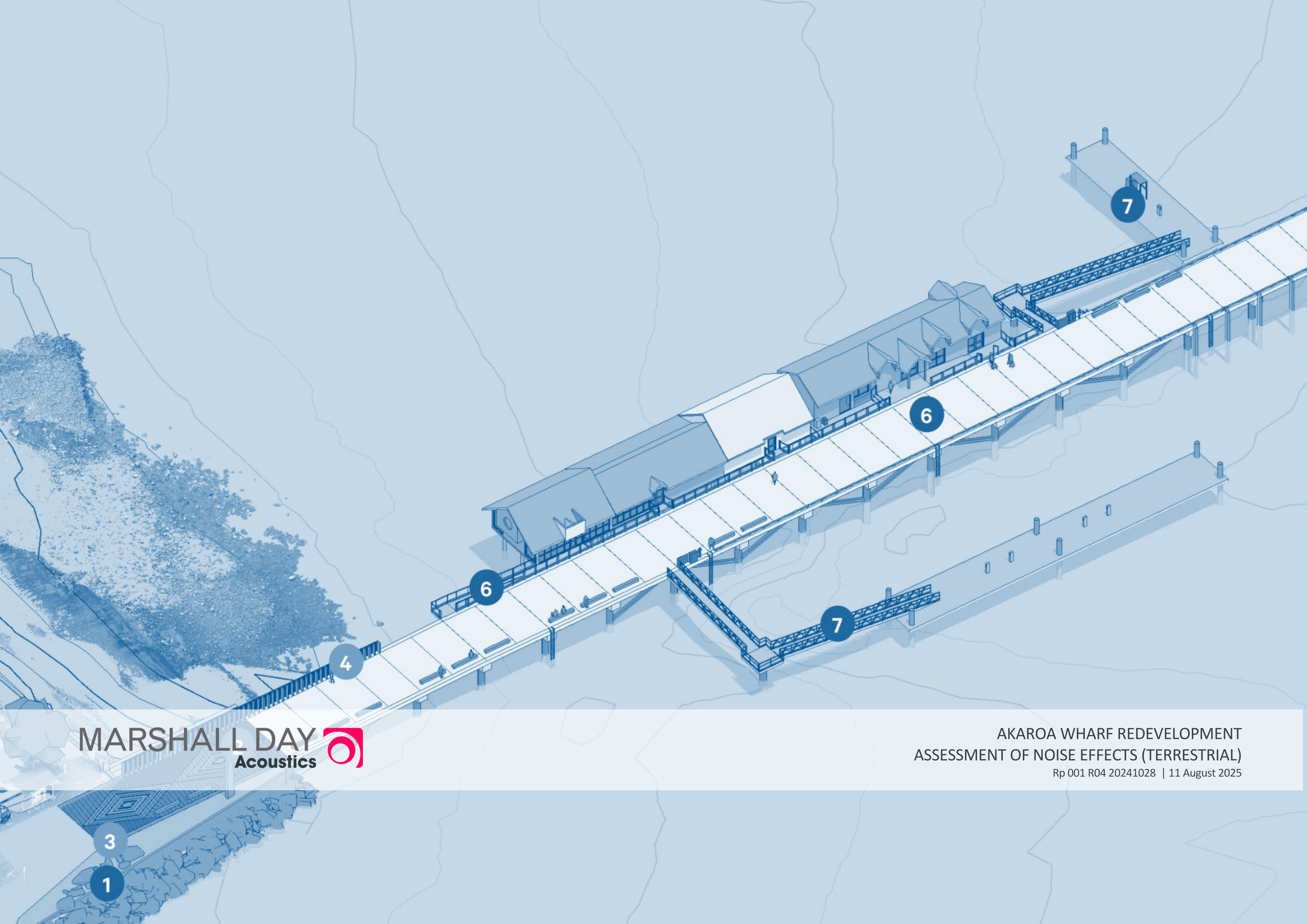

MARSHALL DAY Acoustics

AKAROA WHARF REDEVELOPMENT
ASSESSMENT OF NOISE EFFECTS (TERRESTRIAL)

Rp 001 R04 20241028 | 11 August 2025

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Project:	**AKAROA WHARF REDEVELOPMENT** **ASSESSMENT OF NOISE EFFECTS (TERRESTRIAL)**
Prepared for:	**Christchurch City Council** **c/o Enviser** **10/71 Gloucester Street** **Christchurch 8013**
Attention:	**Alison Peters**
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SUMMARY

Marshall Day Acoustics has undertaken an assessment of potential construction noise and vibration effects associated with the Akaroa Wharf redevelopment, with reference to the following published guidance:

- New Zealand Standard NZS 6803:1999 *Acoustics - Construction Noise*; and
- German Standard DIN 4150-3:2016 *Vibrations in buildings – Part 3: Effects on structures*.

For most of the construction phase, we expect that construction noise levels will be below the applicable limit of 70 dB L_{Aeq} at the nearest occupied commercial and residential activities along Beach Road. However, our assessment indicates that impact piling has the potential to exceed the 70 dB L_{Aeq} limit and therefore any adverse noise effects should be appropriately managed in line with the best practice approach outlined in NZS 6803.

At all times, construction vibration is calculated to be below the most stringent limits of 20 and 5 mm/s PPV for structural damage in commercial and residential buildings respectively, set out in the German Standard DIN 4150-3:2016. However, given the proximity of the Wharf Buildings to piling activity, we recommend that structural condition surveys and vibration monitoring are carried out so that thresholds can be verified in real time.

To ensure that potential noise and vibration effects are minimised, construction activities should be appropriately managed through the implementation of a Construction Noise and Vibration Management Plan (CNVMP) which we recommend is required as a condition of consent. As a minimum the CNVMP should address:

– A nominated person responsible for implementing the CNVMP
– Applicable conditions relating to noise and vibration
– Identification of potentially affected receiver locations
– An activity risk analysis for each phase, including quantification of noise and vibration levels
– Discussion of proposed noise mitigation measures
– Noise and/or vibration monitoring during identified stages
– Training of staff relating to how to minimise noise and vibration
– Procedures for handling complaints

On the basis of our assessment and proposed conditions of consent, we consider that potential construction noise and vibration effects will be reasonable in the context of the receiving environment.

1.0 INTRODUCTION

Marshall Day Acoustics (MDA) has been engaged by Christchurch City Council (CCC) to undertake a terrestrial noise assessment in support of the resource consent application for the Akaroa Wharf Replacement Project. This report addresses both construction and operational noise emissions.

This report provides an assessment of the applicable noise performance standards, predicted noise levels and the noise and vibration effects.

A glossary of technical terms is included in Appendix A.

2.0 PROJECT DESCRIPTION

2.1 General arrangement

As part of the redevelopment project, a new wharf is to be constructed at the site of the existing wharf as indicated in Figure 1, alongside an indication of the District Plan zoning of the nearest noise-sensitive receivers. Two laydown areas are proposed for the storage and handling of materials associated with the wharf construction. These are shown in Figure 1 and Figure 2.

The closest properties to wharf construction activities are on the opposite side of Beach Road and are zoned as *Commercial* in the Christchurch District Plan. There are also *Open Space* and Residential zones in the immediate vicinity. Laydown Area 1, which is located further to the north in Akaroa, is adjacent to Commercial and Open Space zones.

Table 1: Sensitive receivers adjacent to the application sites

Address	Zoning
59-75 Beach Road	Commercial
79 Beach Road (La Voyageur Apartments)	Commercial
82 Beach Road (Akaroa Village Inn)	Commercial
89 -115 Beach Road	Residential
2 Rue Lavaud (Club Lavaud)	Commercial
4 Rue Lavaud (The Grand Hotel – Akaroa)	Commercial
20 Rue Lavaud	Commercial
33-37 Rue Lavaud	Commercial
40G Rue Lavaud	Commercial
39 Rue Jolie	Commercial
40 Rue Jolie	Commercial

Figure 1: Scope of works area, Laydown Area 2 and nearest receivers

Figure 2: Laydown Area 2, Rue Jolie and Rue Brittan, and nearest receivers

2.2 Wharf construction methodology

Based on the indicative contractor's construction methodology, the construction works for Akaroa Wharf include marine and landside activities and can be summarised as follows:

- Establish a laydown area at the recreation ground boat ramp (Laydown 1), and install security, fencing, containers and traffic management at the main wharf area (Laydown 2).
- Establish the boat ramp (and undertake dredging) to allow the Patiki to berth alongside to transfer plant and materials.
- Mobilise the Patiki to Akaroa (from Lyttleton).
- Construct the 'L-wall' at the base of the existing wharf.

The piling methodology will rely on the existing wharf structure for support of the piling gates, so demolition will follow behind the landside piling front. The general sequence is as follows:

Land-based Piling Sequence:

- Enabling works, including L-wall construction for support and staging.
- Piling rig moves to the first bent on the wharf.
- A small deck section is cut for one pile; the other pile will likely be outside the wharf face.
- Piling gate (two piles) is placed and secured.
- Steel piles with driving tips are pitched and driven in a single length.
- A crane based vibro piling hammer will drive piles as far as possible (the proposed hammer has a variable frequency, to avoid resonance and minimise vibration and noise)
- Percussion hammer will achieve the desired embedment in basalt (pre-drilling may be needed).
- Piles are filled with concrete, and capping beams are installed.
- Temporary platforms/grillage are placed on capping beams for rig advancement (temporary support piles may be required).

Marine-based Piling Sequence:

- A second rig on a barge will perform a similar operation from the outer end.
- It will install piles and demolish the existing wharf.
- The marine rig will eventually meet the land-based rig.
- It will assist with capping beams and concrete placement.
- Marine plant will remove conflicting old timber piles (remaining cut at seabed level).
- Piling rigs will not operate concurrently, but their work fronts will advance together.
- Most wharf demolition materials will be moved by marine plant to Laydown 1.
- Some landside demolition material will be transported by road.
- Remaining wharf sections will be demolished.

Wharf Deck Construction:

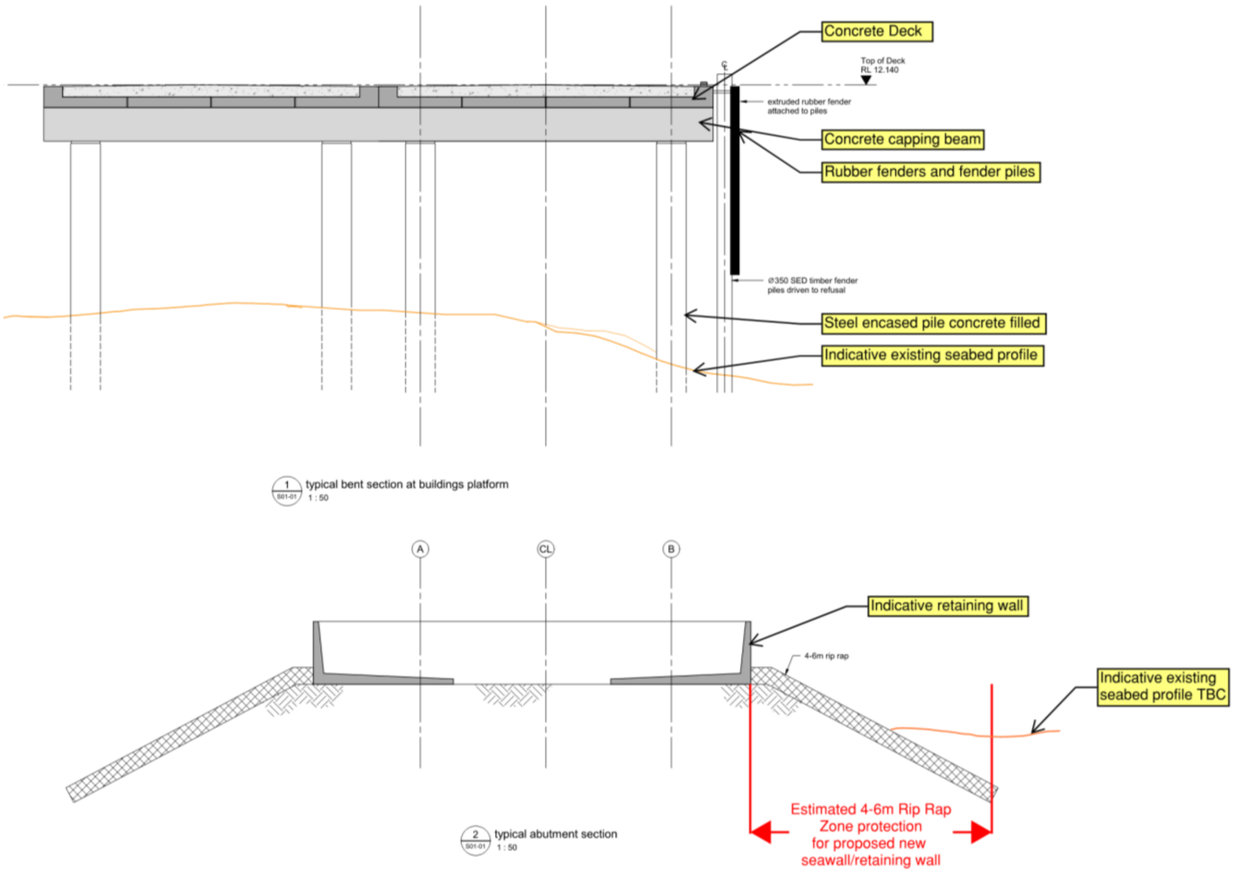
- Placement of precast deck elements on capping beams.
- Installation of temporary formwork.
- Pouring the topping slab

Table 2 provides the key assumptions used in our assessment. Figure 3 shows a cross section of the proposed wharf and key construction elements.

Table 2: Summary of assumptions

Assumption	Key Details
Existing Buildings	Buildings will remain on their existing piles and will connect to the new wharf with a gangway
Transportation of Materials	Large materials (e.g., piles) transported via barge; crane pad and crane likely needed at laydown/staging areas.
Construction Methodology	Primarily marine-based plant or staged from newly constructed sections of the wharf.
Piling Techniques	Combination of percussive, bored and vibratory methods for pile driving; basalt sockets will be drilled.
Demolition Material Handling	Taken to laydown/staging areas prior to disposal.

Figure 3: Wharf cross section



3.0 NOISE PERFORMANCE STANDARDS

3.1 Construction noise

Activities emitting noise within the Coastal Marine Area are controlled by the applicable provisions of the Regional Coastal Environment Plan (RCEP). Rule 8.21.e.iv provides an exemption of construction activities as follows:

> "…the construction or maintenance of a structure where the noise meets the limits recommended in, and measured and assessed in accordance with, NZS 6803:1999 *Acoustics-Construction Noise*".

NZS 6803 represents current best practice for managing construction noise effects in New Zealand and is the Standard referenced in the Christchurch District Plan (CDP) Rule 6.1.6.1.1.P2. The 'long term' noise limits from NZS 6803 will apply as the proposed construction programme (noting some works are concurrent) will be 11-14 months comprising:

- Site setup 1-2 months
- Demolition 2-3 months
- Piling and deck 5-6 months
- Deck furniture, services and pontoons 3-4 months

The 'long-term duration' noise limits from NZS 6803:1999 are summarised in Table 3. The times highlighted in **bold** are the intended hours for construction activities to take place. These times are referred to as 'appropriate construction hours' throughout this report.

Table 3: Construction Noise Limits (Long-Term Duration)

Type of Receiver	Time of week	Time period	Noise Limit	
			L_{Aeq}	L_{AFmax}
Residential Zones	Weekdays	0630-0730	55	75
		0730-1800	**70**	**85**
		1800-2000	65	80
		2000-0630	45	75
	Saturdays	0630-0730	45	75
		0730-1800	**70**	**85**
		1800-2000	45	75
		2000-0630	45	75
	Sundays and public holidays	0630-0730	45	75
		0730-1800	55	85
		1800-2000	45	75
		2000-0630	45	75
Commercial or Industrial areas	All days	**0730-1800**	**70**	-
		1800-0730	75	-

As indicated in Table 3, the noise limit for daytime construction activities (07:30–18:00) is 70 dB L_{Aeq} , which applies equally to both residential and commercial receivers. There is no applicable noise limit for Open Space zones.

The full construction noise limits from NZS 6803:1999 are provided in Appendix B.

3.2 Operational Noise

The RCEP Rule 8.21.b also provides "operational" noise limits for any activity emitting noise in the Coastal Marine Area. The limits, measured and assessed at any point on land outside the Coastal Marine Area, are:

- 0700 to 2200 hrs 65 dB $L_{Aeq(15\ min)}$
- 2200 to 0700 hrs 55 dB $L_{Aeq(15\ min)}$
- All times 85 dB L_{Amax}

Separate noise limits are provided for individual vessels which are not applicable to this assessment.

By way of comparison, activities governed by the CDP noise limits are generally 10 to 15 dB more stringent as illustrated in Table 4,

Table 4: Zone noise limits (excerpt from Table 1, Rule 6.1.5.2.1)

Zone of site receiving noise from the activity	0700 – 2200 hrs		2200 – 0700 hrs	
	dB L_{Aeq}	dB L_{Amax}	dB L_{Aeq}	dB L_{Amax}
All residential zones	50	-	40	65
All commercial zones and open space zones	55	-	45	70

4.0 VIBRATION PERFORMANCE STANDARDS

Neither the Regional Coastal Environment Plan nor the Christchurch District Plan provides vibration criteria, (except for reference to "DIN 4150 1999-02" in the Earthworks chapter - CDP Rule 8.9.2.1.P2.f.).

We note the National Planning Standards requires construction vibration to be consistent with ISO 4866:2010[1]. However, while ISO 4866 provides guidance on vibration measurement techniques and associated metrics, it does not establish specific vibration limits for buildings.

In New Zealand, construction work that potentially affects the structure of buildings is commonly assessed against German Standard DIN 4150-3:2016 *"Vibration in buildings – Part 3: Effects on structures"*. These recommended limits in DIN 4150 are intended to ensure that material vibration damage to structures does not occur. The short-term (transient)[2] vibration limits in Table 5 apply at building foundations.

We have assumed that the proposed piling works constitute short-term, transient vibration as defined in DIN 4150-3:2016.

Table 5: Short-term (transient) 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

5.0 EXISTING NOISE ENVIRONMENT

The existing ambient noise environment for the residential receivers directly to the east and south is generally controlled by traffic movements and pedestrian activities. During our noise measurements, prominent noise sources included tourist buses, motorbikes and light vehicles and patrons. Measurement positions are shown in Figure 4. Noise survey details can be found in Appendix C.

Figure 4: Ambient noise measurement positions

Table 6: Summary of ambient noise survey results

Time (hh:mm)	Measured noise levels dB L_{Aeq}	dB L_{AFmax}	Comments
MP1:			Patron noise dominates. Also light and heavy vehicle movements and one boat (Black Cat cruise departing). Intermittent construction noise
11:28	56	76	
13:58	57	66	
MP2			
10:43	56	81	Power tools at 10.43. Otherwise vehicle movements and pedestrian activity.
12:48	52	68	
MP3			
11:02	54	74	Traffic noise along Beach Road dominates, surf noise, and pedestrians
13:05	56	72	
MP4			
11:18	50	72	Surf noise and pedestrians dominate and irregular vehicle movements
13:23	53	81	

[1] ISO 4866:2010 Mechanical vibration and shock — Vibration of fixed structures — Guidelines for the measurement of vibrations and evaluation of their effects on structures

[2] 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*".

6.0 PREDICTED CONSTRUCTION NOISE LEVELS

6.1 Impact piling will generate the highest noise levels

Demolition and piling are expected to generate the highest noise levels among the proposed construction activities. Several potential piling methods may be used, however, drop hammer (percussive/impact) piling will generate the highest noise levels and is therefore the focus of our assessment.

Noise levels have been calculated using SoundPLAN, an internationally recognised computer noise modelling programme. SoundPLAN uses a digital topographical terrain map of the area as its base. Each noise source is located at an appropriate height above the digital map and the software then calculates noise propagation in multiple directions, allowing for buildings, topography, shielding, reflections and meteorological conditions. The SoundPLAN model uses the calculation algorithms of International Standard ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors – Part 2: General method of calculation*.

The model relies on the following geo referenced base data sourced from LINZ data service obtained (Oct 2024)

- Topographical contours at 1m intervals
- Cadastral boundaries
- Building footprints and heights

The noise contours are obtained by computer interpolation between calculated grid points at 5m intervals.

We have assumed conservative scenarios where all noise sources listed in Table 5 operate simultaneously at full capacity 100% of the time. In practice, such scenarios are unlikely to occur.

Table 7: Input noise data

Scenario	Noise Source	Sound Power Level (dB L_{WA})
Demolition	30 tonne excavator	105
	35 tonne mobile crane	98
	Hand tools (Concrete saw)	109
Piling	Impact piling	117
	30 tonne excavator	105
	100 tonne mobile crane	99
	Hand tools (Angle grinder)	109
	Generator	101

Using sound power levels provided in Table 7, we have calculated worst case noise levels at the façades of the nearest receivers during demolition and impact piling activities when these activities occur in the eastern section of the project site.

Figure 5 and Figure 6 shows the predicted L_{Aeq} worst-case noise contours from both worst-case demolition and impact piling respectively, when conducted at the closest proximity to receivers along Beach Road. For most of the time, noise levels will be lower than those shown in these figures as operations progress further west. Larger versions of these plots are provided in Appendix D.

Table 8 provides a summary of the predicted noise levels at several of the closest residential and commercial receivers shown in Figures 5 and 6.

Figure 5: Predicted Noise Levels for demolition stage

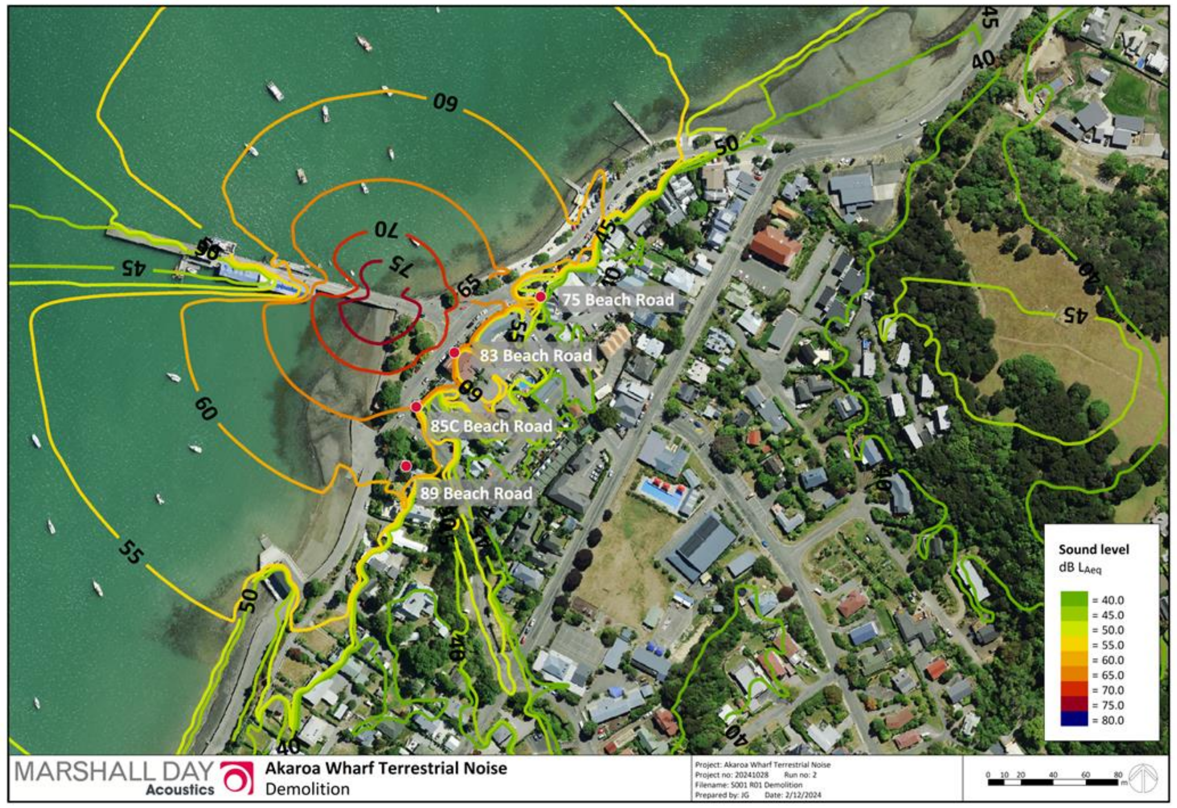
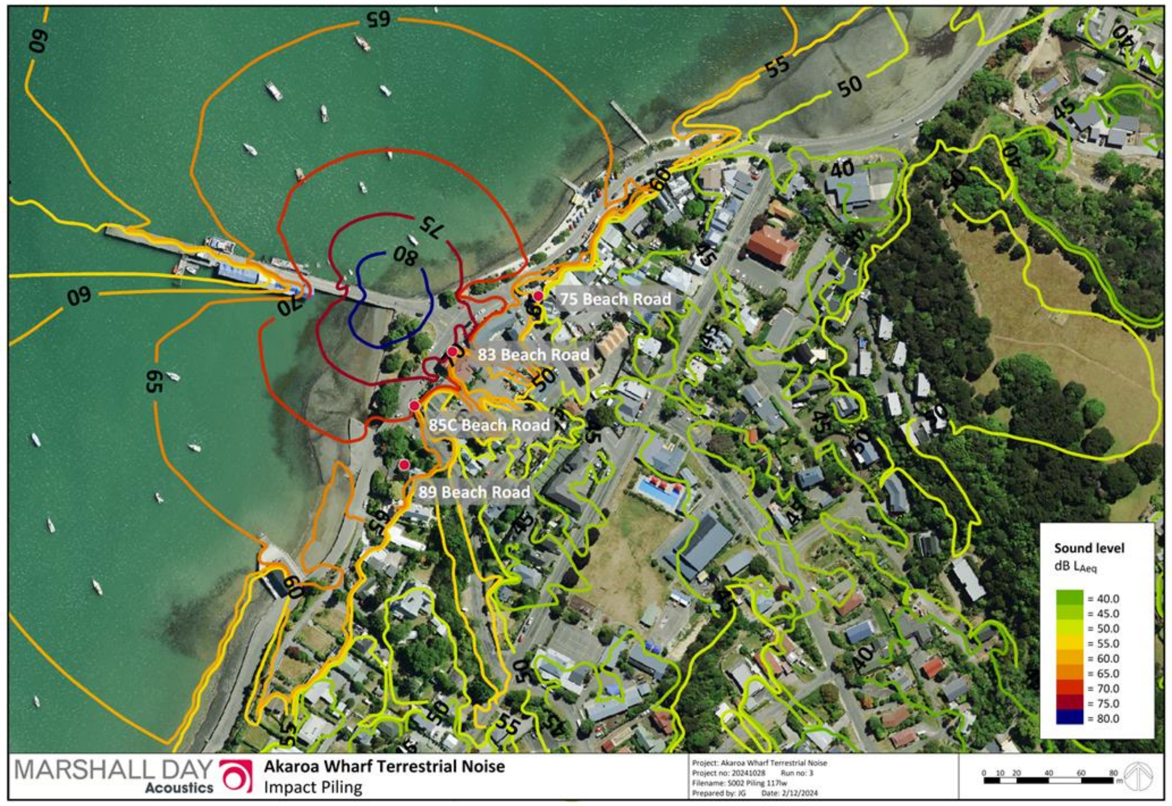


Figure 6: Predicted noise levels for impact piling



The noise contour plots and worst-case predicted noise levels indicate that impact piling has the potential to exceed the applicable 70 dB L_{Aeq} construction noise limits by up to 7 dB. As a result, it will be appropriate to implement management and mitigation to control adverse noise effects as far as practicable in line with the guidance provided by NZS 6803:1999. We discuss noise management and mitigation in Section 9.0. We expect that noise generation at other times, including during the demolition phase, will generally be below the applicable 70 dB L_{Aeq} noise limits.

To address this, we conducted detailed calculations for the closest receivers. Table 8 below presents the predicted noise levels at the façades of the nearest receivers.

Table 8: Predicted noise levels at the façade of nearest receivers during demolition and impact piling

	Calculated noise level, dB L_{Aeq}	
Receiver address	**Demolition**	**Impact Piling**
83 Beach Road	70	77
79A Beach Road	69	76
85A Beach Road	69	75
79 Beach Road	69	75
85B Beach Road	68	75
85C Beach Road	68	74
81 Beach Road	67	74
79C Beach Road	67	74
79D Beach Road	66	73
89 Beach Road	63	69
67 Beach Road	61	68
69 Beach Road	61	68
65 Beach Road	61	68
61 Beach Road	60	67

6.2 Other construction noise sources will generally comply

Outside the demolition and piling phase, a range of other construction equipment will be used. Table 9 provides estimated construction noise levels for other commonly encountered noise sources at various distances. The right-most column illustrates the setback distance required to achieve the 70 dB L_{Aeq} construction noise limit. For example, concrete cutting that occurs further than 30 metres from a sensitive receiver will achieve the 70 dB L_{Aeq} limit.

Table 9: Indicative construction activities noise levels at nominal distances

Equipment	Sound Power Level (dB L_{WA})	Noise Level (dB L_{Aeq})			Setback (m)
		10 m	20 m	50 m	70 dB L_{Aeq}
Concrete cutting*	115	80	74	65	30
Mobile Crane (100 tonne)	99	74	68	59	16
Excavator (30 tonne)	105	80	74	65	30
Wheeled loader	105	80	74	65	30
Compressor	93	68	62	53	8
Truck idling	91	66	60	51	6
Concrete/rock breaker (8-10T)	116	81	75	66	33
Dredging	112	87	81	72	58
Concrete Pumping	106	81	75	66	33

* includes nominal 10 dB screening from localised noise barriers

6.3 Noise from laydown areas

As shown in Figures 1 and 2, two laydown areas have been identified for use during the construction work. These areas will primarily be used for storage of construction and demolition materials. Occasional noise from material handling activities is anticipated. With reference to Table 9, the separation distances are such that an excavator can operate within the laydown areas and remain more than 30 metres from residential activity, thereby complying with the recommended noise limit of 70 dB L_{Aeq} from NZS 6803.

For Laydown Area 1, the establishment of a temporary landing ramp is expected to involve the installation of 2 to 4 steel piles to form a training wall for barge loading and unloading. We expect this activity will take less than two days with relatively brief periods of elevated noise as the piles are being driven. The closest noise-sensitive receiver, at 40 Rue Brittan, is approximately 95 metres away and is expected to experience noise levels below the 70 dB L_{Aeq} recommended noise limit from NZS 6803.

6.4 A CNVMP is proposed to ensure noise effects are reasonable

Our assessment indicates that impact piling has the potential to exceed the applicable 70 dB L_{Aeq} noise limit. All other activities are anticipated to be below this limit. We consider that the most appropriate method to minimise potential adverse noise and vibration effects is through the implementation of a Construction Noise and Vibration Management Plan (CNVMP) throughout the project duration. This will ensure that airborne noise from construction works does not exceed a reasonable level.

The CNVMP should identify a procedure for evaluating appropriate noise mitigation options once the actual construction equipment and techniques are determined. For example, a non-metallic 'dolly' or 'cushion cap' can be used between the impact piling hammer and the driving helmet to minimise noise from impact piling.

7.0 PREDICTED VIBRATION LEVELS

7.1 Impact piling will generate the highest vibration levels

Piling activities, particularly impact and vibratory piling, generate significant vibration levels that can affect nearby structures. Accurately predicting these vibration levels presents challenges due to the variability in subsurface conditions and the complex interaction between piling equipment and ground characteristics.

During the wharf reconstruction, existing commercial buildings on the wharf will remain on site throughout the construction period. These structures face the highest exposure risk due to their proximity to vibration sources. Critical onshore receivers include the Wharfinger's Office and commercial and residential buildings along Beach Road (including the 81 Beach Road Apartments).

7.2 Piling methodologies

We understand the primary pile driving method will be vibratory installation, followed by percussion hammering to achieve the required embedment into basalt. If adequate embedment cannot be achieved through percussion, the pile may require removal. In such cases, a socket will be pre-drilled into the basalt before re-driving the pile.

7.3 Equipment summary

Table 10 below summarises the proposed piling equipment:

Table 10: Summary of piling equipment

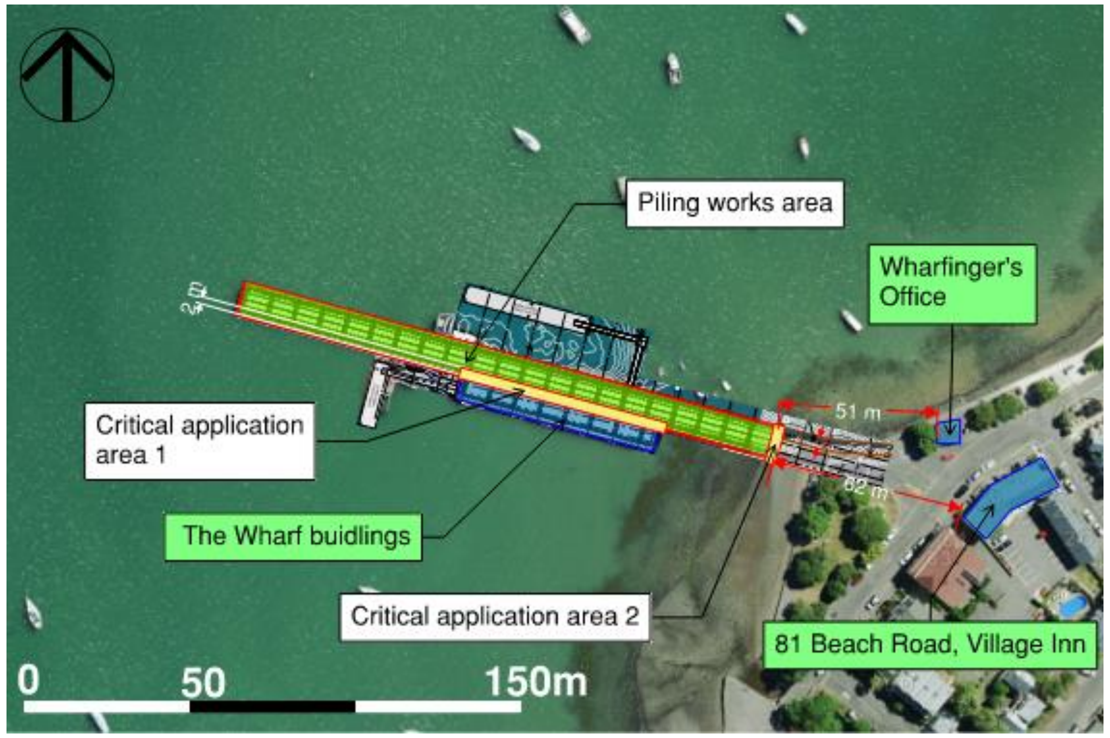
Equipment type	Model/specification	Base machine
Hydraulic Hammer (7-9 tonne)	Junttan HHK9a (or similar sized)	35 tonne Base Machine
Vibro Hammer	ICE 28RF	
Drill Rig	Geax EK110	
100 tonne Crane	-	

7.4 Critical application areas

Figure 7 illustrates the critical application areas considered in our calculations for vibration activities in relation to the sensitive receivers.

- Yellow Shaded Area (critical application area 1 and 2): These areas represent the most critical piling locations due to their close proximity to the Wharf Buildings, as well as the Wharfinger's Office and Beach Road buildings.
- Standard Works Area (Green shaded Area): In the rest of the piling locations project site.

Figure 7: Closest receivers for piling works and critical application areas



7.5 Predicted vibration levels

Given the nature of the proposed piling methods (vibratory, bored, and impact), we have compared the predicted levels against the respective limits for short-term (transient) vibration from DIN4150-3 as previously outlined in Table 5, Section 4.0.

The predictions are based on regression analysis of vibration measurements conducted by Marshall Day Acoustics and others. The calculated levels are conservative in that they include a 100% safety factor to assist in identifying the likely maximum vibration levels that could arise. This screening method approach is appropriate to inform when pre-construction building condition surveys and vibration monitoring may be appropriate.

Table 11 presents calculated vibration levels at nearest receivers and show that vibration levels will typically be below the applicable vibration criterion.

Table 11: Summary of calculated vibration levels at nearest receivers

Receiver	Type of structure	Distance to source (metres)	Vibration Limit (mm/s PPV)	Vibratory piling levels (mm/s PPV)	Impact piling levels (mm/s PPV)	Bored piling levels (mm/s PPV)
Wharfinger's Office	Sensitive / Historic	51	3	0.9	1.5	0.1
Wharf buildings	Commercial	2	20	5.0 -12.6*	7.3 - 18.3*	1.1 - 2.8*
81 Beach Road Akaroa Village Inn	Residential	62	5	0.8	1.3	0.1

**Levels are presented as a range to account for the uncertainty in ground/foundation propagation over relative short distances*

7.5.1 Wharfinger's Office

The vibration sensitivity of the Wharfinger's Office is unclear at this stage. However, to be conservative, we have assumed the most sensitive criterion of 3 mm/s PPV from DIN 4150-3 would apply. The Wharfinger's Office is located approximately 51 metres from the nearest piling position (Critical Application Area 2, as shown in Figure 7).

Vibration predictions indicate that all piling activities will generate vibration levels well below the applicable limit of 3 mm/s PPV., and therefore the risk of building damage for this structure is low. However, as discussed in Section 7.6 it will be prudent to conduct a structural condition survey prior to the works commencing.

7.5.2 Commercial structures - Wharf Buildings

The calculated vibration levels at these buildings are presented as ranges to account for the inherent uncertainty in vibration prediction accuracy at close distances (approximately 2 metres). This proximity limitation results in increased uncertainty and consequently results in a wider range of potential vibration levels.

Table 10 indicates that vibratory and bored piling will generate vibration levels below the applicable 20 mm/s PPV limit. However, impact piling is calculated to produce levels ranging from 7.3 to 18.3 mm/s PPV. While this range falls below the 20 mm/s guidance value, the risk profile suggests that active vibration monitoring should be conducted during piling so that actual levels can be assessed against the applicable guidance.

7.5.3 Residential use buildings 81 Beach Road

While 81 Beach Road is zoned commercial zone, we have adopted the more stringent residential vibration criteria as part of this assessment. 81 Beach Road is located approximately 62 metres from the piling operations, and it will experience relatively low vibration levels across all three piling methodologies. Predicted levels will range between 0.1-1.3mm/s PPV, therefore predicted levels remain well below the applicable residential limit of 5 mm/s PPV.

Our analysis indicates that residential receivers located at similar distances within Critical Application Area 2 will comfortably comply with vibration limits for all three piling methods, with minimal risk of exceedance.

7.6 Overall compliance and mitigation measures

To mitigate potential vibration effects, the following measures are recommended:

Pre-Construction Assessment:

A comprehensive condition survey of both the Wharfinger's Office and the Wharf Buildings should be conducted prior to commencing construction works. This survey will document and record any existing structural defects or vulnerabilities, providing a baseline for post-construction comparison.

Vibration Monitoring Program:

Real-time vibration monitoring should be implemented during all impact piling activities within the Wharf Buildings and potentially other areas depending on the vibration levels that eventuate. This monitoring will verify actual vibration levels and enable immediate response if thresholds are approached or exceeded.

Construction Management:

As outlined in Section 9.10, these recommendations should be incorporated into the Construction Noise and Vibration Management Plan (CNVMP) to ensure systematic implementation and compliance throughout the construction phase.

8.0 OPERATIONAL NOISE

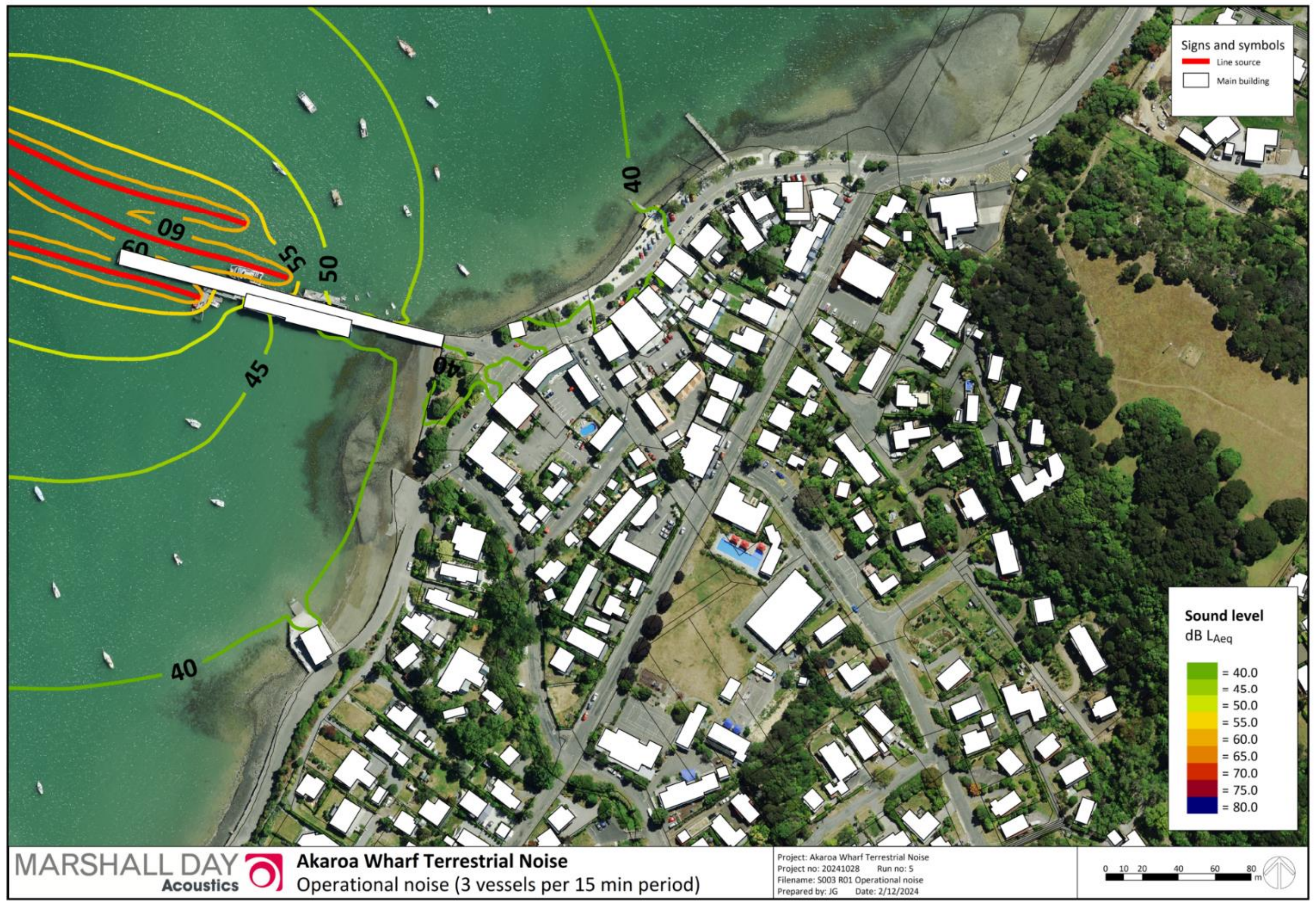
Noise from operations at the existing wharf currently forms part of the existing noise environment. Once the wharf redevelopment is complete, we expect that noise emissions will be very similar.

To give this further context, we have modelled noise levels from medium-sized vessels (e.g. Black Cat Cruises) arriving at or departing from the new wharf, based on measurements taken at Akaroa. We have assumed a conservative scenario of three vessel movements within a 15-minute period.

The predicted noise level contours are provided in Figure 8. A larger version is provided in Appendix D3.

Operational noise levels are predicted to be in the order of 40 dB L_{Aeq} or less at all properties along the waterfront. This level is substantially below the daytime noise limits set out in both the RCEP and CDP, and is significantly lower than the existing ambient noise environment from traffic and other sources. As a result, we expect potential operational noise effects to be negligible.

Figure 8: Operational noise 3 vessels movements in a period of 15 min



9.0 MITIGATION AND MANAGEMENT

The following sections highlight the noise management and mitigation options to minimise potential adverse effects as far as practicable. We recommend that these measures are formalised in the project specific Construction Noise and Vibration Management Plan (CNVMP).

9.1 Training

All staff will participate in an induction training session before starting work on the construction, with attention given to the following matters:

- Activities with the potential to generate high levels of noise and/or vibration
- Sensitive receivers and any agreements made through engagement
- Noise and vibration monitoring requirements

As the construction progresses, any updates to noise and vibration matters will be addressed during regular site meetings and/or 'toolbox' training sessions.

9.2 Equipment Selection

When selecting construction equipment:

- Use quieter construction methodologies where practicable (e.g. bored piling instead of drop hammer piling)
- Use electric motors rather than diesel engines where practicable
- Use rubber-tracked rather than steel-tracked equipment where practicable
- Use equipment that is suitably sized for the task
- Maintain equipment well to minimise rattles, squeaks, etc
- Fit engines with exhaust silencers and engine covers where practicable
- Avoid tonal reversing or warning alarms (beepers). Alternatives include broadband alarms (squawkers/quackers), flashing lights, proximity sensors, reversing cameras and spotters

9.3 Scheduling

Scheduling is an important management tool, particularly where a receiver expresses concern about construction works at a certain time of day. Where necessary, high noise and vibration generating works will be programmed to minimise disturbance.

Scheduling activities to be undertaken when nearby sensitive receiver buildings are unoccupied is the most effective measure as it avoids the effect. For example, piling works could be undertaken when hospitality businesses are least busy.

Scheduling should be considered as the first measure for all activities which are predicted to exceed the relevant noise and vibration limits. If scheduling is not practicable, then other measures such as noise barriers, revising methodology and temporary relocation should be considered.

9.4 General Measures

Complaints can arise even if the noise and vibration levels comply with the Project limits. To minimise complaints, the following common mitigation measures are recommended:

- Avoid unnecessary noise. This means managing the site to ensure:
  - No shouting
  - No unnecessary use of horns
  - No loud site radios
  - No rough handling of material and equipment
  - No banging or shaking excavator buckets
  - No unnecessary steel on steel contact (e.g. during the loading of scaffolding on trucks)
  - No high engine revs. This includes choosing the right sized equipment and turning engines off when idle.
- Avoid unnecessary vibration. This means managing the site to ensure:
  - No unnecessary dropping of heavy objects
  - No potholes, bumps or corrugations in site accessways
  - Excavator operators are skilled and use their machine considerately
- Mitigate track squeal from tracked equipment, such as excavators. This may include tensioning and watering or lubricating the tracks regularly
- Locate stationary equipment (e.g. generators) away from noise sensitive receivers and/or screen them behind site buildings and material stores
- 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
- Utilise specific measures for the following activities (where applicable):
  - Excavators
  - Concrete cutting
  - Concrete and rock breaking
  - Piling
  - Compaction
  - Rattle Guns
- Undertake monitoring

9.5 Noise Barriers and Enclosures

9.5.1 Temporary Noise Barriers

Temporary noise barriers can be considered where an activity is predicted to exceed the construction noise limits unless they are ineffective (e.g. where a receiver is elevated and would look over the barrier). They will be installed prior to works commencing and maintained throughout the works. Effective noise barriers typically reduce the received noise level by up to 10 decibels.

Where practicable, the following guidelines will be used in designing and installing temporary noise barriers:

- The panels will have a minimum surface mass of 6.5 kg/m^2. Suitable panels include 12 mm plywood or the following proprietary 'noise curtains':
  - SealedAir 'WhisperFence 24dB' (www.sealedair.com)
  - Hushtec 'Premium Series Noise Barrier' (www.duraflex.co.nz)
  - Soundbuffer 'Performance Acoustic Curtain' (soundbuffer.co.nz)
  - Hoardfast 'Fast Wall Premium PVC partition panels' (www.ultimate-solutions.co.nz)
  - Safesmart 'Acoustic Curtain 6.5kg/m^2' (www.safesmartaccess.co.nz)
  - Alternatives will be approved by a suitably qualified and experienced acoustic specialist

- The panels will be a minimum height of 2 m, and higher if practicable to block line-of-sight
- The panels will be abutted, battened or overlapped to provide a continuous screen without gaps at the bottom or between panels
- Barriers will be positioned as close as practicable to the high-noise activity to block line-of-sight between the activity and noise sensitive receivers. A site hoarding at the boundary may not be effective for all receivers. Add extra barriers close to high-noise activities to ensure effective mitigation for sensitive receivers on upper floors.

9.5.2 Permanent Noise Barriers

Upgrading a site hoarding or compound fence can provide effective construction noise mitigation. Its construction should be more durable than a temporary barrier (minimum surface mass of 10 kg/m^2, such as 18 mm plywood or 20 mm pine).

9.5.3 Noise Enclosures

Noise enclosures surround the source on more than one side and have a roof (an example is included as Figure B.3 in NZS 6803: 1999). The effectiveness of an enclosure depends on how well the noise source can be enclosed without constraining its operation (e.g. mobility, heat, dust, lighting).

Where practicable, the following guidelines will be used in designing and installing enclosures:

- Enclosures will be considered where a noise barrier can't achieve compliance with noise limits, particularly for stationary plant such as compressors, pumps, generators, air tools and paver cutting stations
- Enclosures can be made from the noise curtains listed above, or the following proprietary options are available:
  - Echo Barrier 'Cutting Station' (www.supplyforce.co.nz)
  - Soundbuffer 'Cutting Enclosure' (soundbuffer.co.nz)
  - Hushtec 'Acoustic Tent' (www.duraflex.co.nz)

If a custom enclosure is needed, a suitably qualified and experienced acoustic specialist, such as a Member of the Acoustical Society of New Zealand (MASNZ), will be involved in its design.

9.6 Excavators

All excavators can generate high noise and vibration levels. The actual level they generate depends on the experience and temperament of the operator.

- Use the right sized excavator for the job
- Operate the bucket and armature with smooth movements (avoid jerking)
- Tip material from the bucket rather than shaking it clean where practicable
- Avoid hitting the bucket on the ground or dropping heavy objects
- Control the weight shift of the excavator to avoid the tracks lifting and thudding on the ground

9.7 Concrete Cutting

- Select blades that:
  - Are sharp
  - Maximise the number of teeth
  - Minimise the blade width
  - Minimise gullet depth
  - Have built-in vibration-damping slots
- Use a unit fitted with a blade shroud and operate with a water supply
- Use noise barriers for concrete cutting and a noise enclosure for paver cutting stations (Section 9.5)
- Minimise the cutting period and/or the number of cutting periods (e.g. complete all cutting in one extended period rather than two shorter periods with the same overall duration)

9.8 Piling

- Prioritise piling methods that minimise noise and vibration as far as practicable (e.g. augured, screw or press-in piles rather than drop-hammer, impact hammer or vibratory methods)
- For bored piling, avoid shaking the auger to remove spoil where practicable. Shaking the kelly bit connection creates very loud banging that often results in noise complaints. If spoil does not fall off the auger easily, use tools to scrape the auger clean if necessary. If shaking is required due to Health and Safety constraints, ensure bushes are well maintained to minimise steel on steel contact.
- For impact piling methods, use a non-metallic (i.e. wooden or plastic) dolly or cushion cap between the hammer and the driving helmet

9.9 Rattle Guns

- Prioritise use of a tension control bolt, hydraulic wrench or manual torque wrench to minimise rattle gun slippage on a tightened nut
- Ensure effective noise mitigation is in place using noise barriers where practicable

9.10 Building Condition Survey

Building condition surveys document the state of a building, including any existing cracks or other damage. Completing this before construction provides a benchmark if damage claims are made during construction.

A condition survey is recommended to be undertaken for the Wharf Buildings and Wharfinger's Office. Typically, a written request is made to the property owner for permission to undertake a building condition survey at the following times:

- Before construction starts, and where vibration is predicted to exceed the cosmetic building damage limits.
- During construction, where vibration is measured to exceed the cosmetic building damage limits and/or in response to reasonable concerns
- Following construction, to minimise the potential for disputes over vibration-related damage

Each building condition survey will:

- Be undertaken by a suitably qualified person
- Provide a description of the building
- Determine the appropriate structure type classification with respect to DIN 4150-3:2016 "Vibrations in buildings – Part 3: 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

9.11 Vibration Monitoring

Construction vibration monitoring is recommended at the Wharf Buildings:

- The first time when vibro or impact piling is used at the appropriate location at the building provided that access to the building 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 "Vibrations in buildings – Part 3: Effects of vibration on structures"

10.0 RECOMMENDATIONS

In order to ensure that construction noise and vibration effects are managed to a reasonable level, we recommend that:

- New Zealand Standard NZS 6803: 1999 *Acoustics - Construction Noise* and German Standard DIN 4150-3:2016 *Vibrations in buildings – Part 3: Effects on structures,* are adopted as the appropriate reference documents for evaluating potential construction noise and vibration effects from the project.
- Construction activities should be appropriately managed through the implementation of a Construction Noise and Vibration Management Plan (CNVMP), and this should be required as a condition of consent.

Suggested wording for appropriate conditions are as follows:

Construction noise and vibration

1. Construction noise shall be measured and assessed in accordance with New Zealand Standard NZS 6803:1999 "Acoustics - Construction Noise" and shall comply with the following noise limits at any occupied building as far as reasonably practicable

Day	Period	dB L_{Aeq}	dB 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 – 0730	45	75
Sundays and public holidays	0730 – 1800	55	85
	1800 – 0730	45	75

2. Construction vibration shall be measured and assessed in accordance with German Standard DIN 4150-3:2016 "Vibrations in buildings – Part 3: Effects of vibration on structures" and comply with the limits in Tables 1 and 4

Construction Noise and Vibration Management Plan (CNVMP)

3. A Construction Noise and Vibration Management Plan (CNVMP) must be prepared by a suitably qualified person and submitted to Christchurch City Council for certification at least 10 days prior to the commencement of the works. The certified CNVMP must be implemented throughout the Project.

   As a minimum, the CNVMP shall address:

   a) A nominated person responsible for implementing the CNVMP
   b) Applicable conditions relating to noise and vibration
   c) Identification of potentially affected receiver locations
   d) An activity risk analysis for each phase, including quantification of noise and vibration levels
   e) Discussion of proposed noise mitigation measures
   f) Noise and/or vibration monitoring during identified stages
   g) Training of staff on how to minimise noise and vibration
   h) Procedures for handling complaints

APPENDIX A GLOSSARY OF TERMINOLOGY

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). The convention is a reference pressure of Pr = 20 μPa in air and Pr = 1 μPa underwater.
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. A-weighting is used in airborne acoustics.
$L_{Aeq (t)}$	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.
L_{peak}	The peak instantaneous pressure level recorded during the measurement period (un-weighted).
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.
NZS 6803:1999	New Zealand Standard NZS 6803: 1999 *"Acoustics - Construction Noise"*
PPV	Peak Particle Velocity. The measure of the vibration aptitude, zero to maximum. Used for building structural damage assessment.
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 the vertical direction (up and down vibration), the horizontal transverse direction (side to side) and the horizontal longitudinal direction (front to back).
DIN 4150	German Standard DIN 4150-3:2016 *Vibrations in buildings – Part 3: Effects on structures*

APPENDIX B NZS 6803:1999

"Residential zones and dwellings in rural areas:

Table 2 – Recommended upper limits for construction noise received in residential zones and dwellings in rural areas

Time of week	Time period	Duration of work					
		Typical duration (dBA)		Short-term duration (dBA)		Long-term duration (dBA)	
		L_{eq}	L_{max}	L_{eq}	L_{max}	L_{eq}	L_{max}
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	0630-0730	45	75	45	75	45	75
	0730-1800	75	90	80	95	70	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75
Sundays and public holidays	0630-0730	45	75	45	75	45	75
	0730-1800	55	85	55	85	55	85
	1800-2000	45	75	45	75	45	75
	2000-0630	45	75	45	75	45	75

Industrial or commercial areas:

Table 3 – Recommended upper limits for construction noise received in industrial or commercial areas for all days of the year

Time period	*Duration of work*		
	Typical duration	***Short-term duration***	***Long-term duration***
	L_{eq} (dBA)	*L_{eq} (dBA)*	*L_{eq} (dBA)*
0730-1800	*75*	*80*	*70*
1800-0730	*80*	*85*	*75*

Notes in the standards to the tables above:

7.2.5 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.

7.2.6 One major factor which should be considered is whether there is a relatively high background sound level (L_{90}) 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).

7.2.7 Where there is no practicable method of measuring noise outside a building, the upper limits for noise measured inside the building shall be the levels stated in tables 2 and 3 minus 20 dBA. This is considered to be a typical value for the sound reduction normally achieved in New Zealand buildings with doors and windows closed."

APPENDIX C NOISE SURVEY DETAILS

The key details of the noise survey are as follows:

Date: 25 October 2024, 1030 to 1420 hrs.

Personnel: Juan Gaviria, Marshall Day Acoustics

Weather: 18-19 °C, mostly clear skies, approx. 3-4 m/s wind from the west

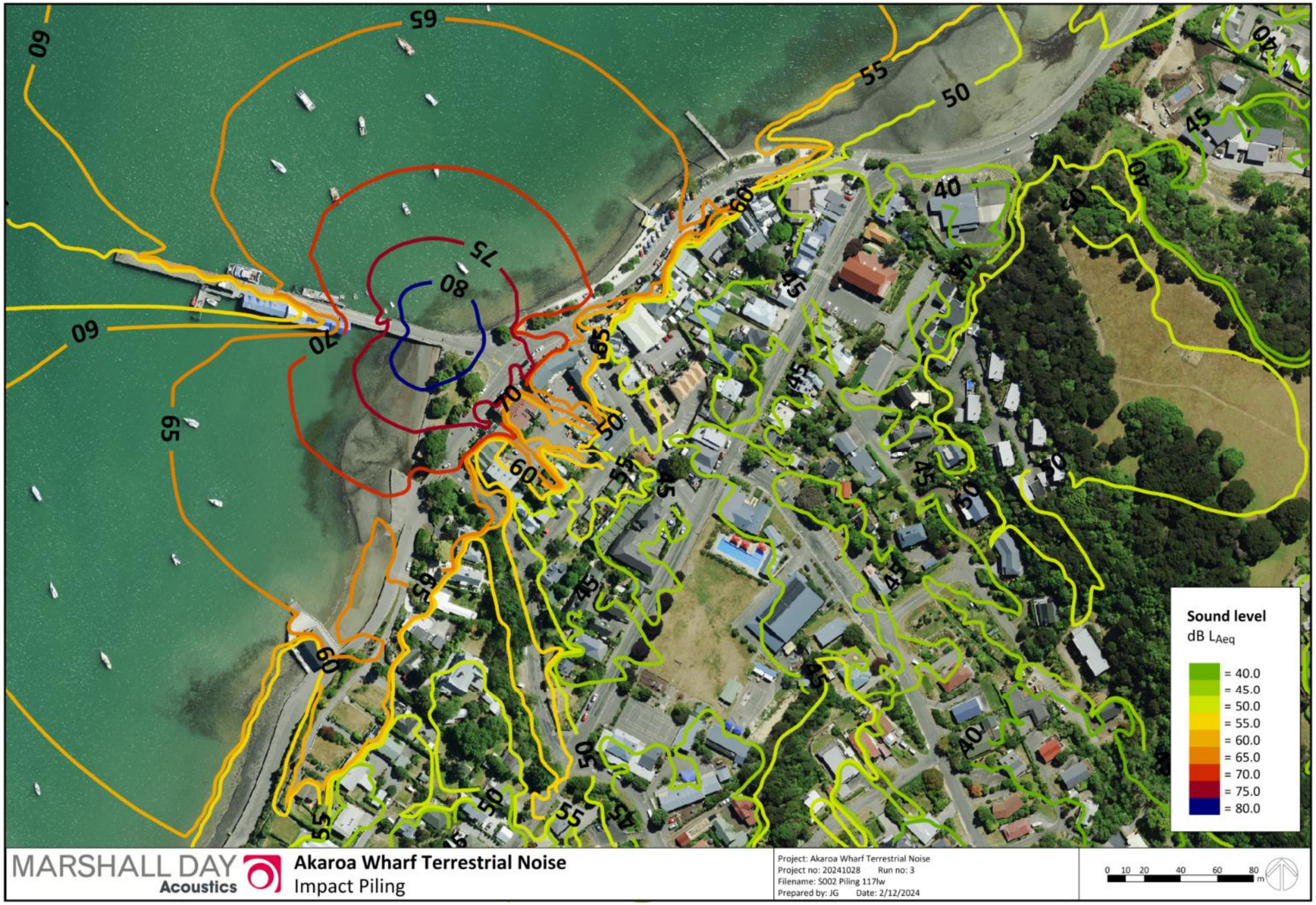
Instrumentation: Brüel & Kjær Type 2250 analyser, serial 3010261, calibration due 30/05/2025
Brüel & Kjær Type 4231 calibrator, serial 3004051, calibration due 12/09/2025

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 D NOISE CONTOURS PLOTS

D1 Demolition

D2 Impact Piling



D3 Operational noise