MARSHALL DAY Acoustics

HWCP INVERCARGILL CENTRAL DEMOLITION AND CONSTRUCTION NOISE AND VIBRATION

Rp 001 R01 20180801 | 23 July 2018

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Report No.: **Rp 001 R01 20180801**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Draft	-	For initial comment	20 July 2018	J Farren	G Walton
Approved	R01	Minor updates	23 July 2018	J Farren	G Walton

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1.0 INTRODUCTION

Marshall Day Acoustics (MDA) has been engaged by HWCP Management Ltd to assess noise and vibration associated with demolition of a number of buildings in the Invercargill CBD and subsequent construction of the proposed Invercargill Central.

This report reviews the proposed activities and assesses compliance against the applicable District Plan noise limits and is intended to support a Resource Consent Application, along with providing a framework for the management of construction noise and vibration effects once operational. In particular, this report provides:

- A description of the proposed development with respect to demolition and construction noise;
- Anticipated noise (and vibration) levels during demolition and construction work;
- A discussion of the applicable District Plan noise provisions and other appropriate guidance; and
- A draft noise and vibration management plan in order to minimise potential adverse noise effects.

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

2.0 DESCRIPTION

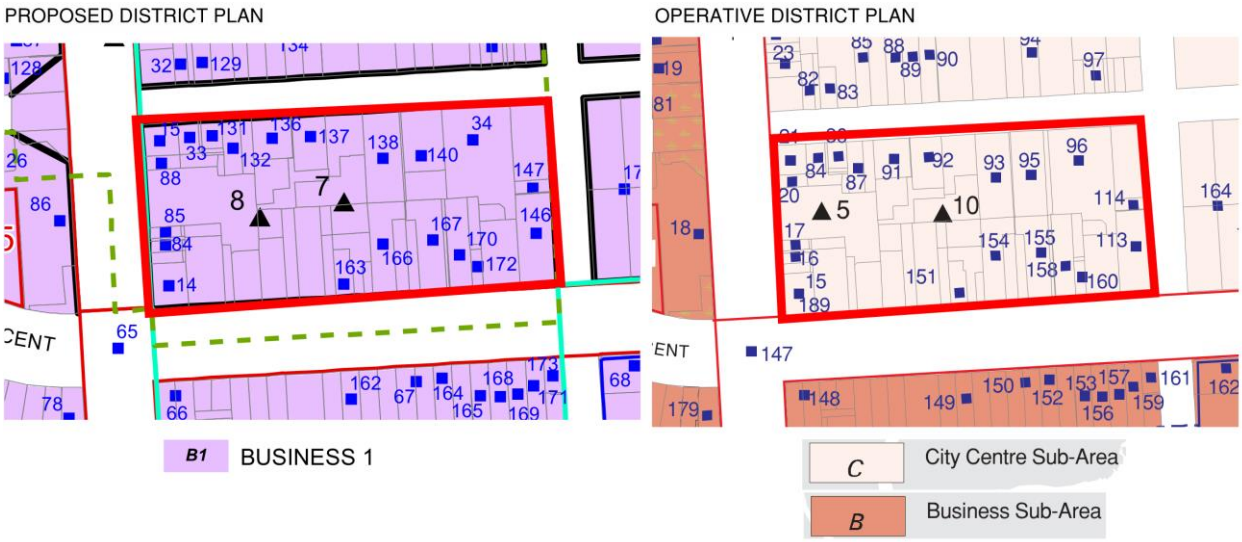
2.1 The Site

The application site is shown in Figure 1 and comprises almost all of the city block bounded by Esk, Kelvin, Tay and Dee Streets. The Kelvin Hotel, Reading Cinemas and currently vacant Bank of NSW sites do not form part of the proposed development.

Figure 1: Approximate extent of site

Figure 2 shows the underlying zoning of the site taken from both the operative and proposed versions of the Invercargill City District Plan. The approximate site extents are shown in red.

Figure 2: Operative and Proposed District Planning Map 9



Under both the operative and proposed District Plan, the proposed site and immediately adjacent sites are provided with a Business or City Centre zoning. With respect to noise, activities in these zones would typically generate a moderate degree of noise and are not considered to be particularly sensitive to noise received.

Whilst there are no residentially zoned properties in the immediate vicinity of the site, there are buildings with an accommodation function such the Kelvin Hotel, IBIS Apartments, Quest Apartments and other privately-owned apartments. We discuss these in greater detail in Section 3.0.

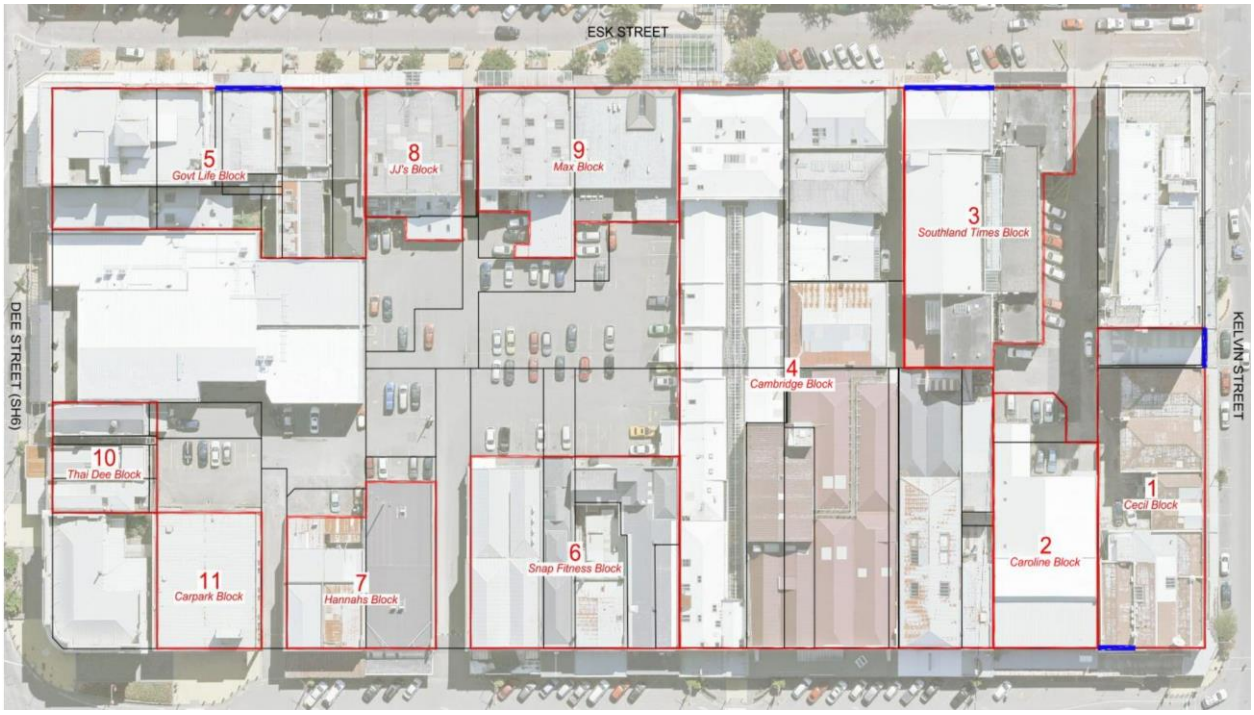
2.2 Proposed Demolition and Construction

2.2.1 Demolition

Extensive demolition works are required for the project. We have reviewed the *Demolition Management Plan* for the site prepared by Ryal Bush Demolition dated 3 July 2018. This document sets out the detail of the demolition process which is expected to occur over approximately 24 months. Demolition will occur over several stages that are loosely aligned with the configuration of the existing buildings as illustrated in Figure 3 and described below:

- Stage 1 – Cecil Block
- Stage 2 – Caroline Block
- Stage 3 – Southland Times Block
- Stage 4 – Cambridge Block
- Stage 5 – Govt Life Block
- Stage 6 – Snap Fitness Block
- Stage 7 – Hannahs Block
- Stage 8 – JJ's Block
- Stage 9 – Max Block
- Stage 10 – Thai Dee Block
- Stage 11 – Carpark Block

Figure 3: Demolition staging plan



Demolition will typically occur from within the site working towards the street boundary, which ensures that much of the demolition noise will be acoustically screened from neighbouring properties.

Whilst the demolition process will occur over 24 months, noise generating activity will be spread geographically over the site so that any one receiver location will only experience elevated noise levels for a relatively short period of time.

The proposed working hours from the demolition management plan are generally:

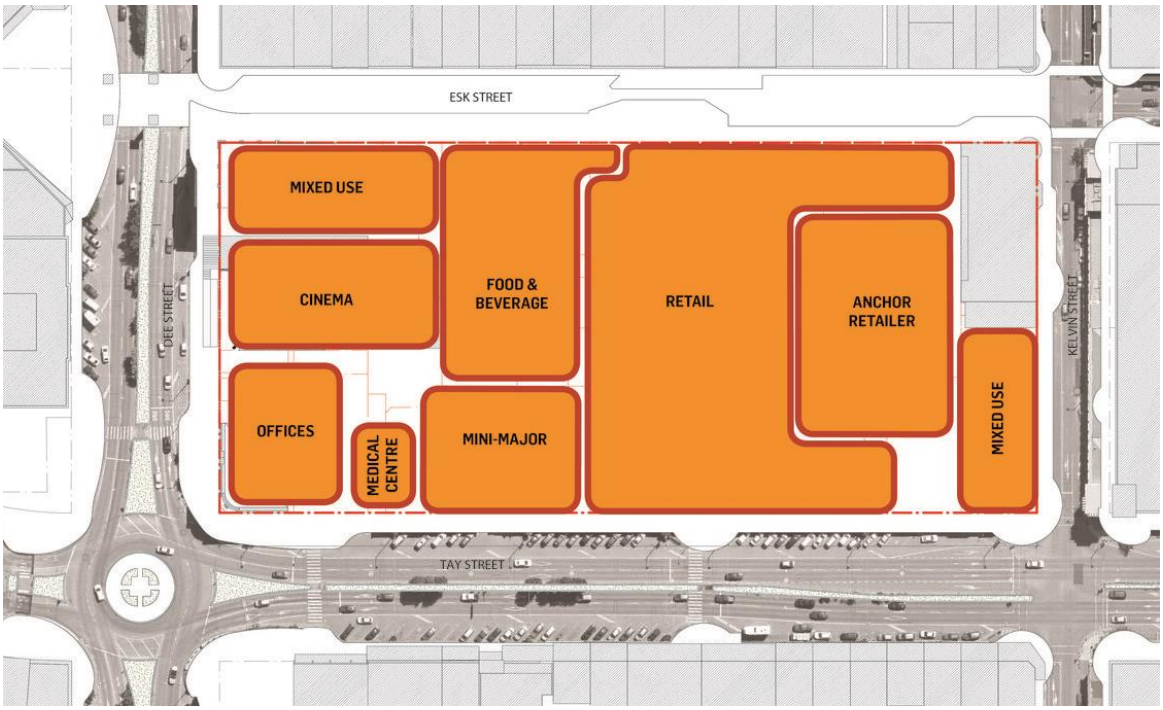
- 0730 to 1800 hrs Monday to Saturday; and
- No work permitted on Sundays or Public holidays

We note that work can occur out of these times provided that the applicable noise limits are met. Anticipated demolition noise levels are discussed in Section 6.0.

2.2.2 Construction

At this stage of the project, the plans for the final development are still being worked through. However, the development is expected to include several retail, office, medical, food and beverage outlets as indicated by the sketch in Figure 4.

Figure 4: Site Plan (source HWCP website)



Once demolition is complete, the construction process will likely include site preparation works followed by the foundation and erection of the building structure. The installation of roof and wall cladding will provide weather protection of the extensive internal works that are likely to be required. As with demolition noise, the construction works will have greatest impact the closer they are to a noise sensitive receiver.

Anticipated noise levels during the construction phase are discussed in Section 6.0.

3.0 RECEIVING ENVIRONMENT

As noted above, it is appropriate to consider potential noise effects at those properties around the site that are commercial in nature but have a residential function. We have also evaluated noise levels at the commercial properties immediately adjacent to the site.

Figure 5 identifies these properties and the noise assessment locations we have used for our analysis. These are:

Table 1: Description of noise sensitive locations shown in Figure 5

Position	Description
1	Representative of Esk St commercial properties to north of site
2	Representative of Dee St commercial properties to west of site including Quest Apartments
3	Representative of Tay St commercial properties to south of site including IBIS and other apartments
4	Representative of Kelvin St commercial properties to east of site
5	Reading Cinema
6	Kelvin Hotel

We understand that there are privately owned apartments at 13, 35/45 and 76 Tay Street.

Figure 5: Location plan showing noise assessment locations and properties with residence or visitor accommodation (shaded Green)

The daytime noise environment on Dee and Tay Streets is dominated by traffic. Both roads carry more than 7,000 vehicles per day[1] (AADT), corresponding to a noise level at the facade of these properties in excess of 60 dB L_{Aeq} during normal business hours.

[1] NZ transport Agency - State highway traffic volumes 1975–2017

Esk Street and Kelvin Street have significantly lower traffic volumes and ambient daytime noise levels are anticipated to be in the order of 50 dB L_{Aeq}.

4.0 CONSTRUCTION NOISE PERFORMANCE STANDARDS

The noise performance standards for the demolition and construction of the site are provided in the District Plan and NZS 6803: 1999 *"Acoustics - Construction Noise"*. These are summarised in the following sections.

For the purposes of our discussion, we have used the broader description of construction noise to apply to both demolition and construction noise sources.

4.1 Invercargill City District Plan

4.1.1 Operative District Plan

The operative District Plan does not address construction noise directly. Rule 4.34.1 requires noise to be assessed in accordance with the provisions of New Zealand Standard NZS 6802:1991 *"Assessment of Environmental Sound"* which, in turn, specifically excludes construction noise from its scope[2] and instead directs the reader other Standards.

Industry best practice is to assess construction noise against NZS 6803:1999 which provides both recommended noise levels and construction noise management techniques. We discuss this Standard in greater detail below.

4.1.2 Proposed District Plan

Rule 3.13.4 of the proposed District Plan states that construction noise shall comply with the following noise limits:

- Monday to Saturday 0730 to 1800 70 dB L_{Aeq} and 85 dB L_{Amax}
- All other times 45 dB L_{Aeq} and 75 dB L_{Amax}

Where an activity does not meet these noise standards it is a *discretionary* activity. These noise limits are a simplified interpretation of the recommended long-term duration construction noise limits for residential areas from NZS 6803:1999.

[2] NZS 6802:1991 *"Assessment of Environmental Sound",* Section 1.2

4.2 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 2 and Table 3. The noise limits apply at 1m from external façades of occupied buildings.

Table 2: NZS 6803 Recommended upper limits for construction noise received in residential zones)

Time of week	Time period	Typical duration[3]		Short-term duration[4]		Long-term duration[5]	
		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

Table 3: NZS 6803 Recommended upper limits for construction noise received in commercial areas

Time of week	Time period	Typical duration[3]	Short-term duration[4]	Long-term duration[5]
		dB L_{Aeq}	dB L_{Aeq}	dB L_{Aeq}
All days	0730 – 1800	75	80	70
	1800 – 0730	80	85	75

[3] Construction work at any one location for more than 14 calendar days but less than 20 weeks

[4] Construction work at any one location for up to 14 calendar days

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

4.3 Discussion of Criteria

There is an apparent conflict between the construction noise requirements of both the operative and proposed District Plan. The former directs the noise assessment to be conducted in line with NZS 6803 whereas the latter is prescriptive in the noise limits to be assessed against.

For this project the receiving environment is commercial in nature and therefore the commercial area noise limits from Table 2 would typically be applied under the operative plan. The proposed plan noise limits are more appropriate for residential areas. A comparison of the noise limits is provided in Table 4.

Table 4: Comparison of operative and proposed District Plan noise limits for commercial areas

District Plan		Noise limit for long term construction	
		Day	Night
Operative	NZS 6803 Table 2	70 dB L_{Aeq}	75 dB L_{Aeq}
Proposed	Rule 3.13.4	70 dB L_{Aeq}	45 dB L_{Aeq}

For this project, there is a difference of 30 dB L_{Aeq} in applicable night-time noise limit between both versions of the District Plan. However, we note that the status of this project is *non-complying* for reasons other than noise and therefore it is appropriate for us to assess the potential effects of the proposed activity.

Whilst the receiving environment around the site is commercial in nature, several properties have a residential function (e.g. visitor accommodation) and it is appropriate to provide appropriate protection of sleep at night.

For that reason, we recommend that the NZS 6803 residential noise criteria for long -term duration construction projects be adopted in this instance (as set out in Table 2 above). As we will discuss shortly in Section 6.0, we anticipate that construction actives will comply with these limits for most of the time. However, there may be occasions when the limits are exceeded, such as when work is occurring directly adjacent to a site boundary. In respect of noise, this will make the activity *discretionary* under both the operative and proposed District Plans – as noted above the activity is *non-complying* for other reasons.

5.0 VIBRATION PERFORMANCE STANDARDS

We note that neither the operative nor proposed District Plan provide vibration noise limits but vibration is listed as a matter for Council's discretion in some situations.

Construction and demolition work that potentially affects the structure of buildings is normally subject to the vibration guidelines in German Standard DIN 4150-3:1999 *"Structural Vibration – Effects of vibration on structures"*. These guideline values are intended to ensure that material vibration damage to structures does not occur. The short-term (transient)[6] vibration limits in Figure 6 apply at building foundations in any axis. 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 has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur"*.

Figure 6: Short-term (transient)[1] vibration at building foundations (DIN 4150-3 1999: Figure 1)

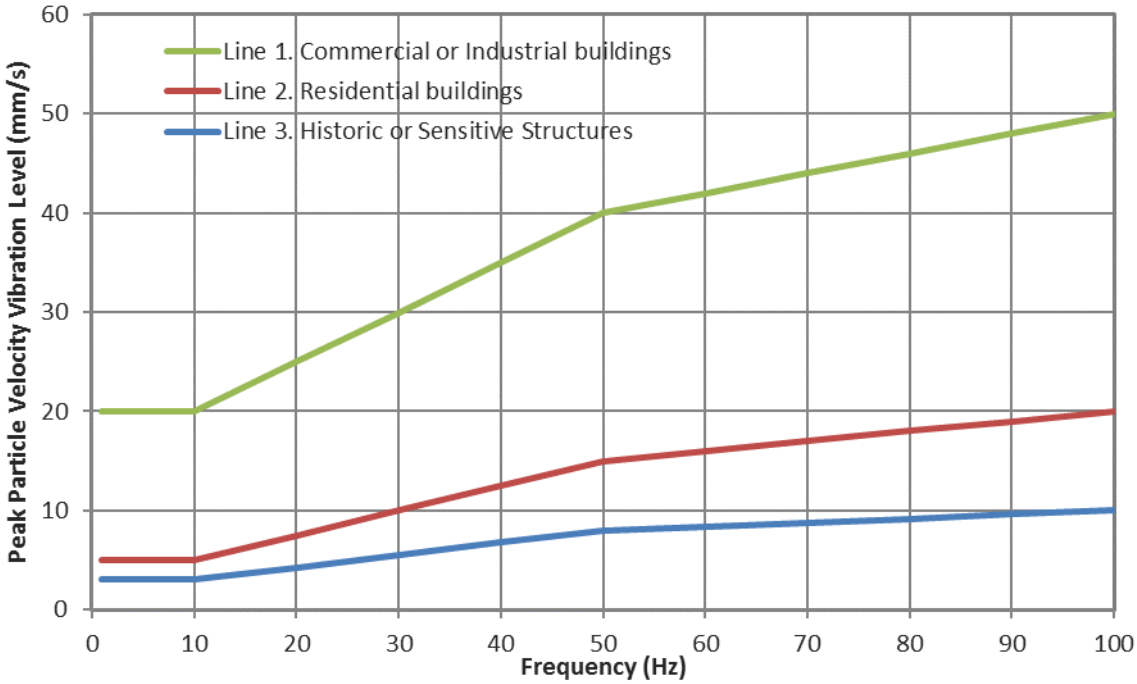


Table 5: Vibration at horizontal plane of highest floor (DIN 4150-3 1999: Tables 1 and 3)

Structure Type	Peak Particle Velocity (PPV) Vibration Level (mm/s)	
	Short-term (transient)[6]	Long-term (continuous)[7, 8]
Line 1. Commercial or Industrial buildings	40	10
Line 2. Residential buildings	15	5
Line 3. Historic or Sensitive Structures	8	2.5

[6] 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*".

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

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

6.0 CONSTRUCTION NOISE LEVELS

This section provides a comprehensive list of construction noise sources that can be encountered during a typical demolition and construction project. We have provided a general summary of potential noise generation in addition to a specific assessment of the noise sensitive locations, discussed in Section 6.2 through to Section 6.6.

6.1 Construction Activities

Table 6 presents the construction noise levels that may be generated on site and are to be used a screening tool for potential noise effects during each phase of the demolition and construction program. Where excessive noise levels are anticipated at specific locations, additional noise mitigation and management measures can be employed to ensure effects are appropriate.

Predicted noise levels are 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 will not be experienced on a continuous basis of the duration of the project.

The detailed list of noise sources used in these calculations is provided in Appendix B.

Table 6: Summary of noise levels during each anticipated phase

Anticipated Staging Plan	Activity Combined Sound Power	Activity Mitigation	Activity Noise Level (Façade), dB L_{Aeq} at distance, m				Required Setback, m to achieve
	dB L_{Aw}	dB	5	10	20	50	70 dB L_{Aeq}
DEMOLITION PHASE							
1 Site preparation							
a Disconnect services	109	10	**80**	**74**	68	59	16
b Establish office/laydown area	110	10	**81**	**75**	69	59	18
c Asbestos survey and removal	111	10	**82**	**76**	70	61	20
d Erect fencing/hoarding	110	10	**81**	**75**	69	60	18
2 Demolition of each stage							
a Cut and remove roof structures	110	10	**81**	**75**	69	60	19
b Cut and remove wall/floor sections	117	10	**88**	**82**	**76**	67	37
c Remove waste	106	10	**77**	**71**	65	55	11
d Breakout and remove slab and foundations	120	10	**91**	**85**	**79**	70	48
e Site levelling	114	10	**85**	**79**	**73**	63	27

Anticipated Staging Plan		Activity Combined Sound Power	Activity Mitigation	Activity Noise Level (Façade), dB L_{Aeq} at distance, m				Required Setback, m to achieve
		dB L_{Aw}	dB	5	10	20	50	70 dB L_{Aeq}
CONSTRUCTION PHASE								
3	Earthworks and piling[1]	110	10	**81**	**75**	69	60	19
4	Superstructure	112	10	**83**	**77**	**71**	61	21
5	Roof and cladding	112	10	**83**	**77**	**71**	61	21
6	Internal fitout (external plant)	96	10	67	61	55	46	4
7	Landscaping, etc.	114	10	**85**	**79**	**73**	63	27
8	Deliveries/laydown area	105	10	**76**	70	64	55	10

[1] With bored piles the source of the noise is mainly the engine/exhaust rather than the auger. The piling rig would be orientated to maximise the distance between the engine exhaust and the nearest sensitive building façade.

In the following sections, we have used the predicted noise levels from Table 6 to assist with screening those activities with the potential to generate excessive construction noise levels at each identified receiver location.

6.2 Position 1 – Esk Street Commercial Properties

This location will be subject to the highest noise levels during demolition of the stages listed below and shown in Figure 7:

- Stage 3 – Southland Times Block
- Stage 4 – Cambridge Block
- Stage 5 – Govt Life Block
- Stage 8 – JJ's Block
- Stage 9 – Max Block

Figure 7: Construction stages affecting Esk St commercial properties

All demolition and construction work will occur on the opposite side of the Esk St from these properties, with a minimum separation distance of approximately 20 metres. Table 7 discusses the noise level generation during each phase of the project.

Table 7: Construction noise levels at Position 1 – Esk Street

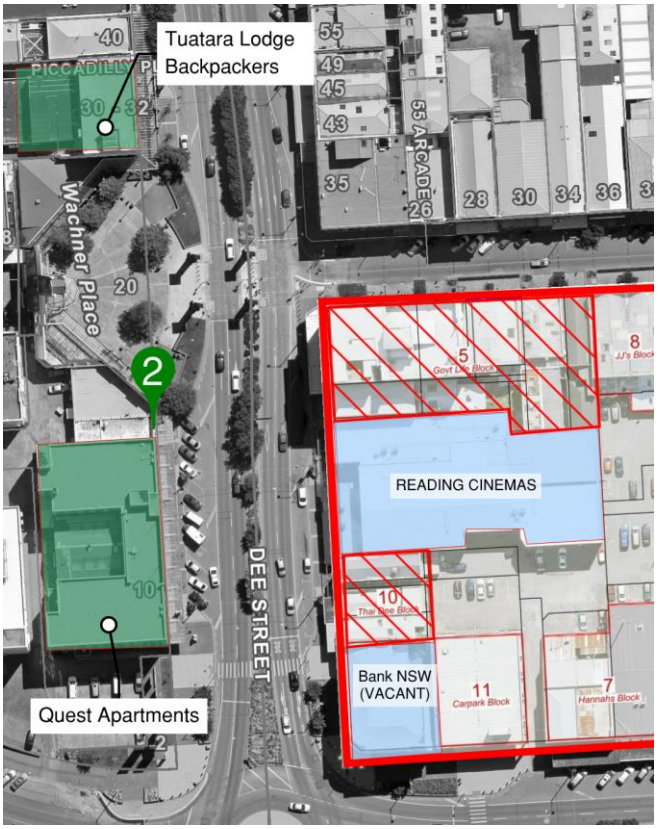
Scenario	Activity	Potential to exceed criteria
Site Preparation	Various power tools and light mobile machinery	Unlikely to exceed 70 dB L_{Aeq} at any time
Demolition of each stage	Long reach excavator with nibbler, concrete saw, etc.	Demolition activities are expected to move from the south towards the Esk Street façade. The noise reduction provided by the façade will mean that noise generation will be generally be below 70 dB L_{Aeq} apart from the last stages where the facades have been removed
Earthworks and piling	Heavy machinery e.g. compactors, piling rigs	Unlikely to exceed 70 dB L_{Aeq} apart from work at closest points when there may be a negligible excess.
Structure	Cranes, elevated work platforms, hand tools	Unlikely to exceed 70 dB L_{Aeq} apart from work at closest points when there may be a negligible excess
Roof and cladding	Cranes, elevated work platforms, hand tools	Unlikely to exceed 70 dB L_{Aeq} at any time
Internal fitout (external plant)	External generators, cranes, vehicles	Unlikely to exceed 70 dB L_{Aeq} at any time
Landscaping, etc.	Mobile machinery and hand tools	If extensive landscaping is required, there will some potential to exceed 70 dB L_{Aeq}.
Deliveries/laydown area	Trucks and other mobile plant	Unlikely to exceed 70 dB L_{Aeq} at any time

6.3 Position 2 – Dee Street commercial properties

This location will be subject to the highest noise levels during demolition of the stages listed below and shown in Figure 8:

- Stage 5 – Govt Life Block
- Stage 10 – Thai Dee Block

Figure 8: Construction stages affecting Dee St commercial properties



All demolition and construction work will occur on the opposite side of the Dee St from these properties, with a minimum separation distance of approximately 40 metres. Table 8 discusses the noise level generation during each phase of the project.

Table 8: Construction noise levels at Position 2 – Dee Street

Scenario	Activity	Potential to exceed criteria
Site Preparation	Various power tools and light mobile machinery	Unlikely to exceed 70 dB L_{Aeq} at any time
Demolition of each stage	Long reach excavator with nibbler, concrete saw, etc.	Demolition activities are expected to move from south towards the Dee Street façade. The noise reduction provided by the façade will mean that noise generation will be generally be below 70 dB L_{Aeq} apart from the last stages where the facades have been removed and some further concrete removal may be required.
Earthworks and piling	Heavy machinery e.g. compactors, piling rigs	Unlikely to exceed 70 dB L_{Aeq} at any time

Scenario	Activity	Potential to exceed criteria
Structure	Cranes, elevated work platforms, hand tools	Unlikely to exceed 70 dB L_{Aeq} at any time
Roof and cladding	Cranes, elevated work platforms, hand tools	Unlikely to exceed 70 dB L_{Aeq} at any time
Internal fitout (external plant)	External generators, cranes, vehicles	Unlikely to exceed 70 dB L_{Aeq} at any time
Landscaping, etc.	Mobile machinery and hand tools	Unlikely to exceed 70 dB L_{Aeq} at any time
Deliveries/laydown area	Trucks and other mobile plant	Unlikely to exceed 70 dB L_{Aeq} at any time

6.4 Position 3 – Tay Street commercial properties

This location will be subject to the highest noise levels during demolition of the stages listed below and shown in Figure 9:

- Stage 1 – Cecil Block
- Stage 2 – Caroline Block
- Stage 4 – Cambridge Block
- Stage 6 – Snap Fitness Block
- Stage 7 – Hannahs Block
- Stage 11 – Carpark Block

Figure 9: Construction stages affecting Tay St commercial properties

All demolition and construction work will occur on the opposite side of the Tay St from these properties, with a minimum separation distance of approximately 40 metres. Table 9 discusses the noise level generation during each phase of the project.

Table 9: Construction noise levels at Position 3 – Tay Street

Scenario	Activity	Potential to exceed criteria
Site Preparation	Various power tools and light mobile machinery	Unlikely to exceed 70 dB L_{Aeq} at any time
Demolition of each stage	Long reach excavator with nibbler, concrete saw, etc.	Demolition activities are expected to move from south towards the Dee Street façade. The noise reduction provided by the façade will mean that noise generation will be generally be below 70 dB L_{Aeq} apart from the last stages where the facades have been removed and some further concrete removal may be required.
Earthworks and piling	Heavy machinery e.g. compactors, piling rigs	Unlikely to exceed 70 dB L_{Aeq} at any time
Structure	Cranes, elevated work platforms, hand tools	Unlikely to exceed 70 dB L_{Aeq} at any time
Roof and cladding	Cranes, elevated work platforms, hand tools	Unlikely to exceed 70 dB L_{Aeq} at any time
Internal fitout (external plant)	External generators, cranes, vehicles	Unlikely to exceed 70 dB L_{Aeq} at any time
Landscaping, etc.	Mobile machinery and hand tools	Unlikely to exceed 70 dB L_{Aeq} at any time
Deliveries/laydown area	Trucks and other mobile plant	Unlikely to exceed 70 dB L_{Aeq} at any time

6.5 Position 4 – Kelvin Street commercial properties

This location will be subject to the highest noise levels during demolition of the stages listed below and shown in Figure 10:

- Stage 1 – Cecil Block
- Stage 2 – Caroline Block
- Stage 4 – Cambridge Block
- Stage 6 – Snap Fitness Block
- Stage 7 – Hannahs Block
- Stage 11 – Carpark Block

Figure 10: Construction stages affecting Kelvin St commercial properties

All demolition and construction work will occur on the opposite side of Kelvin St from these properties, with a minimum separation distance of approximately 20 metres. Table 10 discusses the noise level generation during each phase of the project.

We note that the apartments at 76 Tay Street are acoustically screened from the construction work by the intervening H&J Smith department store and, correspondingly, anticipated noise levels will be significantly less than those discussed below in Table 10.

Table 10: Cconstruction noise levels at Position 4 – Kelvin Street

Scenario	Activity	Potential to exceed criteria
Site Preparation	Various power tools and light mobile machinery	Unlikely to exceed 70 dB L_{Aeq} at any time
Demolition of each stage	Long reach excavator with nibbler, concrete saw, etc.	Demolition activities are expected to move from the south and west towards the Kelvin Street façade. The noise reduction provided by the façade will mean that noise generation will be generally be below 70 dB L_{Aeq} apart from the last stages where the facades have been removed.
Earthworks and piling	Heavy machinery e.g. compactors, piling rigs	Unlikely to exceed 70 dB L_{Aeq} apart from work at closest points when there may be a negligible excess.
Structure	Cranes, elevated work platforms, hand tools	Unlikely to exceed 70 dB L_{Aeq} apart from work at closest points when there may be a negligible excess
Roof and cladding	Cranes, elevated work platforms, hand tools	Unlikely to exceed 70 dB L_{Aeq} at any time
Internal fitout (external plant)	External generators, cranes, vehicles	Unlikely to exceed 70 dB L_{Aeq} at any time
Landscaping, etc.	Mobile machinery and hand tools	If extensive landscaping is required, there will some potential to exceed 70 dB L_{Aeq}.
Deliveries/laydown area	Trucks and other mobile plant	Unlikely to exceed 70 dB L_{Aeq} at any time

6.6 Positions 5 and 6 – The Kelvin Hotel and Reading Cinemas

As demolition and construction work will be occurring right up to the boundary of these properties, they will be subject to relatively high noise levels and, at times, these might significantly exceed 70 dB L_{Aeq}. However, in terms of potential disturbance, it is the noise that is received within these buildings that is of the greatest interest. We discuss each building in turn below.

6.6.1 Kelvin Hotel

We understand that hotel's main function is visitor accommodation and, as such, night-time noise effects and potential sleep disturbance are important to consider. No construction work is proposed at night and therefore sleep amenity should be preserved. The proposed night-time noise limits for the activity will ensure this.

However, the hotel may host conferences and other similar noise sensitive functions during the day and construction work has the potential to interfere with these activities.

Figure 11 shows Google Street View images of the southern and western hotel façades. The general absence of windows in the southern façade means that work during *Stage 1 Cecil Block* is likely to generate lower internal noise levels than work adjacent to the west façade with its significant areas of glazing.

Figure 11: Kelvin Hotel south and west façades (Source: Google Street View)

As noted in the *Ryal Bush Demolition Management Plan*, ongoing dialogue with the hotel owners (Invercargill Licensing Trust) will be critical to ensure minimal disruption during the day.

6.6.2 Reading Cinemas

We anticipate that the cinemas busiest times are evenings and weekends when no significant demolition and construction work will be occurring. There should therefore be no disruption to the cinemas during these times.

However, the cinemas do offer several viewings during the day when demolition work will be in progress. It is possible that some demolition activities during *Stage 5 Govt Life Block* and *Stage 10 Thai Dee Block* may generate internal noise levels that prevent use of cinemas.

This possibility has already been highlighted in Section 2.4 of the *Demolition Management Plan* and dialogue between Reading Cinemas management and contractors is encouraged.

7.0 CONSTRUCTION VIBRATION LEVELS

Table 11 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 applicable criteria.

Table 11: Indicative distances to comply with vibration limits at building foundations

Equipment	Cosmetic Building Damage Setback (m)[9]		
	Heritage 2.5 mm/s PPV	Residential 5 mm/s PPV	Commercial 10 mm/s PPV
Vibratory Roller	30	14	6
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.

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

8.0 DISCUSSION OF CONSTRUCTION NOISE LEVELS

The analysis in the preceding sections confirms that the proposed activity has the potential to exceed the applicable noise limits from NZS 6803 when work is occurring close to adjacent properties. Short term exceedances of the applicable noise limits can be unavoidable in some situations. 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.

Construction activities will not typically occur at night and therefore provide adjacent visitor accommodation will have an appropriate noise environment for protection of sleep.

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

A CNVMP should be a requirement for this project as a condition of consent 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 construction noise and vibration
- Noise and vibration monitoring requirements, with triggers and feedback mechanisms
- Communication, consultation and complaints response protocols

We have provided a draft CNVMP as Appendix C.

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

9.0 ASSESSMENT OF CONSTRUCTION NOISE AND VIBRATION EFFECTS

While construction noise is usually undesirable, it is 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 and vibration levels will be generally reasonable with the adoption and implementation of a Construction Noise and Vibration Management Plan (CNVMP). This CNVMP should outline the Best Practicable Option (BPO) measures to mitigate construction noise and vibration.

10.0 PROPOSED CONDITIONS OF CONSENT

We recommend that the following conditions be included in any consent granted.

1. Construction noise (including demolition) shall comply with the recommended residential noise limits for long term construction taken from Table 2 of NZS 6803: 1999 *"Acoustics - Construction Noise"* as far as practicable.
2. A Construction Noise and Vibration Management Plan (CNVMP) must be prepared by a suitably qualified person and submitted to Invercargill City Council 5 days prior to the commencement of the works. At a minimum, the CNVMP must address the relevant measures in Annex E of NZS 6803:1999 "*Acoustics - Construction Noise*" and Appendix B of DIN 4150-3:1999 "*Structural vibration - Part 3 Effects of vibration on structures*". The CNVMP must be implemented throughout the project and a copy must be maintained on site.

APPENDIX A GLOSSARY OF TERMINOLOGY

SPL or L_P	Sound Pressure Level. 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. 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.
dB	Decibel - The unit of sound level. 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.
$L_{Aeq\,(t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (15 min) would represent a period of 15 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{Amax}	The A-weighted maximum noise level. The highest noise level which occurs during the measurement period.
NZS 6801:2008	New Zealand Standard NZS 6801:2008 *"Acoustics – Measurement of environmental sound"*
NZS 6802:2008	New Zealand Standard NZS 6802:2008 *"Acoustics – Environmental Noise"*
NZS 6803:1999	New Zealand Standard NZS 6803: 1999 "Acoustics - Construction Noise"
DIN 4150-3:1999	German Standard DIN 4150-3:1999: "Structural Vibration - Effects of Vibration on Structures"
BS 5228-1:2009	British Standard BS 5228-1:2009: "Code of practice for noise and vibration control on construction and open sites"
PPV	Peak Particle Velocity For Peak Particle Velocity (PPV) is the measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment.

APPENDIX B CONSTRUCTION NOISE SOURCE LEVELS

#	Anticipated Staging Plan	Equipment	BS 5228 Ref.	Quantity	Sound Power	Usage Time	Source Mitigation	Source Rating Level	Activity Sound Power	Activity Mitigation	Activity Noise Level (Façade), dB L_{Aeq} at distance, m				Required Setback, m
					dB L_{Aw}	%	dB	dB L_{Aw}	dB L_{Aw}	dB	5	10	20	50	70
DEMOLITION PHASE															
1	*Site preparation*														
a	Disconnect services	Hand tools	D2.15	1	112.0	50%	0	109.0	109	10	80	74	68	59	16
b	Establish office/laydown area	small mobile crane	C4.41	1	99.0	50%	0	96.0	110	10	81	75	69	59	18
		Hand tools	D2.15	1	112.0	50%	0	109.0							
		Roller	C2.39*	1	102.0	50%	0	99.0							
		Bobcat	C4.55	2	98.0	50%	0	98.0							
c	Asbestos survey and removal	Hand tools	D2.15	1	112.0	50%	0	109.0	111	10	82	76	70	61	20
		Grinder/saw	C4.72	1	107.0	50%	0	104.0							
		Air extraction system	C4.72	1	107.0	50%	0	104.0							
d	Erect fencing/hoarding	Hand tools	D2.15	1	112.0	50%	0	109.0	110	10	81	75	69	60	18
		Excavator	C2.18	2	103.0	50%	0	103.0							
		Telehandler/bobcat	C4.55	2	98.0	50%	0	98.0							
2	*Demolition of each stage*														
a	Cut and remove roof structures	Crane	C4.41	1	99.0	50%	0	96.0	110	10	81	75	69	60	19
		Circular saw	C4.72	1	107.0	50%	0	104.0							
		Hand tools	D2.15	1	112.0	50%	0	109.0							
b	Cut and remove wall/floor sections	Long-reach excavator with "nibbler"	C1.12	1	110.0	50%	0	107.0	117	10	88	82	76	67	37
		Crane	C4.41	1	99.0	50%	0	96.0							
		Circular saw	C4.70	1	119.0	50%	0	116.0							
		Hand tools	D2.15	1	112.0	50%	0	109.0							
c	Remove waste	Trucks	C2.34*	1	108.0	50%	0	105.0	106	10	77	71	65	55	11
		Telehandler/bobcat	C4.55	2	98.0	50%	0	98.0							
d	Breakout and remove slab and foundations	Excavator with breaker	C1.9	1	118.0	50%	0	115.0	120	10	91	85	79	70	48
		Concrete crusher	C1.14	1	110.0	50%	0	107.0							
		Excavator	C2.18	1	103.0	50%	0	100.0							
		Hand-held pneumatic breaker	C1.7	1	121.0	50%	0	118.0							
		Compressor	C5.5	3	93.0	50%	0	94.8							
		Dewatering pump	C5.40	2	96.0	50%	0	96.0							
e	Site levelling	Excavator	C2.18	2	103.0	50%	0	103.0	114	10	85	79	73	63	27
		Grader	C6.31*	1	114.0	50%	0	111.0							
		Hand tools	D2.15	1	112.0	50%	0	109.0							
		Telehandler/bobcat	C4.55	2	98.0	50%	0	98.0							

MARSHALL DAY Acoustics

#	Anticipated Staging Plan	Equipment	BS 5228 Ref.	Quantity	Sound Power	Usage Time	Source Mitigation	Source Rating Level	Activity Sound Power	Activity Mitigation	Activity Noise Level (Façade), dB L_{Aeq} at distance, m				Required Setback, m
					dB L_{Aw}	%	dB	dB L_{Aw}	dB L_{Aw}	dB	5	10	20	50	70
CONSTRUCTION PHASE															
3	*Earthworks and piling*								***110***	***10***	***81***	***75***	***69***	***60***	***19***
		Excavator	C2.18	2	103.0	50%	0	103.0							
		Dozer	C2.10	1	108.0	50%	0	105.0							
		Piling rig (screw)	C3.16	1	107.0	50%	0	104.0							
		Concrete truck and pump	C4.32	1	106.0	50%	0	103.0							
		Floats, vibro-pokers etc.	C4.34	2	97.0	50%	0	97.0							
		Genset	C4.87	3	93.0	50%	0	94.8							
		Dewatering pump	C4.88	2	96.0	50%	0	96.0							
4	*Superstructure*								***112***	***10***	***83***	***77***	***71***	***61***	***21***
		Crane	C4.48	1	104.0	50%	0	101.0							
		Welding	C3.31	2	101.0	50%	0	101.0							
		Hand tools	D2.15	1	112.0	50%	0	109.0							
		Genset	C4.87	2	93.0	50%	0	93.0							
		Grinder	C4.93	1	108.0	50%	0	105.0							
		MEWP	C4.57	4	95.0	50%	0	98.0							
5	*Roof and cladding*								***112***	***10***	***83***	***77***	***71***	***61***	***21***
		Crane	C4.48	1	104.0	50%	0	101.0							
		Nail gun	C4.95	2	101.0	50%	0	101.0							
		Hand tools	D2.15	1	112.0	50%	0	109.0							
		Genset	C4.87	2	93.0	50%	0	93.0							
		Circular saw	C4.72	1	107.0	50%	0	104.0							
		MEWP	C4.57	4	95.0	50%	0	98.0							
		Telehandler/bobcat	C4.55	2	98.0	50%	0	98.0							
6	*Internal fitout (external plant)*								***96***	***10***	***67***	***61***	***55***	***46***	***4***
		Genset	C4.87	2	93.0	50%	0	93.0							
		Lifting equipment	C4.61	1	96.0	50%	0	93.0							
7	*Landscaping, etc.*								***114***	***10***	***85***	***79***	***73***	***63***	***27***
		Excavator	C2.18	2	103.0	50%	0	103.0							
		Roller	C2.39*	1	102.0	50%	0	99.0							
		Grader	C6.31*	1	114.0	50%	0	111.0							
		Hand tools	D2.15	1	112.0	50%	0	109.0							
		Telehandler/bobcat	C4.55	2	98.0	50%	0	98.0							
8	*Deliveries/laydown area*								***105***	***10***	***76***	***70***	***64***	***55***	***10***
		Trucks	C2.34*	1	108.0	50%	0	105.0							
		Telehandler/bobcat	C4.55	1	98.0	50%	0	95.0							

Table no.	Activity	Equipment	Power rating kW	Equipment size,	Octave band sound pressure level at 10m									Octave band sound power level								
					63	125	250	500	1000	2000	4000	8000	dBA	63	125	250	500	1000	2000	4000	8000	dBA
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C4.41	Lifting	Mobile telescopic crane	280	100t	73	71	68	70	66	63	54	49	**71**	101	99	96	98	94	91	82	77	**99**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C2.39*	Rolling and compaction	Vibratory roller	29	4t	88	83	69	68	67	65	62	59	**74**	116	111	97	96	95	93	90	87	**102**
C4.55	Lifting	Telescopic handler	75	3.7t	82	72	63	65	67	64	56	49	**70**	110	100	91	93	95	92	84	77	**98**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C4.72	Cutting concrete blocks / paving s	Hand-held circular saw (petrol-cu	3	9kg	69	75	77	74	71	70	74	69	**79**	97	103	105	102	99	98	102	97	**107**
C4.72	Cutting concrete blocks / paving s	Hand-held circular saw (petrol-cu	3	9kg	69	75	77	74	71	70	74	69	**79**	97	103	105	102	99	98	102	97	**107**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C2.18	Ground excavation/earthworks	Tracked excavator	134	27t	81	77	74	70	70	66	60	56	**75**	109	105	102	98	98	94	88	84	**103**
C4.55	Lifting	Telescopic handler	75	3.7t	82	72	63	65	67	64	56	49	**70**	110	100	91	93	95	92	84	77	**98**
C4.41	Lifting	Mobile telescopic crane	280	100t	73	71	68	70	66	63	54	49	**71**	101	99	96	98	94	91	82	77	**99**
C4.72	Cutting concrete blocks / paving s	Hand-held circular saw (petrol-cu	3	9kg	69	75	77	74	71	70	74	69	**79**	97	103	105	102	99	98	102	97	**107**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C1.12	Breaking and spreading rubble	Tracked excavator	228	44t	79	81	83	79	77	75	70	62	**82**	107	109	111	107	105	103	98	90	**110**
C4.41	Lifting	Mobile telescopic crane	280	100t	73	71	68	70	66	63	54	49	**71**	101	99	96	98	94	91	82	77	**99**
C4.70	Cutting concrete floor slab	Petrol hand-held circular saw	3	9kg/ 300mm diar	72	89	81	80	80	82	86	85	**91**	100	117	109	108	108	110	114	113	**119**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C2.34*	Distribution of material	Lorry	-	4-axle wagon	73	78	78	78	74	73	68	66	**80**	101	106	106	106	102	101	96	94	**108**
C4.55	Lifting	Telescopic handler	75	3.7t	82	72	63	65	67	64	56	49	**70**	110	100	91	93	95	92	84	77	**98**
C1.9	Breaking up brick foundations	Breaker mounted on excavator	-	-	88	88	86	89	83	83	80	76	**90**	116	116	114	117	111	111	108	104	**118**
C1.14	Crushing concrete/rubble	Tracked crusher	172	47t	93	86	79	81	75	71	66	59	**82**	121	114	107	109	103	99	94	87	**110**
C2.18	Ground excavation/earthworks	Tracked excavator	134	27t	81	77	74	70	70	66	60	56	**75**	109	105	102	98	98	94	88	84	**103**
C1.7	Breaking up concrete	Hand-held pneumatic breaker	-	-	82	81	87	87	88	86	83	87	**93**	110	109	115	115	116	114	111	115	**121**
C5.5	Breaking road surface	Compressor for hand-held pneum	-	1t	84	73	64	59	57	55	58	47	**65**	112	101	92	87	85	83	86	75	**93**
C5.40	Pumping water	Electric water pump	15	6in	71	64	64	67	63	57	54	49	**68**	99	92	92	95	91	85	82	77	**96**
C2.18	Ground excavation/earthworks	Tracked excavator	134	27t	81	77	74	70	70	66	60	56	**75**	109	105	102	98	98	94	88	84	**103**
C6.31*	Levelling haul road	Grader	205	25t	88	87	83	79	84	78	74	65	**86**	116	115	111	107	112	106	102	93	**114**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C4.55	Lifting	Telescopic handler	75	3.7t	82	72	63	65	67	64	56	49	**70**	110	100	91	93	95	92	84	77	**98**

Table no.	Activity	Equipment	Power rating kW	Equipment size, '	Octave band sound pressure level at 10m									Octave band sound power level								
					63	125	250	500	1000	2000	4000	8000	dBA	63	125	250	500	1000	2000	4000	8000	dBA
C2.18	Ground excavation/earthworks	Tracked excavator	134	27t	81	77	74	70	70	66	60	56	**75**	109	105	102	98	98	94	88	84	**103**
C2.10	Ground excavation/earthworks	Dozer	239	41t	89	90	81	73	74	70	68	64	**80**	117	118	109	101	102	98	96	92	**108**
C3.16	Rotary bored piling – cast in situ	Crane mounted auger	-	-	87	86	77	73	75	72	67	59	**79**	115	114	105	101	103	100	95	87	**107**
C4.32	Pumping concrete	Concrete mixer truck + truck mou	-	-	73	73	77	76	72	70	65	62	**78**	101	101	105	104	100	98	93	90	**106**
C4.34	Concreting other	Poker vibrator	2.2	-	62	70	70	64	62	61	59	56	**69**	90	98	98	92	90	89	87	84	**97**
C4.87	Power for lighting	Diesel Generator	7.5	6kVA / 3000rpm	77	72	64	60	59	57	54	42	**65**	105	100	92	88	87	85	82	70	**93**
C4.88	Pumping water	Water pump (diesel)	10	100kg	70	65	66	64	64	63	56	46	**68**	98	93	94	92	92	91	84	74	**96**
C4.48	Lifting	Tower crane	88	22t	82	77	80	76	66	66	56	50	**76**	110	105	108	104	94	94	84	78	**104**
C3.31	Welding / cutting steel piles	Hand-held welder (welding piles)	-	-	67	68	69	68	69	66	61	56	**73**	95	96	97	96	97	94	89	84	**101**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C4.87	Power for lighting	Diesel Generator	7.5	6kVA / 3000rpm	77	72	64	60	59	57	54	42	**65**	105	100	92	88	87	85	82	70	**93**
C4.93	Miscellaneous	Angle grinder (grinder steel)	2.3	4.7kg	57	51	52	60	70	77	73	73	**80**	85	79	80	88	98	105	101	101	**108**
C4.57	Lifting	Lifting platform	35	8t	78	76	62	63	60	59	58	49	**67**	106	104	90	91	88	87	86	77	**95**
C4.48	Lifting	Tower crane	88	22t	82	77	80	76	66	66	56	50	**76**	110	105	108	104	94	94	84	78	**104**
C4.95	Miscellaneous	Handheld cordless nail gun	-	15 to 50mm nails	63	65	65	66	65	69	64	61	**73**	91	93	93	94	93	97	92	89	**101**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C4.87	Power for lighting	Diesel Generator	7.5	6kVA / 3000rpm	77	72	64	60	59	57	54	42	**65**	105	100	92	88	87	85	82	70	**93**
C4.72	Cutting concrete blocks / paving s	Hand-held circular saw (petrol-cu	3	9kg	69	75	77	74	71	70	74	69	**79**	97	103	105	102	99	98	102	97	**107**
C4.57	Lifting	Lifting platform	35	8t	78	76	62	63	60	59	58	49	**67**	106	104	90	91	88	87	86	77	**95**
C4.55	Lifting	Telescopic handler	75	3.7t	82	72	63	65	67	64	56	49	**70**	110	100	91	93	95	92	84	77	**98**
C4.87	Power for lighting	Diesel Generator	7.5	6kVA / 3000rpm	77	72	64	60	59	57	54	42	**65**	105	100	92	88	87	85	82	70	**93**
C4.61	Lifting	Caged material hoist (electric)	-	500kg	64	64	65	65	63	61	59	52	**68**	92	92	93	93	91	89	87	80	**96**
C2.18	Ground excavation/earthworks	Tracked excavator	134	27t	81	77	74	70	70	66	60	56	**75**	109	105	102	98	98	94	88	84	**103**
C2.39*	Rolling and compaction	Vibratory roller	29	4t	88	83	69	68	67	65	62	59	**74**	116	111	97	96	95	93	90	87	**102**
C6.31*	Levelling haul road	Grader	205	25t	88	87	83	79	84	78	74	65	**86**	116	115	111	107	112	106	102	93	**114**
D2.15	Boarding windows	Hand-held hammer	—	—	-	-	-	-	-	-	-	-	**84**	-	-	-	-	-	-	-	-	**112**
C4.55	Lifting	Telescopic handler	75	3.7t	82	72	63	65	67	64	56	49	**70**	110	100	91	93	95	92	84	77	**98**
C2.34*	Distribution of material	Lorry	-	4-axle wagon	73	78	78	78	74	73	68	66	**80**	101	106	106	106	102	101	96	94	**108**
C4.55	Lifting	Telescopic handler	75	3.7t	82	72	63	65	67	64	56	49	**70**	110	100	91	93	95	92	84	77	**98**

APPENDIX C CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN

(following pages)

MARSHALL DAY Acoustics

HWCP INVERCARGILL CENTRAL CONSTRUCTION NOISE AND VIBRATION MANAGEMENT PLAN

Rp 002 R01 20180801 | 23 July 2018

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Report No.: **Rp 002 R01 20180801**

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
DRAFT		Draft for resource consent	20 July 2018	J Farren	G Walton
DRAFT	01	Minor corrections	23 July 2018	J Farren	G Walton

TABLE OF CONTENTS

1.0 INTRODUCTION

Marshall Day Acoustics (MDA) has been engaged by HWCP Management Ltd to prepare a Construction Noise and Vibration Management Plan (CNVMP) for [Invercargill Central project].

This CNVMP 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 CNVMP 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 CNVMP.

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 CNVMP 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 1999: Figure 1)

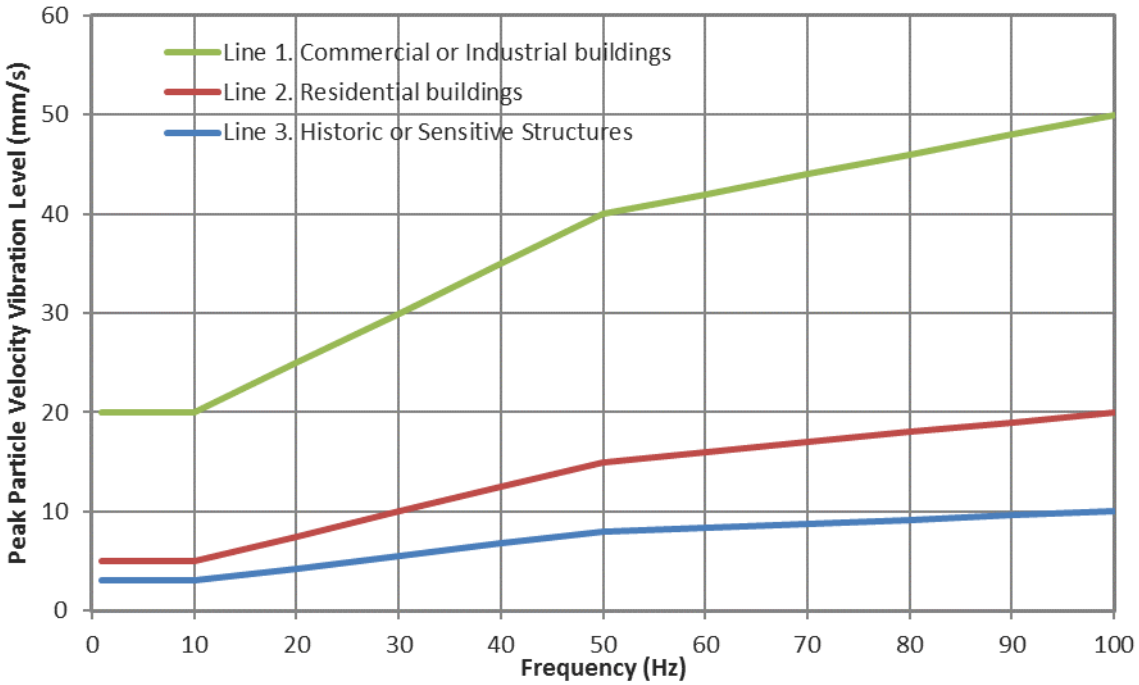


Table 3: Vibration at horizontal plane of highest floor (DIN 4150-3 1999: Tables 1 and 3)

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 basalt 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 RECIPT 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 CNVMP 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

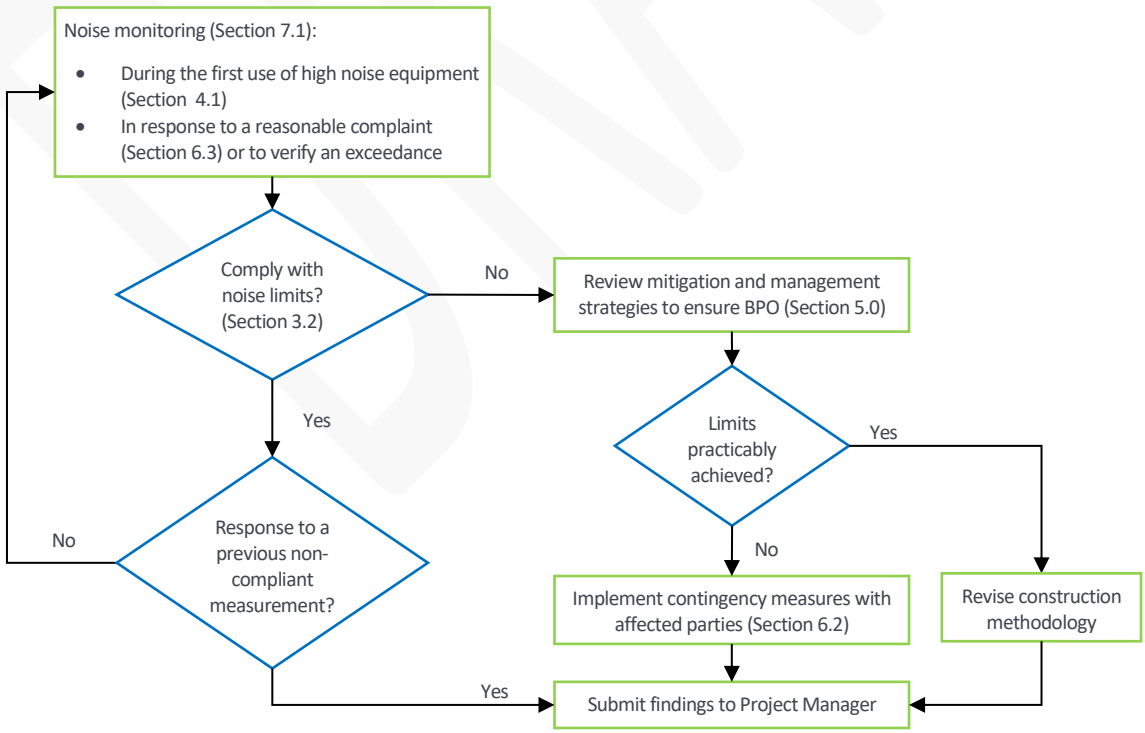
7.1 Noise

Construction noise levels should be monitored:

- During the first occurrence of [insert activity e.g. rock breaking, signature hole analysis (test blasts), production blasting, impact 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



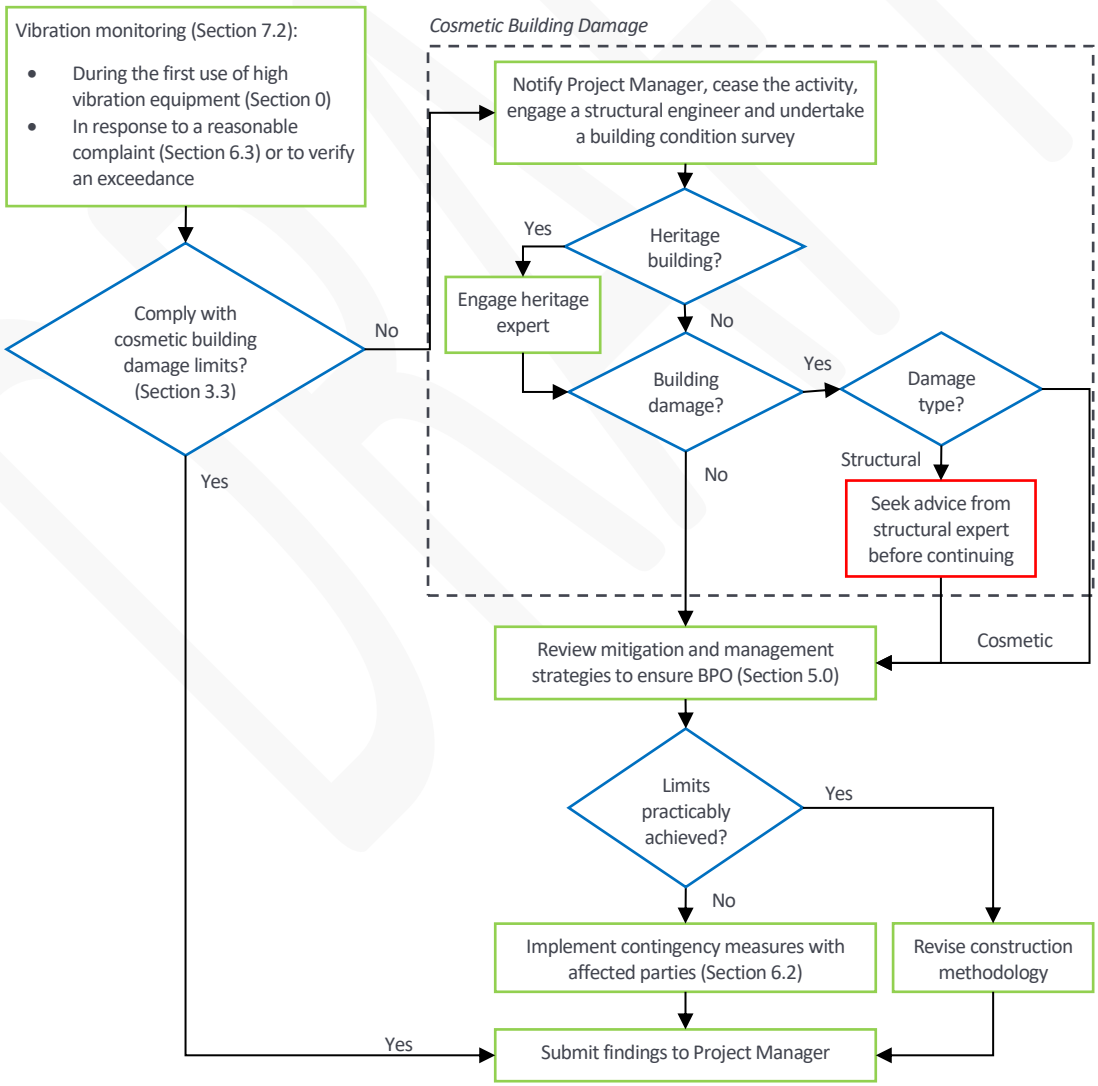
7.2 Vibration

Construction 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 4150-3:1999 "*Structural vibration – Part 3: Effects of vibration 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 4150-3:1999 *"Structural Vibration - Effects of Vibration 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 4150-3:1999 *"Structural Vibration - Effects of Vibration 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