprietary 'noise curtains':
  - Duraflex 'Noise Control Barrier - Performance Series' (www.duraflex.co.nz)
  - Soundex 'Acoustic Curtain - Performance Series' (www.ultimate-solutions.co.nz)
  - Flexshield 'Sonic Curtain with 4 kg/m$^2$ mass loaded vinyl backing' (www.flexshield.co.nz)

  - Alternatives should be approved by a suitably qualified acoustic specialist because some proprietary noise curtains have insufficient surface mass for general use
- The panels should be a minimum height of 2 m, and higher if practicable to block line-of-sight
- The panels should be abutted or overlapped to provide a continuous screen without gaps at the bottom or sides of the panels
- The panels should be positioned as close as practicable to the noisy construction activity to block line-of-sight between the activity and noise sensitive receivers

Where positioned on the site boundary, additional local barriers should be considered near the activity to ensure effective mitigation for sensitive receivers on upper floor levels.

### 5.5.2 Permanent Noise Barriers

Permanent boundary fences may be constructed, or existing fences upgraded, to provide effective noise mitigation during construction. However, where required for mitigating noise from future activities (post construction), the panels must be constructed from materials with a minimum surface mass of 10 kg/$m^2$, such as 18 mm plywood or 20 mm pine. Other guidelines for the design and utilisation of barriers are the same as those in Section 5.5.1.

## 5.6 Concrete Cutting

Where practicable:

- Minimise the cutting period, and, the number of cutting periods (e.g. complete all cutting in one extended period rather than two shorter periods with the same overall duration)
- Use a unit fitted with a blade shroud and a 'quiet' blade type (tooth design)

## 5.7 Concrete Breaking

Where practicable:

- Minimise the duration of breaking (e.g. small rocks should be excavated directly and larger boulders removed by truck for breaking offsite), and, the number of breaking periods (e.g. complete all breaking in one extended period rather than two shorter periods with the same overall duration)
- Match the size of breaker to the scale of the works (i.e. large enough to undertake the works efficiently, but avoiding oversized units)
- Match the chisel/tip type to the material and use a dampened bit to avoid ringing
- Avoid 'blank' firing by engaging the material before commencing and stopping before it fires through the material
- For concrete breaking, an initial perimeter saw cut should be made at the perimeter to reduce vibration transfer to nearby buildings
- For rock breaking, initial breaking should be undertaken at the perimeter of the rock excavation area. This will enable monitoring of the highest vibration levels received at nearby buildings for compliance purposes (Section 7.2). It will also mitigate the vibration transfer from subsequent breaking by creating a 'trench' of fractured rock between the breaker and nearby buildings.

## 5.8 Piling

Where practicable:

- Prioritise piling methods that minimise noise and vibration (e.g. augured, screw or press-in piles over impact driven or vibratory piling methods)

- TO BE COMPLETED ON RECEIPT OF FURTHER DETAIL

## 6.0 ENGAGEMENT

### 6.1 Communication

Written communication (e.g. newsletter) should be provided to occupiers of buildings within 40 m of the site at least 1 week prior to the Project commencing. It should acknowledge that some activities are predicted to generate high noise and/or vibration levels that may result in disturbance for short periods. It should include details of the overall works, its timing, duration and contact details where complaints and enquiries should be directed.

Written communication during the works:

- Public site signage should include contact details
- Regular project updates should include details of impending activities that may result in disturbance, including concrete cutting (Section 5.6), concrete breaking (Section 5.7) and piling (Section 5.8). It should include scheduled timing and duration of these activities and contact details where complaints and enquiries should be directed.
- Occupants of buildings within 100m of night works should be advised at least 5 days prior to the works commencing. While the communication should focus on construction noise as the predominant effect, it should also note the potential for perceptible vibration.

### 6.2 Consultation

Table 8 and Figure 4 in Appendix B identify sensitive receivers where noise and/or vibration is predicted to exceed the performance standards.

**Table 8: Sensitive receivers**

| Address | Building Type[9] | Occupancy | Noise (Section 4.1) | Vibration (Section 4.2) |
|---|---|---|---|---|
| | | | | Cosmetic Building Damage |
| X Name Street | Residential | Dwelling | X | X |
| Y Name Street | Commercial | XXX Retail Shop | X | - |

Consultation should be undertaken to address reasonable concerns about noise and vibration on a case-by-case basis. The <INSERT NAME> should address any concerns and complaints in accordance with Section 6.3. When discussing vibration concerns, it is important to convey that vibration can be felt at levels well below those that pose a risk of cosmetic building damage. A copy of all correspondence should be made available to Council upon request.

The following process will be implemented by the Project Manager (or nominated person). It is for any construction activity measured to exceed the relevant construction noise and vibration performance standards:

- For exceedances of the construction vibration standards, activities should cease as soon as safe and practicable to do so
- Review the construction methodology, mitigation measures and management strategies to ensure they represent the BPO. This should consider affected parties interests, practicability and material benefit of further measures, and implications to Project timing, duration and cost

[9] Classifications with respect to Tables 1 and 3 of DIN 4150-3:1999 *"Structural Vibration - Effects of Vibration on Structures"* (i.e. historic/sensitive, residential or commercial/industrial)

- Undertake consultation with affected parties to understand their sensitivities, including times, activities and locations. Consultation should focus on a collaborative approach to managing the adverse effects from construction noise and vibration. A project representative should be contactable during works. A record of consultation should be kept at the site office and be available to the affected parties and Council if requested.
- Implement measures to avoid significant adverse effects as agreed with the affected party and monitor the activity to verify the extent of any adverse effects
- For exceedances of the construction vibration cosmetic building damage thresholds in Section 3.3, a detailed building condition survey will be undertaken in accordance with Section 7.3. If damage has not occurred, then that activity can continue provided the measured vibration level is not exceeded further and the construction methodology is the BPO. If damage has occurred, alternative construction methods should be investigated, and the consent holder should commit to repairing the damage within a reasonable timeframe.
- The installation of mechanical ventilation should be considered for noise sensitive receivers where external windows must be closed to avoid significant adverse noise effects and no alternative ventilation system is present. This will be implemented only after all other general noise management and mitigation have been deemed impracticable.
- Temporary relocation should be considered for sensitive receivers where all practicable noise and vibration management and mitigation measures have been implemented and significant adverse noise effects are predicted. This will be in exceptional cases only, and advice from the Acoustic Specialist will be sought prior.

## 6.3 Complaints Response

All construction noise and/or vibration complaints should be recorded in a complaints file that is available to Council on request. For each complaint, an investigation should be undertaken involving the following steps as soon as practicable:

- Acknowledge receipt of the concern or complaint within 24 hours and record:
  - Time and date the complaint was received and who received it
  - Time and date of the activity subject to the complaint (estimated where not known)
  - The name, address and contact details of the complainant (unless they elect not to provide)
  - The complainant's description of the activity and its resulting effects
  - Any relief sought by the complainant (e.g. scheduling of the activity)
- Identify the relevant activity and the nature of the works at the time of the complaint
- If a reasonable complaint relates to building damage, inform the on-duty site manager as soon as practicable and cease associated works pending an investigation.
- Review the activity noise and/or vibration levels (Section 4.0) to determine if the activity is predicted to comply with the relevant performance standards (Section 0) at the complainants building. Consider addended monitoring to verify the underlying reference level assumptions.
- Review the mitigation and management measures in to ensure the activity represents the BPO (Section 5.0). Review the relief sought by the complainant. Adopt further mitigation and management measures as appropriate.
- Review the potential residual effects (Section 4.0) of activities that are predicted to exceed the relevant performance standards

- Report the findings and recommendations to the Project Manager, implement changes and update this NVMP as appropriate
- Report the outcomes of the investigation to the complainant, identifying where the relief sought by the complainant has been adopted or the reason(s) otherwise.

In most cases, ceasing the activity would provide immediate relief. In some cases, this may not be practicable for safety or other reasons. The complainant shall be kept updated regularly during the time it takes to resolve the matter.

## 7.0 MONITORING

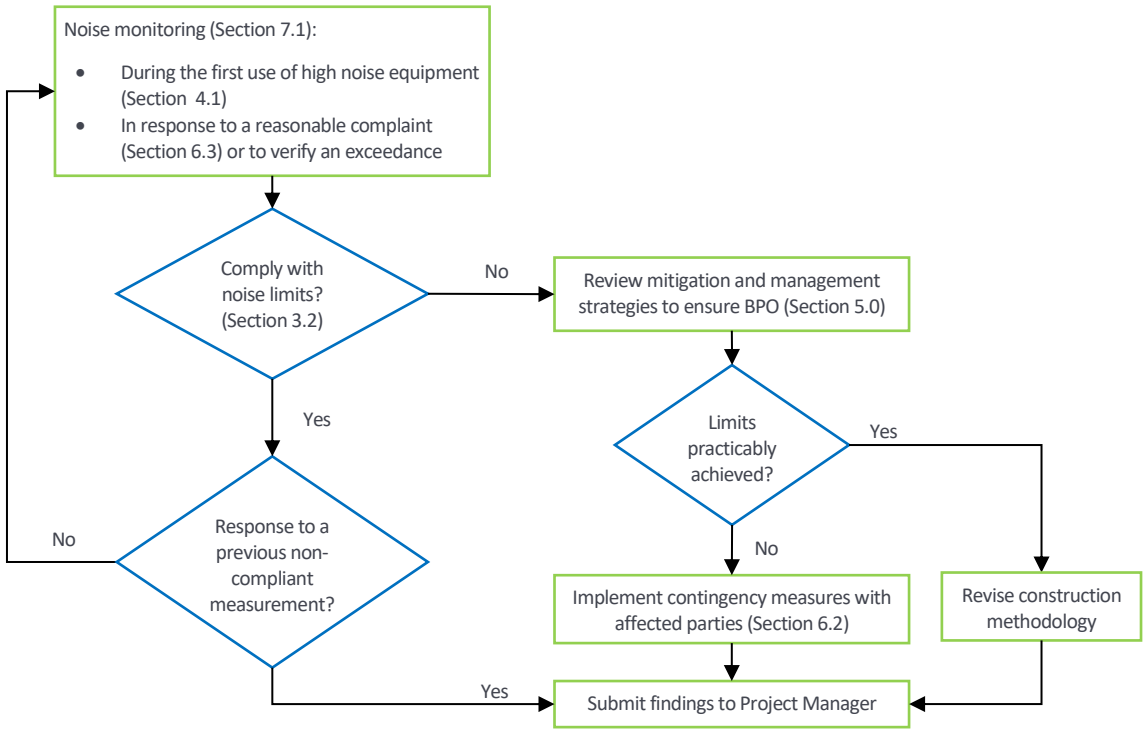
### 7.1 Noise

Noise levels should be monitored:

- During the first occurrence of [insert activity e.g. concrete breaking, sheet piling and other] activities that are predicted to exceed the noise limits (Section 4.1), and
- In response to a reasonable noise complaint (Section 6.3)
- At 1m from the most affected building façade, or proxy position and adjusted for distance and façade reflections where appropriate
- By a suitably qualified and experienced specialist (e.g. Member of the Acoustical Society of New Zealand) in accordance with the requirements of New Zealand Standard NZS 6803:1999 *"Acoustics - Construction Noise"*
- For a representative duration, reported with the measured level (e.g. 65 dB $L_{Aeq\,(30min)}$)
- The results should be used to update Section 4.1 if appropriate

A noise monitoring flowchart is presented in Figure 2.

**Figure 2: Noise Monitoring Flow Chart**



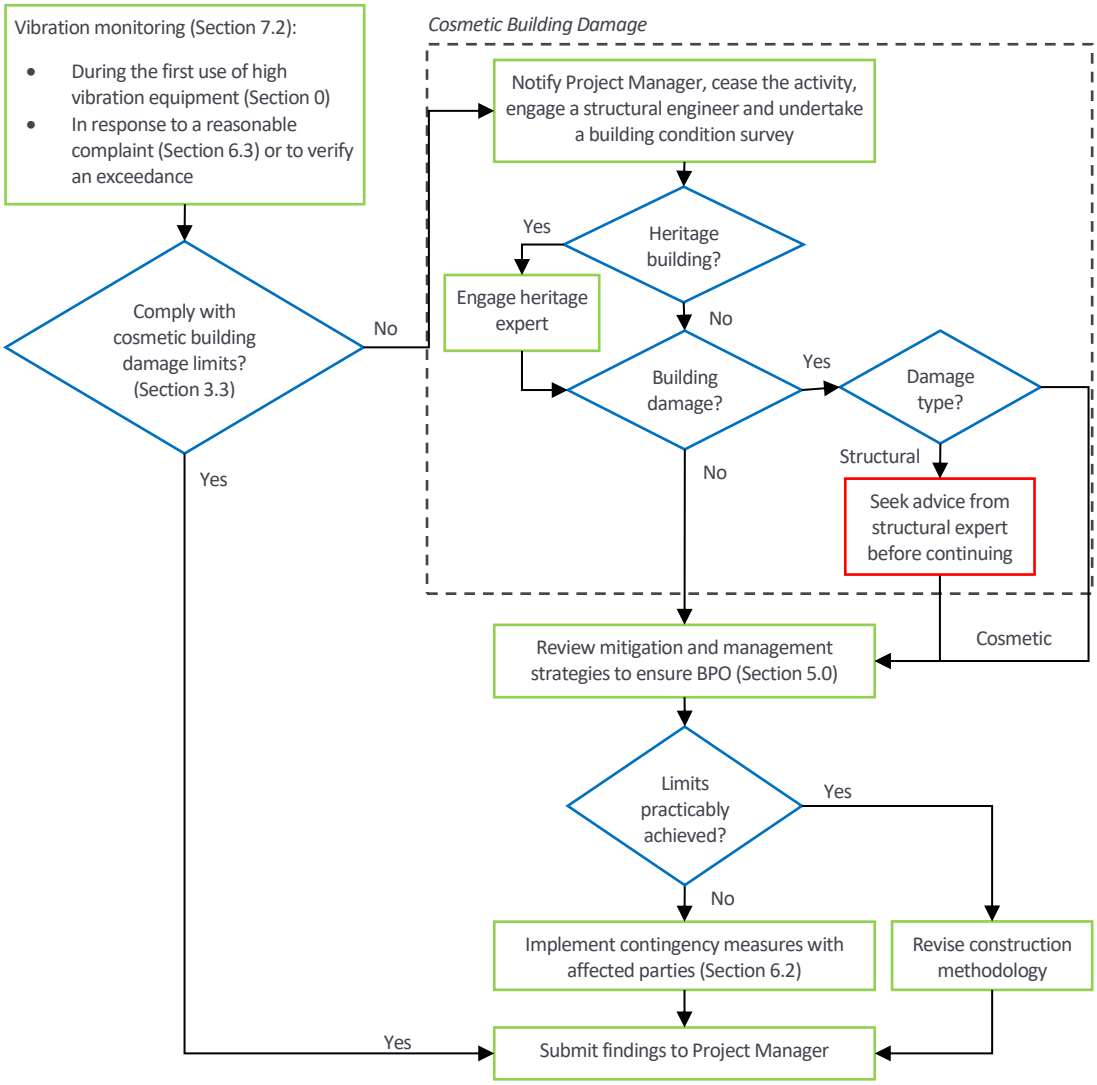

### 7.2 Vibration

Vibration should be monitored:

- During the first occurrence of [insert activity e.g. concrete breaking] activities that are predicted to exceed the vibration limits (Section 4.2) and following the completion of pre-construction building condition surveys (Section 7.3)
- In response to a reasonable vibration complaint (Section 6.3)
- At the closest building foundations and/or the top floor level as appropriate where consent to access the building of interest has been requested and granted
- By a suitably qualified and experienced specialist (e.g. Member of the Acoustical Society of New Zealand) in accordance the requirements of German Standard DIN 4150-3:2016 "*Vibration in buildings – Part 3: Effects on structures*"
- For a representative construction duration, measured in [2] second intervals
- The results should be used to update Section 4.2 if appropriate

A vibration monitoring flowchart is presented in Figure 3.

**Figure 3: Vibration Monitoring Flow Chart**




## 7.3 Building Condition Surveys

Cosmetic building damage (e.g. plaster or paint cracking) is an effect that is relevant to the building owner only (i.e. rather than tenants or leaseholders). People generally perceive vibration at levels

significantly lower than those levels that would result in cosmetic building damage and an understanding of this often alleviates receivers' concerns.

A condition survey should be undertaken for the following buildings (Sections 4.2 and 6.2):

- Address X (Building Type: historic / residential / commercial)
- Address Y (Building Type: historic / residential / commercial)
- Address Z (Building Type: historic / residential / commercial)

The Project Manager should request in writing the approval of the property owner to undertake a building condition survey at the following times:

- Prior to construction commencing, as required by Condition X (Section 3.1) and where vibration is predicted to exceed the cosmetic building damage limits (Section 4.2)
- During construction, as required by Condition Y (Section 3.1), where vibration is measured to exceed the cosmetic building damage limits in (Section 4.2) and/or in response to a reasonable claim of damage from construction vibration (Section 6.3)
- Post construction, as required by Condition Z (Section 3.1) and to avoid subsequent claims of damage from construction vibration (Section 6.3)

If a vibration exceedance has occurred but there is no resulting cosmetic damage, then that activity can continue provided the measured vibration level is not exceeded further and the construction methodology already adheres to the BPO. If damage has occurred, alternative construction methods should be investigated and the [the client] should rectify the damage at its own cost, as soon as practicable, in consultation with the owner of the property.

Each building condition survey should:

- Be undertaken by a suitably qualified person
- Provide a description of the building
- Determine the appropriate structure type classification[10] with respect to DIN 4150-3:2016 *"Vibration in buildings – Part 3: Effects on structures"* (i.e. historic/sensitive, residential or commercial/industrial)
- Document and photograph the condition of the building, including any cosmetic and/or structural damage
- The results should be provided to the property owner and be available to Council on request

[10] Classifications with respect to Tables 1 and 3 of DIN 4150-3:2016 *"Vibration in buildings – Part 3: Effects on structures"* (i.e. historic/sensitive, residential or commercial/industrial)

## APPENDIX A GLOSSARY OF TERMINOLOGY

| | |
|---|---|
| **Noise** | A sound that is unwanted by, or distracting to, the receiver. |
| **dB** | Decibel (dB) is the unit of sound level. Expressed as a logarithmic ratio of sound pressure (P) relative to a reference pressure (Pr), where dB = 20 x log(P/Pr). |
| **dBA** | The unit of sound level which has its frequency characteristics modified by a filter (A-weighted) to more closely approximate the frequency bias of the human ear. A-weighting is used in airborne acoustics. |
| $L_{Aeq\ (t)}$ | The equivalent continuous (time-averaged) A-weighted sound level commonly referred to as the average level. The suffix (t) represents the period, 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. |
| $L_{AFmax}$ | The A-weighted maximum noise level. The highest noise level which occurs during the measurement period. |
| **NZS 6803:1999** | New Zealand Standard NZS 6803: 1999 "Acoustics - Construction Noise" |
| **Vibration** | When an object vibrates, it moves rapidly up and down or from side to side. The magnitude of the sensation when feeling a vibrating object is related to the vibration velocity. Vibration can occur in any direction. When vibration velocities are described, it can be either the total vibration velocity, which includes all directions, or it can be separated into vertical (up and down vibration), horizontal transverse (side to side) and horizontal longitudinal direction (front to back) components. |
| **PPV** | Peak Particle Velocity (PPV) is the measure of the vibration amplitude, zero to maximum, measured in mm/s. |
| **BS 5228:2009** | British Standard BS 5228:2009 "Code of practice for noise and vibration control on construction and open sites, Part 1: Noise, Part 2: Vibration" |
| **DIN 4150-3:1999** | German Standard DIN 4150-3:1999 *"Structural Vibration - Effects of Vibration on Structures"* |

## APPENDIX B SITE

**Figure 4: INSERT SITE PLAN**